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El Dr. Jesús Enrique Lossada, luego de trabajar infatigablemente hasta lograr la reapertura de la Universidad del Zulia, el 01 de octubre de 1946, le aportó a esta institución su primera revista científica: la *Revista de la Universidad del Zulia*, fundada por este insigne zuliano, el 31 de mayo de 1947. En su Tercera Época la revista mantiene la orientación que le asignara su fundador: es un órgano científico de difusión de trabajos parciales o definitivos de investigadores y/o equipos de investigación nacionales y extranjeros. La revista posee un carácter multidiscliplinario, por ello su temática se divide en tres grandes ejes: a. ciencias sociales y arte; b. ciencias del agro, ingeniería y tecnología; c. ciencias exactas, naturales y de la salud. Su publicación es cuatrimestral. Cada número, de los tres del año, se corresponde con uno de los tres ejes temáticos. La *Revista de la Universidad del Zulia*, por su naturaleza histórica y patrimonial, está adscrita a la Cátedra libre Historia de la Universidad del Zulia.

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Contenido

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La territorialidad y el principio del *Uti Possidetis Iuris Itapossideatis*

Édixon Ochoa *

RESUMEN

En la presente investigación, fraguada a modo de revisión histórica, jurídica y editorial, se escudriña nuevamente el principio jurídico del *uti possidetis iuris itapossideatis* que, no obstante, su clásica vinculación con los contextos de demarcación, definición y esclarecimiento de las líneas divisorias internacionales, constituye el fundamento para el abordaje de varias situaciones relacionadas con el concepto de la territorialidad desde una óptica transdisciplinaria.

PALABRAS CLAVE: Frontera; Derecho territorial; instrumento internacional; Derecho de los Estados.

Territoriality and the principle of uti possidetis iuris itapossideatis

ABSTRACT

In the present investigation, forged as a historical, legal and editorial review, the legal principle of uti possidetis iuris itapossideatis is scrutinized again, which, nevertheless, its classic link with the contexts of demarcation, definition and clarification of international dividing lines, constitutes the foundation for addressing various situations related to the concept of territoriality from a transdisciplinary perspective.

KEYWORDS: Boundaries; Territorial rights; International instruments; Rights of states

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Un territorio es conceptuado como la apropiación del espacio con fines políticos, gestionado internacionalmente como consecuencia del devenir histórico (Spíndola, 2016). La significación sociocultural de dicho territorio con fines identitarios es lo que se denomina territorialidad, concepto éste que puede abordarse desde miradas históricas, geográficas, sociológicas, jurídicas y hasta literarias.

En el marco de esta mirada transdisciplinaria, se plantea a continuación la revisión de un principio jurídico fundamental para el concepto de territorialidad, allende el enfoque desde el cual pueda ser tratado. Se trata del *uti possidetis iuris itapossideatis* (como poseísteis, así seguiréis poseyendo), cuyo más lejano antecedente se encuentra en el Tratado de Alianza y Federación entre Cundinamarca y Venezuela, suscrito el 28 de mayo de 1811 en Santa Fe de Bogotá por Jorge Tadeo Lozano de Peralta, Jefe del Poder Electoral Constituyente de Cundinamarca, y el Pbro. Dr. José Cortés de Madariaga, Representante de la Suprema Junta de Caracas (Ojer, 1982). Éste fue el primer instrumento legal bilateral en invocar dicho principio, pues al referirse a la cuestión limítrofe, menciona:

> La demarcación y límites de los dos Estados se acordarán por un tratado separado, tirándose la línea divisoria de los dos Estados por la parte que parezca más oportuna, proporcionándose una recíproca indemnización de lo que mutuamente cedan, y esta división se hará por geógrafos nombrados por ambas partes (Perazzo, 1965).

Más adelante, en 1821, luego de enviar ministros plenipotenciarios a Perú, Argentina y México con el propósito de delimitar, federar e integrar a las nuevas repúblicas, Simón Bolívar expresa (Echeverría, 2004):

> Las partes se garantiza mutuamente la integridad de sus respectivos territorios en el mismo pie en que se hallaban antes de la presente guerra debiendo respetarse los límites que tenía en aquel tiempo cada Capitanía General o Virreinato que ha reasumido en el día, el ejercicio de su soberanía.

Durante el periodo colonial, España creó diversos tipos de circunscripciones territoriales: comerciales (intendencias y consulados), judiciales (audiencias o presidencias), eclesiásticas (misiones, diócesis y arquidiócesis), y jurídico-militares (virreinatos y capitanías

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generales). Éstas últimas eran las más precisas, por lo cual Bolívar las escoge, no hablando de herencia hispana, sino de reconocimiento mutuo de los territorios poseídos por tales entidades, de las cuales emergían las repúblicas. A esto agrega una fecha límite: antes y después de 1810, que selecciona especialmente para Suramérica, pues fue en este año cuando la mayoría de las colonias hispanoamericanas inició su transformación política (Echeverría, 2004).

Una vez culminada la emancipación de Hispanoamérica en 1824, las incipientes repúblicas emprendieron la búsqueda de un principio jurídico propio, fundamentado en la tradición y la aceptación colectiva, que constituyera el punto de partida para la delimitación de sus territorios. Para ello, Bolívar elige una regla jurídica del derecho romano. Según éste, los pretores fallaban provisionalmente el derecho de ocupación de un solar u objeto a favor del ocupante: mientras se demuestra lo contrario, es de quien lo tiene. Era un *uti possidetis facti* (como lo poseísteis de hecho). Bolívar reformula la regla manifestando su contraparte, es decir, el *uti possidetis iuris* (como lo poseísteis de derecho) (Echeverría, 2004).

El nuevo principio jurídico fue acogido por las repúblicas hispanoamericanas, hallándose plenamente asentado para 1830, año desde el cual estuvo consagrado, por cierto, en todas las constituciones de Venezuela promulgadas hasta la presente fecha Años después, en 1845, España reconoció oficialmente la independencia de sus antiguas colonias y sus fundamentes jurídico-territoriales. En 1847, el *uti possidetis iuris itapossideatis* fue aprobado y ratificado en el Congreso Hispanoamericano de Lima (Echeverría, 2004). Su aplicación se vislumbró sencilla: para determinar que un territorio pertenecía a determinada nación hispanoamericana, bastaría con demostrar que dicho territorio pertenecía al país en cuestión para 1810.

Sin embargo, en 1883, a propósito del centenario del natalicio de Simón Bolívar, numerosos dignatarios extranjeros se reunieron en Caracas. El entonces presidente Antonio Guzmán Blanco reunió a los latinoamericanos y les presentó un protocolo confidencial, a consideración de sus gobiernos. En él se instaba a reconocer, entre otros aspectos, el *uti possidetis iuris itapossideatis* como base del derecho internacional de América, que se consagraría en un congreso continental convocado a tal efecto. Las respuestas fueron excusas, ambigüedades y negaciones, siendo estas últimas las de Argentina y Chile (Consalvi, 2011).

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Así fue como surgió un principio jurídico novedoso, aunque de raíces pretéritas, esencial para la tranquilidad de las repúblicas hispanoamericanas, en pro de solucionar sus problemas internos territoriales como también para contrarrestar las pretensiones geófagas de las potencias europeas de entonces. Una norma jurídica que ha sido aplicada, incluso, en el resto del orbe por no pocos países, entre ellos, las propias potencias europeas en sus antiguas posesiones coloniales, al momento de dirimir sus eventuales litigios fronterizos. En suma, el *uti possidetis iuris itapossideatis* trascendió y perduró hasta la actualidad como doctrina del derecho público moderno.

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La certificación Rainforest Alliance como estrategia competitiva para el sector agrícola exportador ecuatoriano

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RESUMEN

Las transformaciones que experimentan los mercados internacionales son una constante que deben enfrentar las empresas para su expansión comercial, poniendo a prueba su capacidad de respuesta y adaptación a los nuevos escenarios. Para cumplir con las estrictas regulaciones y ganar la confianza de los consumidores, los exportadores están adoptando diferentes tipos de certificación como estrategia para gestionar la sostenibilidad en mercados exigentes. Este trabajo se plantea como objetivo identificar la influencia de la certificación Rainforest Alliance en la competitividad de las empresas exportadoras ecuatorianas en el mercado internacional. El análisis se enfoca en varios productos del sector agrícola. Se ha empleado el método teórico analítico-sintético para revisar artículos en revistas científicas y documentos bibliográficos de instituciones oficiales. Entre los principales resultados se destaca que esta certificación contribuye de forma significativa a la protección del medio ambiente, la equidad y la viabilidad económica de la empresa. Se concluye que al aplicar este sello ambiental se obtienen beneficios en la fincas o empresas aumentando la producción permitiendo el acceso a nuevos mercados.

PALABRAS CLAVE: Comercio Internacional; desarrollo sostenible; estrategia de diferenciación; Rainforest Alliance.

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Rainforest Alliance certification as a competitive strategy for the Ecuadorian agricultural export sector

ABSTRACT

The transformations that international markets are undergoing are a constant that companies must face for their commercial expansion, testing their ability to respond and adapt to new scenarios. To comply with strict regulations and win the trust of consumers, exporters are adopting different types of certification as a strategy to manage sustainability in demanding markets. The objective of this work is to identify the influence of the Rainforest Alliance certification on the competitiveness of Ecuadorian exporting companies in the international market. The analysis focuses on various products in the agricultural sector. The analytical-synthetic theoretical method has been used to review articles in scientific journals and bibliographic documents of official institutions. Among the main results, it stands out that this certification contributes significantly to the protection of the environment, equity and the economic viability of the company. It is concluded that by applying this environmental seal, benefits are obtained in the farms or companies by increasing production, allowing access to new markets.

KEYWORDS: International Trade; sustainable development; differentiation strategy; Rainforest Alliance.

Introducción

El dinamismo que se observa en los mercados internacionales se asocia a los cambios de comportamiento que ha tenido el consumidor. Se destaca la preocupación por los efectos de actividades productivas en el medio ambiente y el desarrollo sostenible. Así, un creciente número de empresas reconocen mediante sus prácticas, la necesidad de adaptarse a las transformaciones derivadas del medio ambiente para mantenerse en la competencia.

Dentro de este marco se puede recalcar que las organizaciones han empezado a tomar acciones basadas en la responsabilidad social, puesto que la misma es un factor importante dentro de la competitividad en las empresas, de modo que esta comprende diversos campos que van desde los precios hasta la calidad del producto. En este sentido, las empresas han recurrido

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a diversas estrategias que van direccionadas al desarrollo sostenible, para poder incrementar su aceptación en el mercado.

Existe evidencia de empresas que se destacan por aplicar como estrategia de diferenciación la certificación Rainforest Alliance, que fomenta la acción colectiva entre el hombre y la naturaleza. Dicha certificación respalda empresas que emplean mecanismos efectivos para vincular a los pequeños agricultores de los países en desarrollo con mercados de alto valor (Sellare et al., 2020), generando patrones de producción y comercio respetuosos con el medio ambiente y socialmente aceptables, que permiten destacarse de forma significativa en el mercado competitivo al que se está expuesto, estableciendo estrategias basadas en el conocimiento de lo que desea el consumidor (Carro et al., 2019). La certificación Rainforest Alliance se enfoca en la protección del medio ambiente desde la producción hasta las cadenas de supermercados asegurando a los consumidores productos que han sido labrados y cosechados, cumpliendo con cada uno de sus estándares (Vera y Cañón, 2018) aportando valor a millones de agricultores y cientos de empresas a nivel mundial.

En Ecuador, existen empresas agrícolas exportadoras que han podido mantenerse a través del tiempo defendiendo su competitividad mediante la inclusión de la certificación Rainforest Alliance en las plantaciones de banano, café, bosques, aceite de palma, cacao, té, helechos y flores. Se destaca el sector florícola que, en el año 2018, registraba 45 empresas con la implementación de esta autenticación (Mena et al., 2018).

En la línea de lo expuesto, esta investigación se desarrolla enmarcada en el objetivo de identificar la influencia de la certificación Rainforest Alliance en la competitividad de las empresas exportadoras ecuatorianas en el mercado internacional. Para alcanzar el propósito, esta investigación se realizó bajo un enfoque descriptivo, a través del análisis de artículos de revistas científicas y escritos de instituciones oficiales asociados a varios sectores que integran al sector agrícola. Se emplearon los métodos teóricos analítico-sintético. La investigación se direcciona a dar respuesta a la interrogante ¿Cuáles son las oportunidades que brinda la certificación Rainforest Alliance a las empresas agrícolas exportadoras?

El presente trabajo se estructura a partir de la introducción, luego se expone en la revisión de literatura la relación entre la competitividad y las certificaciones tomando en cuenta

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fundamentos teóricos. Se indaga la situación de la certificación Rainforest Alliance en el sector agrícola exportador ecuatoriano. Después de hacer la descripción de la metodología, se presentan los resultados enfocados a la eficacia de las certificaciones en los mercados internacionales y su impacto en las empresas agrícolas ecuatorianas. Se presentan las conclusiones enmarcadas en los impactos de los sellos de desarrollo sostenible como parte competitiva de las empresas agrícolas. Finalmente, se exponen los obstáculos y las propuestas de nuevas líneas de investigación a futuro.

1. Revisión de Literatura

1.1 Estrategias de diferenciación para la competitividad del sector agrícola

El término estrategia se asocia a la organización de las actividades y recursos de la empresa, empleando aquellas ventajas de las cuales el adversario carece (Weihrich y Koontz, 1993). A partir de los años 60 la aplicación de la estrategia en el ámbito empresarial conlleva el interés de varios autores considerados clásicos. Chandler (1962) y Andrews (1971) precisan que tanto la estrategia como la estructura empresarial deben estar acordes entre sí para asegurar una ejecución airosa en un tiempo prolongado. A su vez Ansoff (1965) asocia la estrategia al vínculo común que existe entre las actividades organizativas y las relaciones producto-mercado. Es así que, en el progreso de las perspectivas, Sallenave (1994) describe a la estrategia como el arte de vincular todos los aspectos de la gestión empresarial para buscar una mayor competitividad de modo que nos permita saber hacia dónde vamos y cómo obtenerlo.

Por esta razón, la definición de la estrategia en una organización puede ser la mejor apuesta para establecer un orden y asignación efectiva de recursos para lograr una situación viable (Mintzberg et a., 1997). La estrategia es una base fundamental en la proyección de la internacionalización (Heiss, 2017), considerando que procura una adaptación favorable ante los cambios que surgen en el mercado. Así, una forma de aprovechar esta oportunidad es utilizar factores diferenciadores en los productos o servicios para proporcionar un valor superior. En este contexto, en la tabla 1 que reúne propuestas manifestadas por diversos autores sobre la estrategia de diferenciación.

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Tabla 1. Conceptualización de estrategia de diferenciación

Autor	Descripción
(Job y Nyongesa, 2016)	Las corporaciones requieren desarrollar estrategias que las diferencien de sus competidores por ello necesitan de capacidades superiores de ingeniería y diseño. Los diversos grados de diferenciación comprenden cambiar los atributos del producto, la marca y el empaque, etiquetado y ofrece servicios distinguidos de soporte al producto.
(Semuel et al., 2017)	Las empresas que utilizan una estrategia de diferenciación consideran la primera entrada al mercado como una prioridad absoluta. Al ser la primera en el mercado, la empresa tiene la discreción de establecer precios y explotar el amplio segmento del mercado en la búsqueda de lograr altas ganancias y crecimiento
(Méndez, 2017)	En las empresas fusionadas la diferenciación puede ser beneficiosas de manera que aumenta el grado de distinción en relación al de la competencia, por lo tanto, proyecta un resultando sostenible y provechoso desde el punto de vista del valor añadido
(Brüning et al., 2018)	Una estrategia de diferenciación reside en ofrecer características de producto por las que los clientes están dispuestos a pagar un precio superior.
(López et al., 2019)	La diferenciación no solo se enfoca en el producto ya que también intervienen otros procesos que constituyen una fuente de prioridad los cuales pueden iniciar en la producción, marketing y culminar en el servicio de post venta

Fuente: Elaboración propia a partir de los autores citados

La ejecución de la estrategia de diferenciación puede contribuir a mejorar la competitividad, ya que en el entorno globalizado la contienda entre las empresas se agudiza, de tal manera que el desarrollar características únicas en un producto o servicio se convierte en una capacidad indispensable. Porter (1980) destaca que en el ámbito de consecución se crea una posición provechosa a través de la dimensión básica de diferenciación que busca instaurar un conjunto de capacidades distintas, con atributos exclusivos e incomparables a los de su oposición. En este sentido el interés por analizar la estrategia de diferenciación se revela en los trabajos de los autores como Chirinos y Rosado (2016) quienes manifiestan que deben ser única y valiosa, llevando iniciativas como la planificadas a largo plazo (Mora et al., 2020) para lograr

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superioridad ante la competencia (Onufrey y Bergek, 2021; Pavlović y Čelić, 2020) con el fin de que la empresa se pueda distinguir dentro de su industria (Gallegos et al., 2020).

Al hilo de lo expuesto, la relación que existe entre la estrategia de diferenciación y la competitividad puede manifestarse a través de la innovación en productos y procesos, a la cual el público consumidor se muestra muy receptivo. Así, Bernal y Rodriguez (2019) precisan que al consolidarse la competitividad esta genera un crecimiento a nivel global como resultado de la satisfacción fundada por los usuarios.

En síntesis, a lo expuesto se asevera que las empresas pueden generar mayor competitividad adoptando estrategias que les permitan hacer evidente los factores diferenciadores entre sus contendientes. Por lo tanto, de acuerdo con los estándares internacionales, la diferenciación basada en modelos de gestión es una alternativa que están empleando las compañías exitosas en el mercado.

1.2 La Certificación Rainforest Alliance como estrategia de diferenciación

La certificación Rainforest Alliance es una organización creada en 1987, dirigida al sector agrícola sin fines de lucro. El sello está representado por una rana verde que permite al demandante reconocer la sostenibilidad económica, social y ambiental (Fantin y De Lara, 2020). Se encuentra asociado al compromiso con los tres pilares del desarrollo sostenible: mejora continua, sostenibilidad y rentabilidad para los agricultores (Rainforest Alliance, 2018), el cual busca conservar un equilibrio entre la existencia humana y los recursos naturales a través de prácticas de plantaciones amigables (Martinez García et al., 2017).

Siendo la protección de los recursos naturales un aspecto que recibe la atención de un creciente número de consumidores, la certificación Rainforest Alliance aporta de forma significativa en la credibilidad de la institución otorgándole un reconocimiento a nivel internacional, salvaguardando la confiabilidad del etiquetado frente a la competencia del mercado.

Rainforest Alliance afirma garantizar la salud a largo plazo de la comunidad al proteger el ecosistema, mantener el bienestar de la comunidad local y aumentar la productividad (Vanderhaegen et al., 2018). Asegurando medios de vida sostenibles a través de cambios en el uso

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de la tierra (Brenton, 2018) e instaurando un futuro mejor para las personas al hacer que los negocios responsables sean el nuevo modelo a seguir.

La cobertura que tiene esta certificación a nivel mundial se ve reflejada en todos los países, de tal manera, que en la actualidad se ve inmersa en 70 naciones. "Este sello se aplica principalmente en los cultivos de árboles (como el cacao, café), té, fruta (como los cocos, piñas y bananos), nueces (como las avellanas) y flores cortadas, verduras y palma, especialmente en tipo de organizaciones pequeñas y grandes" (Rainforest Alliance, 2020). Por consiguiente, al aplicar esta certificación su valor de referencia varía de acuerdo a la ubicación y tamaño de la finca, así como el producto que se vaya a certificar. En Ecuador la entidad que se encarga auditar, certificar y formar auditores en temas de sostenibilidad en los campos de agricultura bajo la certificación RA es Conservación y Desarrollo (C y D Certified S.A).

Varios autores entre ellos González (2018) y Caviedes et al. (2020) concuerdan en señalar que las empresas que adoptan de forma voluntaria la certificación Rainforest Alliance, están definiendo su estrategia para mejorar su desempeño ambiental y consolidar su prestigio en el acatamiento de rigurosos protocolos sobre el proceso de producción y la cadena de suministro. En este sentido, están empleando la certificación como una herramienta para entrar a nuevos mercados ya su vez mantener una posición competitiva frente a la demanda sustancial de productos sostenibles.

2. Metodología

La investigación es desarrollada con un enfoque cualitativo y de alcance descriptivo fundamentado en revisión de literatura, de acuerdo al objetivo planteado de identificar la influencia de la certificación Rainforest Alliance en la competitividad de las empresas exportadoras ecuatorianas en el mercado internacional.

Las bases de datos examinadas fueron Ebsco, Redalyc, Scopus, Scielo, Taylor & Francis ScienceDirect y además del motor de exploración de Google Académico. De manera que, las indagaciones de información se ejecutaron por título, resumen y palabras claves, utilizando los siguientes términos de búsqueda en español, inglés y portugués, las cuales se enmarcaron en palabras como "evolución conceptual de la certificación RA", "aplicación y evolución de la

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certificación RA", "enfoque estratégico de RA para el logro de ventajas competitivas", "la certificación RA como estrategia de diferenciación", "estrategia de diferenciación como fuente de ventaja competitiva", "La certificación RA como estrategia para medirse en negocios internacionales" y "la certificación RA en empresas exportadoras".

En esta fase fue elemental la lectura rápida de la introducción de los artículos conseguidos, y los predefinidos se ordenan en la matriz de contenido bibliográfico. Se obtuvieron 40 artículos aceptados. La segunda estrategia de búsqueda comprendió la revisión y evaluación de los artículos previamente definidos entre los cuales constan 15 aceptaciones. Posteriormente, los métodos de lectura y análisis ayudaron a afinar las referencias bibliográficas obtenidas, es decir aquellos que cumplían con los siguientes criterios de inserción:

- Temática principal Rainforest Alliance
- El origen de la información debe estar comprendida por artículos de revisión, artículos científicos y libros
- Las publicaciones deben ser entre los años de 2016 y 2021, excepto para autores clásicos.
- En el apartado de resultados, las publicaciones deben presentar un diseño de investigación cuantitativo que aborde casos de empresas que mantengan vigente la aplicación de la certificación Rainforest Alliance para la obtención de ventajas competitivas.

En las evaluaciones de resultados literarios y las discusiones, se ha implementado el método teórico analítico-sintético e inductivo-deductivo. El análisis se logra extrayendo información relevante y asociando u ordenando la información obtenida por medio de la escritura se alcanza la síntesis. El método deductivo-inductivo se considera en la identificación de las variables que muestra la gestión estratégica de las organizaciones para fortalecer la ventaja competitiva del sector agrícola, en el ámbito de casos de empresas que han adquirido la certificación Rainforest Alliance.

3. Resultados

En base al objetivo planteado, se exponen los resultados de la investigación realizada, de acuerdo a la recopilación de trabajos que hacen mención a la certificación Rainforest Alliance,

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bajo un enfoque descriptivo se expone en la tabla 2 la sistematización de 15 artículos científicos en la cual se obtiene información relevante como la muestra, el país de estudio y los principales resultados.

Tabla 2. Certificación Rainforest Alliance aplicada en las fincas o empresas exportadoras.

Autor/Año	Muestra/País	Resultados
(Munasinghe et al., 2021)	74 productores de té. (Sri Lankan)	El sello Rainforest Alliance en los catálogos de los corredores es sumamente importante debido a que permite crear un intercambio económico desde los suministros de las plantaciones de té con los consumidores de mentalidad ética. También permite que los intermediarios observen la diferencia de precios que genera la demanda de consumidores, promoviendo a implementar la certificación.
(Dietz y Grabs, 2021)	659 productores de café hondureños. (Honduras)	Los agricultores certificados por Rainforest Alliance tuvieron los rendimientos más altos en cuanto a precios, logrando así ingresos significativos por hectárea de café.
(Mora et al., 2020)	Empresas exportadoras y cinco productos del sector agropecuario. (Ecuador)	Las certificaciones como RA cumplen un gran papel debido a que contribuyen a generar beneficios a las empresas exportadoras ecuatorianas, permitiendo incrementar sus ventas, fidelizar clientes y lograr ingresar a nuevos mercados.
(Teopista et al., 2020)	454 hogares agrícolas productores de café, de los cuales 126 cuentan con certificación Fairtrade, 81 con certificación Rainforest Alliance y 247 sin certificación. Etiopía y Uganda	Los ingresos totales cafeteros y el ingreso familiar per cápita son mayor para los productores con certificación RA, en comparación con los no certificados, esto se da debido a los altos rendimientos especialmente por la combinación de la certificación RA con la certificación 4C y Utz que se enfocan directamente en las buenas prácticas agrícolas. Los ingresos de los productores con certificación FT son más altos (pero menos que los de hogares con certificación RA) en comparación con los de productores no certificados en Etiopía.

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(Donovan et al., 2019)	3 tipos de empresas cafeteras en cada país en total 9 empresas cafeteras (Guatemala, Honduras y Nicaragua)	Esta certificación ha ayudado a que los productores vendan su café a compradores exigentes debido a la competencia que existe en el mercado internacional, también permitió demostrar la calidad del producto, negociar precios, mejorar las opciones de comercialización, reducir riesgos en el mercado y aumentar el acceso a servicios e insumos.
(Annunziata et al., 2019)	Sur de Italia en una muestra de 305 personas de entre 18 y 26 años. (Italia)	Existe un bajo consumo de alimentos con marca sustentable especialmente con la de RA debido a la etiqueta poco visible mencionando los encuestados que no han consumido tales productos con estos sellos. En términos de facilidad de interpretación, RA se considera el más difícil de interpretar.
(Martinez et al., 2017)	58 encuestas personalizadas a caficultores certificados con el RA de las provincias comuneras (Colombia)	Los caficultores mencionaron en las encuestas en un 100% que la certificación ha permitido el aumento de la rentabilidad y competitividad, mejorando el precio por el producto, mientras que el 95% mencionaron que se ha creado una conciencia amigable con el medio ambiente reflejándose en la calidad de vida, producción y calidad del producto.
(Takahashi y Todo, 2017)	Área de Prioridad Forestal Regional de Belete-Gera. Café forestal (Etiopía)	En esta investigación se identificó que los productores certificados con RA vendieron el café a un precio más alto entre un 15% y un 20% que el café convencional. Las evaluaciones o auditorías continuas podría ser un factor que motivaría a los productores certificados a conservar los bosques debido al incentivo económico que existe.
(De Andrade et al., 2017)	126 consumidores de chocolate amargo (Brasil)	El estudio expresa que un alto porcentaje de los encuestados considera importante saber el origen del producto ya que nunca han consumido chocolate con sellos de calidad. De tal forma que el 79% está dispuesto a pagar un precio mayor por el chocolate amargo certificado.

(Teopista y Maertens, 2017)	Sector cafetero (Uganda)	Productores certificados por Utz_RA_4C poseen una mayor producción de café, rendimiento y productividad laboral, el 57% del café certificado tiene producción superior frente a la no certificada. Este esquema con las 3 certificaciones reduce la probabilidad de ser pobres en 16 puntos porcentuales, aumentando tanto el ingreso familiar y el per cápita que son efectos importantes en la incidencia de la pobreza.
(Mitiku et al., 2017)	El sector cafetero del suroeste de Etiopía (Etiopía)	Los agricultores con certificación RA reciben un precio entre un 40% y un 60% más alto, teniendo ganancias elevadas permitiendo mejorar el bienestar de cada uno de ellos. En comparación con la certificación FT y Org tiene un mejor funcionamiento en el impacto de los ingresos familiares y reduciendo la pobreza.
(Becerril, 2016)	Sat Camposeven (España)	La certificación ecológica permite a los productores ofrecer alimentos con calidad reforzados por las certificaciones internacionales dando a conocer al consumidor el origen del mismo, ayudando a que los productos con sellos ecológicos se diferencian de los demás influyendo en los clientes que desean consumir alimentos sanos potenciando la imagen empresarial en los mercados extranjeros.
(Calderón et al.,2014)	Se seleccionaron 36 fincas certificadas con el sello Rainforest Alliance por un período mínimo de 3 años. (Colombia)	Las condiciones de vida en las fincas de Cundinamarca y Santander han mejorado gracias a la certificación RA, aumentando la calidad del producto, reduciendo las quejas de trabajadores e incrementando la productividad y mejorando la parte financiera. La certificación ayudó a los agricultores a una mejor exposición en el momento de la venta, diferenciación del producto, precios Premium y acceso mejorado al crédito.
(Guedes et al., 2014)	55 fincas individuales y 11 grupos	Tanto las fincas individuales y grupales de café certificados por RA tienen niveles comparables de

	de productores individuales. (Brasil)	productividad es decir que se sugiere el uso de prácticas de manejos similares.
(Omondi et al., 2013)	18 empresas de té (Kenia)	Los resultados de la investigación manifiestan que las fincas de café certificado tienen mejores consideraciones ambientales a pesar de alcanzar el umbral de sostenibilidad. La certificación RA ha proporcionado importantes beneficios tanto en el aspecto medioambiental, factores sociales y económicos.

Fuente: Elaboración propia a partir de los autores citados

De la recopilación extraída se puede observar que los principales resultados manifiestan que al aplicar la certificación RA han obtenido muchos beneficios tanto para productores, fincas y trabajadores. Desde el enfoque de Calderón et al. (2014) se puede apreciar que al certificarse con este sello les ha permitido tener exposición en el mercado, precios más elevados, mejor ambiente laboral tanto productor como trabajador, aumento en la producción y acceso a créditos.

Según Mora et al. (2020) manifiestan que las certificaciones incluida la RA contribuyen en el acceso a nuevos mercados, fidelizando clientes y aumentando las ventas, también la certificación RA ha permitido vender a compradores muy exigentes en la parte de la calidad del producto, negociar precios y tener acceso a servicios e insumos permitiendo ser más competitivos en el mercado exterior (Donovan et al., 2019).

En la tabla 3 se presenta el alcance que ha tenido la certificación y el crecimiento relativo del periodo 2019-2020, en base a los productos como el café cacao, té y banano a nivel internacional.

Como lo menciona en sus informes Rainforest Alliance y UTZ (2021a) el mayor crecimiento relativo lo ha tenido el café en el número de productores con un 18% seguido por un 15% en el aumento de la producción estimada, también se puede notar un decrecimiento en las hectáreas de producción del cacao con un 33% por ende el número de productores y la producción estimada bajó en un 25%, sin embargo el número de trabajadores se elevó a un 8%

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mientras que en el té hubo un crecimiento en casi todos los ítems del alcance del programa, a excepción del número de trabajadores manteniéndose en un 0%.

Tabla 3. Alcance del programa Rainforest Alliance y el crecimiento relativo

Alcance del programa	Café	Cacao	Té	Banano	Crecimiento Relativo 2019-2020			
					Café	Cacao	Té	Banano
Área (hectáreas)	519,828	544,207	643,184	189,227	+10%	-33%	+5%	+2%
Número de productores	228,430	156,391	958,528	2,123	+18%	-25%	+2%	-3%
Producción estimada (TM)	770,295	327,915	1,367,875	9,462,755	+15%	-25%	+12%	+2%
Número de trabajadores (Temporales y permanentes)	334,449	8,880	734,120	184,954	+14%	+8%	0%	+2%
Ventas mundiales	403,241	186,005	375,283	9,462,755	+2%	-8%	+2%	+2%

Fuente: Adaptado a partir de Rainforest Alliance y UTZ (2021c)
Elaborado: por los autores

Las ventas mundiales se puede notar un crecimiento del 2% en el café, té y banano más sin embargo el cacao tuvo un decrecimiento del 8% debido a los cambios de demanda y al COVID-19 (Rainforest Alliance y UTZ, 2021b).

A continuación, en la tabla 4 y 5 se presentan la participación de Ecuador con la certificación Rainforest Alliance en el mercado mundial.

En base a lo expuesto en la tabla 4 se puede observar que el mayor crecimiento relativo 2019-2020 ha sido el cacao teniendo un 53% en ventas mundiales sin embargo existe un decrecimiento en la producción estimada en un 28% al igual que el té mientras que el banano presenta un incremento del 11%.

En la tabla 5 se presentan las fincas certificadas con el programa de Rainforest Alliance en Ecuador en productos como banano, cacao, flores, rosas, aceite de palma, maracuyá, mango, piña, plátano, pitahaya y té.

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Tabla 4. Participación de Ecuador con la certificación Rainforest Alliance

Alcance de Ecuador	Cacao	Té	Banano	Crecimiento Relativo 2019-2020		
				Cacao	Té	Banano
Ventas mundiales según su origen (TM)[a]	12,688	3,408	338,281	+53%	-	-
Producción estimada según su origen	21,260	3,233	1,275,686	-28%	-13%	+11%

Nota. Ecuador está considerado con otros países en la venta de té, pese a ello no refleja información del crecimiento relativo al igual que el banano.
Fuente: Adaptado a partir de Rainforest Alliance y UTZ (2021c)
Elaborado: por los autores

En la tabla 5 se presenta las fincas certificadas con Rainforest Alliance en Ecuador, de las cuales la mayoría se encuentran en las provincias de Guayas (68), El Oro (60), Los Ríos (55) y Pichincha (44), las mismas que en su mayoría son banano y cacao y flores mientras que los productos como piña, mango, maracuyá, pitahaya, té, rosas y aceite de palma son las que tienen un menor número de fincas certificadas. Cabe recalcar que la única provincia certificada por parte de la región Oriental es Morona Santiago, con dos productos diferentes como la pitahaya y el té. Las provincias del Chimborazo y Santa Elena son las únicas que tienen una finca certificada. Es decir, en Ecuador se cuenta con un total de 270 fincas certificadas con RA.

Tabla 5. Fincas certificadas con el programa Rainforest Alliance en Ecuador.

Provincia	Tipo de producto	Número de fincas	Total, de fincas certificadas
Cañar	Banano	3	4
	Cacao	1	
Chimborazo	Banano	1	1
Cotopaxi	Flores	7	10
	Banana	1	
	Rosas	1	
	Cacao	1	

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El Oro	Banano	57	60
	Cacao	3	
Esmeraldas	Aceite de Palma	1	5
	Cacao	4	
Guayas	Banano	60	68
	Maracuyá	1	
	Cacao	5	
	Flores	1	
	Mango	1	
Imbabura	Flores	3	3
Los Ríos	Banano	44	55
	Cacao	9	
	Mango	1	
	Piña	1	
Manabí	Plátano	2	8
	Cacao	4	
	Banano	2	
Morona Santiago	Pitahaya	1	2
	Té	1	
Pichincha	Flores	38	44
	Rosas	6	
Santa Elena	Banano	1	1
Santo Domingo	Piña	4	9
	Banano	3	
	Cacao	2	
Total			270

Fuente: Adaptado a partir de (CyD, 2021)
Elaborado: por los autores

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Conclusiones

El presente trabajo se desarrolló bajo la perspectiva de abordar la certificación Rainforest Alliance como una estrategia de diferenciación que posibilita a las empresas exportadoras ecuatorianas generar una ventaja competitiva en el mercado internacional a través de las buenas prácticas ambientales aportando al desarrollo sostenible y a la concientización del consumidor. El certificado de calidad en la empresa es una buena medida para aprovechar su alto volumen de producción e ingresar al comercio exterior (Botello, 2016) adquiriendo un plus diferenciador a través de RAC, lo que permite ser competitivos donde existen estándares meticulosos para validar el producto (Morán et al., 2019).

Mediante el análisis de la certificación RA en la participación de los productos ecuatorianos se ha podido identificar que el café es uno de los productos agrícolas que no se encuentra certificado con este sello, sin embargo, podemos encontrar un alto número de fincas certificadas siendo el té, la pitahaya, maracuyá, mango, piña, aceite de palma y plátano uno de los productos no tradicionales que implementan dicha certificación para garantizar sus procesos, logrando distinguir de forma única en el mercado competitivo. También se puede observar que varias fincas alrededor del mundo han logrado mejorar su capacidad de producción, disminuir riesgos, perfeccionar el ambiente laboral, acceder a créditos financieros basados en tres principios esenciales como son la mejora continua, desarrollo sostenible y una buena utilidad para los campesinos.

En base al objetivo planteado en la investigación, se concluye que las empresas exportadoras implementan la estrategia de diferenciación mediante estándares de sostenibilidad que representa el sello, dado que el mercado es muy exigente, por ende, las organizaciones se han ido adaptando a estos cambios, ofertando productos de calidad desde su producción hasta su consumo otorgándole satisfacción al demandante.

El estudio y evaluación de las estadísticas de los diversos productos dan a conocer el crecimiento de la certificación en Ecuador de manera que aporta un incentivo para las pequeñas y grandes empresas a implementar el sello en su mercancía como elemento diferenciador que lo hace único de la competencia.

La principal limitación de esta investigación se asocia a su enfoque cualitativo de carácter descriptivo, en donde se utilizaron las publicaciones de otros autores que examinaron el contexto de las empresas de diferentes sectores productivos, y países, de modo que las deducciones no podrían ser generalizadas a la realidad de otras empresas. Para las investigaciones futuras se deberían considerar estudios estadísticos correlacionales que permitan determinar el tipo de relación entre la variable de la estrategia de diferenciación (fundamentada en la RA) y la variable de la ventaja competitiva.

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Comercio y desarrollo México-Estados Unidos: una aproximación

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RESUMEN

El propósito general de este trabajo es analizar la agenda de comercio y desarrollo binacional entre México y Estados Unidos (EU), en lo que concierne a los apartados comercio bilateral, remuneraciones y relaciones laborales, Derechos Humanos, seguridad fronteriza y cooperación contra el crimen, así como migración. Se justifica relevante dada la transición de gobierno en EU y sus implicaciones para México. Considerando las estadísticas y documentos de las variables seleccionadas se plantea la necesidad de ir a mayor profundidad en estos asuntos de la agenda bilateral en el marco del Derecho Internacional y la Diplomacia y su ánimo conciliador para beneficio común.

PALABRAS CLAVE: Comercio internacional; remuneración; Derechos Humanos; seguridad internacional; migración.

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Mexico-United States Trade and Development: An Approach

ABSTRACT

The general purpose of this work is to analyze the binational trade and development agenda between Mexico and the United States (US), regarding the sections of bilateral trade, wages and labor relations, Human Rights, border security and cooperation against crime. as well as migration. Relevance is justified given the transition of government in the US and its implications for Mexico. Considering the statistics and documents of the selected variables, the need is raised to go deeper into these matters on the bilateral agenda within the framework of International Law and Diplomacy and its conciliatory spirit for common benefit.

KEY WORDS: International trade; remuneration; Human Rights; International security; migration.

Introducción

El tema del comercio internacional (CI) y de aquellos que están implícitos en las relaciones de los países siempre se halla vigente. De hecho, lo está más ahora, dadas las intenciones de algunos países respecto de revisar las relaciones comerciales que se advierten recientemente como EU y el Reino Unido. El propósito de este trabajo es analizar la agenda de comercio y desarrollo binacional entre México y Estados Unidos (EU), relativos a los aspectos del comercio bilateral, remuneraciones y relaciones laborales, Derechos Humanos, seguridad fronteriza y cooperación contra el crimen, así como migración. La relación histórica entre estos países ha manifestado altibajos, inclusive de grado bélico. Existe un esfuerzo de ambos gobiernos para mejorar el bienestar ciudadano, además de implementar acciones para favorecer el comercio más libre.

La relación entre México y EU nunca ha sido un asunto sencillo, ya que a lo largo de su historia se han experimentado encuentros y desencuentros. En algunos periodos las relaciones comerciales y diplomáticas han sido estables en lo general. Sin embargo, en forma particular la administración del presidente Trump (2016-2020) se caracterizó por una política exterior hacia México de exigencias de cooperación en los temas de seguridad fronteriza y la revisión del Tratado de Libre Comercio de América del Norte (TLCAN), fundamentalmente. El asunto

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migratorio y los demás constituyeron una prioridad para su gobierno. Ahora con el presidente Biden, la situación requiere un abordaje de estas temáticas dado que siguen siendo relevantes.

Sería muy deseable que se privilegiaran la cooperación y desarrollo entre las naciones; más aún si son vecinas. Sin embargo, no siempre ello se privilegia. Las partes involucradas debieran reconocen la necesidad de construir acuerdos políticos, de comercio y cooperación de cara a reducir a las desigualdades entre ellos. En el siglo XX las relaciones comerciales de México y EU se caracterizaron por una gradual reducción de los derechos de importación y de los gravámenes aplicados a las importaciones. Las exportaciones de México hacia EU se limitaron a materias primas y metales preciosos.

Con el transcurso del tiempo, ya en el marco de la liberalización comercial de los ochenta, participaron en mayor medida las manufacturas de mayor valor agregado. Las de EU hacia México fueron, en su mayoría, alimentos procesados, bienes agrícolas, tecnología, equipo y gas, gasolina y demás energéticos. En buena medida el gobierno mexicano fue abandonando su política industrial proteccionista, lo cual le permitió adecuarse a las exigencias norteamericanas. Los altos aranceles decretados por México tuvieron el propósito de obtener ingresos aduaneros extraordinarios, pero fueron reduciéndose con la liberalización de la economía nacional (Martínez et al., 2021).

De acuerdo con la oficina representativa de comercio de los EU, en 2019 el volumen de comercio entre este país y México fue de 6,673 billones USD, de las cuales fueron de 289.5 billones en exportaciones y de 387.8 billones por concepto de importaciones. De ese modo, México se constituye en el principal socio comercial de los EU.

Las exportaciones de EU a México han crecido a aproximadamente un 517 % de 1993 al 2021. Las principales compras realizadas por México son: maquinaria (45 billones de USD); maquinaria eléctrica (42); combustibles minerales (34); vehículos (21); plásticos (16) y productos agrícolas (20). Las exportaciones de servicios se estimaron en 32.9 billones USD desde en el mismo periodo por concepto de viajes, transporte y propiedad intelectual fundamentalmente.

Por su parte, México se ha convertido en el segundo proveedor de los EU, después de China, y los bienes que exporta son: vehículos (101 billones de USD); maquinaria (66);

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maquinaria eléctrica (64); instrumentos ópticos y médicos (16); combustibles minerales (13); productos agrícolas (28). Las exportaciones de México a EU han crecido alrededor del 30 por ciento en el periodo referido. La inversión extranjera directa en México fue de 100.9 billones de USD en 2019, y se ha realizado en sectores como la manufactura, finanzas, seguros, hotelería y demás servicios.

Los dos países comparten una frontera de 2,000 millas con 55 puertos de entrada terrestres activos, y las relaciones bilaterales entre ambos tienen un impacto directo en la vida y los medios de subsistencia de millones de estadounidenses, ya sea que se trate de reformas comerciales y económicas, intercambio educativo, seguridad ciudadana, control de drogas, migración, trata de personas, emprendimiento, innovación, cooperación energética o salud pública. El alcance de las relaciones entre EU y México es amplio y va más allá de las relaciones diplomáticas y oficiales. Abarca amplios lazos comerciales, culturales y educativos, con $ 1.7 billones USD de comercio de ida y vuelta y durante tiempos económicos y de salud normales; hay cientos de miles de personas que cruzan la frontera legalmente cada día (US Departament of State, 2021).

El Tratado México, Estados Unidos y Canadá (T-MEC) o USMCA por sus siglas en inglés, entró en vigor el 1 de julio de 2020. El T-MEC apoyará el comercio de beneficio mutuo que conducirá a mercados más libres, un comercio más justo y un crecimiento económico sólido en América del Norte. Se espera que el citado Acuerdo genere oportunidades laborales; mejore la protección de los trabajadores; prevenga el trabajo forzoso; incremente el comercio agrícola; aliente nuevas inversiones en industrias manufactureras vitales; proteja los derechos de propiedad intelectual; propicie un conjunto similar de estándares ambientales en los tres países; y trasladar las protecciones comerciales digitales al siglo XXI (US Departament of State, 2021).

De acuerdo con el Departamento de Agricultura de EU (US Department of Agriculture, 2020) el comercio agrícola entre EU y México es fundamentalmente complementario, lo que significa que dicho país tiende a exportar diferentes productos básicos a México. Aproximadamente tres cuartas partes de las exportaciones agrícolas de EU a México son cereales, semillas oleaginosas, carne o productos relacionados. México no produce suficientes granos y oleaginosas para satisfacer la demanda interna, por lo que los productores de alimentos

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y ganado importan volúmenes considerables de estos productos básicos para fabricar productos de valor agregado como carne, aceite vegetal y productos de trigo.

El desarrollo económico de los países requiere de los factores productivos indispensables, además de una serie de arreglos institucionales. A lo largo de la historia las naciones imperialistas han echado mano de dichos arreglos políticos. En el caso de México, a finales del siglo XIX y comienzos del XX —en la época del porfiriato— las inversiones de nacionales y extranjeros crecieron de manera significativa. Bajo el lema de *orden y progreso* se realizaron inversiones en infraestructura como la construcción de vías férreas, presas, comunicaciones y demás. La frontera norte, como también el sur y amplias regiones del país sufrieron de desatención. Era de esperar con ello que los asuntos fundamentales como la justicia social, la falta de libertades y de desarrollo se dejaron de lado; razones que alentaron la Revolución mexicana. En términos reales esta situación pone de manifiesto que el modelo de economía que privilegió a los ricos entró en grave crisis.

El presente trabajo se estructura de la siguiente manera: En la primera parte se revisa la literatura y destaca la importancia del comercio binacional México-EU y cómo este se ha trasformado en un contexto de liberación y expansión global de los mercados. La segunda parte se refiere a los métodos y resultados se analizan datos que tienen que ver con la dinámica comercial y no comercial, señalándose los aspectos fundamentales característicos de dicha agenda binacional. La última parte destaca las conclusiones.

1. Revisión de la literatura

El comercio internacional (CI) constituye uno de los fundamentos del desarrollo, pues en él ocurren intercambios de bienes y servicios entre dos o más países o regiones económicas. Las economías que participan de él se denominan *economías abiertas* (Samuelson y Nordahus, 2010). Como antecedentes del CI en el siglo XX deben señalarse a las reuniones de *Bretton Woods* en 1944 y la materialización del Acuerdo General sobre Aranceles Aduaneros y Comercio (GATT) en 1948. La Organización Mundial de Comercio (OMC) se creó en 1995 como institución de fomento, regulación y arbitraje entre los países. Durante ese periodo el intercambio de

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mercancías estuvo regido por un conjunto de normas diseñadas para reducir las barreras arancelarias y no arancelarias a partir de la implementación de varias rondas de negociaciones. Este proceso de liberalización global cobró dinamismo en la década de los noventa, al incorporarse a las economías de Latino América, de Europa del Este y del sur de Asia. El resultado ha sido una mayor interrelación comercial y no comercial en los mercados internacionales.

En estos procesos de liberalización de la economía mundial las corporaciones pretenden alcanzar los más altos niveles de competitividad en base a elevados estándares de desempeño y rentabilidad, considerando reducir los costos de producción y demás condiciones favorables para la expansión de sus operaciones. Por su parte, Mendoza Cota (2021) destaca que la inversión extranjera directa en México ha sido positiva en el contexto de la liberalización comercial. Además de ello, las relaciones con EU han experimentado un crecimiento en las cadenas de valor entre ambos países. Así, las políticas de ambos países requieren del desarrollo de infraestructura y demás arreglos para la potenciación de dichas relaciones económicas.

Sobre las relaciones de comercio bilateral deben destacarse diversos trabajos, entre los cuales se encuentra el de Ortiz Valenzuela (2020), en el cual se plantea la necesidad de profundizar los acuerdos de vinculación en la industria automotriz entre Colombia y Venezuela. Así, en este tipo de acuerdos las empresas toman ventajas al acceder al financiamiento en las mejores condiciones, a las tecnologías de vanguardia, así como a mercados con mayor poder de compra. En la medida en que se hacen más globales, su identidad nacional se va perdiendo. En ese propósito, ha sido indispensable contar con la infraestructura de comunicaciones y transportes, acceso a tecnología, trabajo y demás arreglos institucionales.

Respecto a las relaciones comerciales en el contexto de bloques de países, la experiencia de América Latina no es la excepción. En estos países también se advierten los beneficios de la integración y de las economías de escala derivados de los arreglos institucionales que se han desarrollado a través del tiempo, especialmente en el largo plazo. Aunque no están exentos de dificultades y desacuerdos, existen patrones de estabilidad que dan cuenta de que la cooperación económica y la voluntad política son elementos que favorecen el desarrollo económico a partir de sus vínculos con el comercio internacional (Bejarano Copo et al, 2020).

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Según Daniels (2009) el CI está basado en una serie de condiciones que lo favorecen, entre las cuales se hallan las siguientes:

-La prevalencia del comercio como factor natural, a pesar de las restricciones de idioma, geografía, leyes y demás. La geografía está asociada al CI y ocurre de manera intencionada o no.

-La consideración de la existencia de mercados en el exterior ante las crisis nacionales.

La investigación de mercados como *punta de lanza* para colocar bienes y servicios, considerando los flujos de personas y de recursos en las diversas fronteras nacionales.

-La exportación de tecnologías y bienes innovadores, especialmente hacia países en vías de desarrollo.

-La formación de economías de escala debido a potenciación de los recursos físicos, materiales y humanos de dentro y de fuera del país.

-La extensión del ciclo de la vida de las empresas y sus bienes a otros países.

Por otro lado, el enfoque básico de la economía internacional para la inmigración es el teorema de Rybczynski (1955). Esta teoría, desde luego sujeta a un conjunto de suposiciones, se describe de la siguiente manera: un aumento en la dotación de trabajo del país a través de la inmigración aumentará más que proporcionalmente la producción de esos productos, cuya tecnología de producción requiere mucha mano de obra. Así, la producción de bienes intensivos en otros factores, por ejemplo, capital, tendrá que disminuir (Benacek, 2010: 70).

De acuerdo con Terrazas y Basante y Garza (2012) el CI presenta asimetrías, las cuales en el caso de México-EU significan un mayor control de los recursos y del comercio por parte de los EU. Esta situación ha significado mayor vulnerabilidad para la economía mexicana, especialmente en lo que concierne a la pérdida de un mayor mercado destino de sus exportaciones. Desde entonces, se evidencia una tendencia a concentrar el mercado y la producción en México. Se observa, adicionalmente, una seria dificultad para diversificar exitosamente las exportaciones mexicanas a otros mercados del exterior.

Por otro lado, según Reyes (2021: 1), la relación de México y EU en el actual contexto de cambio de gobierno en EU, ya como presidente Biden, puede ser agridulce y lo plantea de la siguiente forma:

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> "Además del comercio, hay una serie de temas que tradicionalmente han marcado la agenda bilateral: seguridad, migración, control del narcotráfico, cambio climático, política energética, respeto a los derechos humanos y condiciones laborales. La administración Biden basará su relación con México en el marco de un estricto cumplimiento de los compromisos establecidos bajo el T-MEC. Ello en principio debería ser benéfico para nuestro país, ya que el T-MEC ha sido reconocido por nuestro gobierno como un instrumento para promover el desarrollo. Sin embargo, hay algunos temas que Biden remarcará y en los que el gobierno mexicano tiene visiones diferentes como en los temas de energía y la promoción de energías limpias, la supervisión de la ley laboral y el control de la pandemia".

2. Métodos y resultados

El trabajo en cuestión es de tipo cualitativo fundamentalmente, pues partiendo del propósito general, así como revisión de la literatura, se procedió a recopilar los datos e información referentes a las variables de interés: el comercio entre México y EU, las remuneraciones (manufactureras) y relaciones laborales; Derechos Humanos; la seguridad fronteriza y cooperación contra el crimen, además de migración.

2.1. Comercio binacional

El primer aspecto que se revisa es el del comercio binacional México-EU. Para los propósitos perseguidos en la presente investigación es conveniente destacar el significado que tiene el comercio entre estos países. En 1988 EU y Canadá iniciaron su tratado bilateral. México se incorporó en 1994, creándose así el denominado TLCAN. En la conformación del citado bloque se establecieron reglas tendientes a incrementar los flujos comerciales y de inversión, así como a mejorar el empleo y el nivel de bienestar. Como oportunidades para el crecimiento de la economía mexicana el país tiene firmados diez acuerdos comerciales con 45 países, lo cual equivale al 60 por ciento del PIB mundial. Los principales acuerdos son el TLCAN y el firmado con la Unión europea (TLCUEM). También existen acuerdos con otros bloques y naciones por separados: Mercosur, Alianza del Pacífico, Israel, Japón, Centroamérica, entre otros.

En el contexto de la liberalización de la economía, la relación bilateral México-EU presenta la caracterización que muestra la tabla 1:

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Tabla 1 La relación bilateral México-EU en el contexto del TLCAN-TMEC

	Para México	Para Estados Unidos
Objetivos	— Asegurar el acceso de la tecnología, materias primas, equipo y bienes finales de EU. — Acceder a un mercado diverso y con poder de compra. — Atraer la inversión directa e indirecta para generar empleos.	— Integrar sus cadenas productivas y complementar su producción de recursos minerales. — Detener la inmigración mexicana — Aprovechar el capital humano competitivo y con costos salariales menores. — Mejorar la competitividad respecto a Europa, Japón y el sur de Asia.
Medios y estrategias	— Liberalizar el comercio — Privatizar empresas estatales — Atraer la inversión por la vía de las reformas estructurales (laboral y energética). — Ajustar las políticas económicas a nuevas condiciones internacionales.	— Especializar industria de alta tecnología. — Diversificar la economía: énfasis en el comercio, el turismo y la profundización financiera. — Realizar inversiones, adquisiciones y fusiones con empresas de México.

Fuente: Elaborado por los autores

Idealmente las relaciones entre los países debieran ser fructíferas y basadas en las reglas acordadas y la cooperación. No obstante, en la historia universal no son pocos los episodios de saqueo y explotación de recursos y personas en las naciones colonizadas. Los contrastes en el CI en lo concerniente a intercambios y valor agregado entre los países son descritos en los siguientes términos:

> Las diferencias entre los países en vías de desarrollo y los desarrollados son mayores cuando se examina la composición del comercio. Los países en vías de desarrollo suelen ser exportadores de bienes básicos. Las materias primas, los cultivos destinados a los grandes mercados y a veces los productos alimenticios constituyen importantes artículos de exportación. Los textiles y los artículos de la industria ligera también figuran en la lista. En cambio, la mayor parte de las exportaciones de los países desarrollados pertenecen a la categoría de bienes manufacturados y van desde bienes de capital hasta bienes de consumo duradero (Ray, 2002: 37).

En este mismo orden de ideas, el crecimiento del PIB mundial ha mostrado un descenso en el ámbito internacional desde 2010 hasta el presente, explicado por la adopción de prácticas proteccionistas entre no pocos países; alentadas estas por el bajo crecimiento y la prevaleciente

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incertidumbre económica. Persisten aun prácticas de barreras arancelarias y no arancelarias, retrasos en las aduanas, nuevos impuestos y nuevas regulaciones que suelen afectar más a las naciones en vías de desarrollo.

De acuerdo con Burfisher et al (2001), dado el contexto del TLCAN, el mismo ha implicado diversidad de aspectos para los EU, entre los cuales deben destacarse los costos del ajuste derivados de la liberalización comercial, las políticas comerciales y los vínculos entre los acuerdos regionales y el comercio mundial.

La dinámica comercial de EU con otros países seleccionados se observa en la gráfica 1. En la misma se muestra un patrón general de crecimiento de las exportaciones de EU con respecto a México, considerado un socio estratégico de larga data. Después del 2009 se observa un crecimiento importante en el comercio bilateral entre los países. Aunque la gráfica 1 no muestra datos del 2020, es un hecho que la dinámica referida ha sido menor, pues el Covid 19 ha afectado las inversiones y el comercio entre los países.

Las exportaciones de México han crecido significativamente a lo largo del periodo. De hecho, el balance comercial es desfavorable para EU. Sin embargo, el crecimiento de los cruces de personas y los flujos de transporte y comunicaciones confirman la importancia de la integración económica. Es muy significativo que los ciudadanos de ambas fronteras tengan más alternativas de consumo e inversión.

Pese a lo anterior, en su retórica, el gobierno mexicano ha expresado la confianza en que el libre comercio coadyuve al desarrollo nacional. Como otras naciones del Continente, el país está experimentado un cambio significativo en su orientación de política comercial, aunque esto último aún no se ha traducido en un mayor nivel de bienestar para el grueso de la población. Las políticas de liberación comercial desventajosas, aunadas a la carga fiscal creciente han contribuido al "malestar en la globalización", término descrito por Stiglitz (2011). Los efectos de estas políticas han sido contrarios a los objetivos prometidos por la clase gobernante, pues lejos de formalizar las actividades empresariales, se ha dado un crecimiento desmedido de mercados negros, empleo atípico y desempleo con graves consecuencias.

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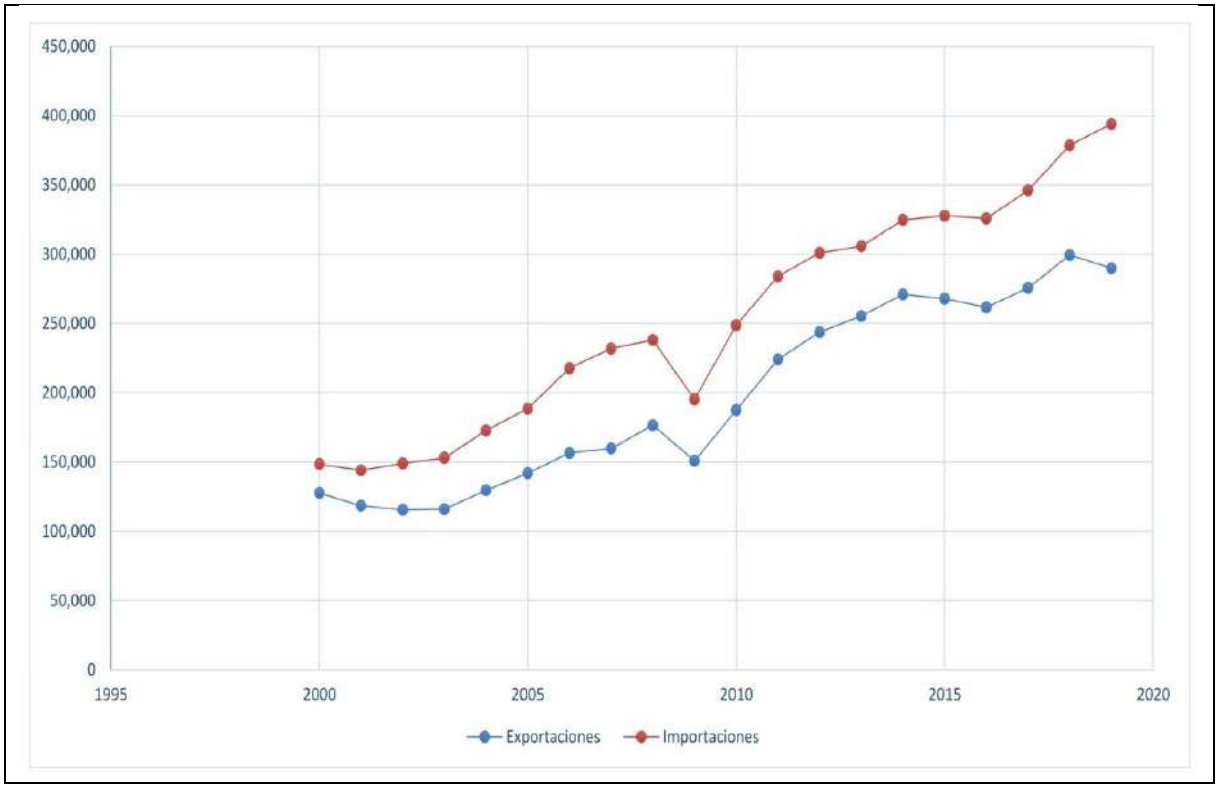
Gráfica 1. Comercio bilateral México-EU en millones de USD (2000-2019)



Fuente: Elaborado por los autores en base al Bureau of Economic Analysis, USA (2020).

La relación comercial de EU con otros países se caracteriza por las siguientes singularidades, las cuales se desprenden de la tabla 2. Con Canadá se han intensificado las transacciones comerciales las cuales tienden a equilibrarse. De hecho, por su vecindad y su acuerdo bilateral es de esperar un crecimiento mayor. Con China las relaciones comerciales han crecido exponencialmente, aunque el déficit se ha elevado con mayor rapidez; de ahí los motivos del expresidente Trump de limitar las relaciones con dicho país y buscar negociaciones donde EU pudiese obtener mayores beneficios. Con la Unión Europea han crecido las transacciones, pero el déficit tiende a persistir. Con respecto a los países de la Organización de Países Exportadores de Petróleo (OPEP), debe señalarse su crecimiento del volumen de exportaciones. Sin embargo, debido a la independencia energética que va adquiriendo, las importaciones de crudo han venido reduciéndose considerablemente. Con América Central y Sud América el comercio ha crecido, aunque aquí EU va logrando un superávit comercial.

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Tabla 2: Comercio de EU con países seleccionados (en millones de USD)

	Periodo	Exportaciones	Importaciones	Balance
Canadá	2000	204,334	253,312	-48,978
	2005	246,291	319,543	-73,252
	2010	307,571	310,341	-2,770
	2015	341,326	334,254	7,072
	2019	361,226	363,893	-2,667
China	2000	21,862	103,340	-81,478
	2005	50,685	251,791	-201,106
	2010	113,576	377,619	-264,043
	2015	163,323	499,676	-336,353
	2019	164,480	472,321	-307,841
Unión Europea	2000	260,504	306,423	-45,919
	2005	318,913	426,347	-107,434
	2010	427,636	474,511	-46,875
	2015	509,217	608,134	-98,917
	2019	617,360	726,165	-108,805
Países OPEP	2000	24,124	69,035	-44,911
	2005	46,118	137,742	-91,624
	2010	78,010	164,065	-86,055
	2015	104,913	75,147	29,766
	2019	79,416	54,109	25,307
América Central y Sud América	2000	101,050	107,261	-6,211
	2005	117,974	174,266	-56,292
	2010	229,135	219,494	9,641
	2015	282,834	200,131	82,703
	2019	287,025	203,304	83,721

Fuente: Bureau of Economic Analysis, USA, 2020.

La relación Trump-López Obrador, aunque inicialmente no fue sencilla, gradualmente fue definiendo las diversas agendas diversas respectivas y comunes, pues se habían negociado los temas de comercio (al aprobar el T-MEC en 2020), la seguridad fronteriza y la migración, la cuestión energética, entre otras. Con Biden en la presidencia de EU las cosas plantean relativa incertidumbre, pues esta nueva administración tiene otros enfoques y prioridades como la de las energías verdes, lo cual no encaja necesariamente con las políticas energéticas tradicionales de EU y de México respectivamente.

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En la era Trump, la política económica se centró en un conjunto de medidas consideradas como nacionalistas en el tenor de *Make America Great Again*, con lo cual obligó a renegociar el TLCAN, disminuyó los impuestos corporativos para repatriar empresas y empleos, entre otras acciones. No fueron pocos los gobiernos y corporaciones globalistas que cuestionaron tales medidas, considerándolas como anticuadas y contrarias al espíritu de libre comercio. Este repliegue proteccionista fue defendido por Trump en foros internacionales; ello en franca oposición a las políticas adoptadas por los gobiernos que le precedieron, los cuales contribuyeron en gran medida a la desindustrialización del país que fortaleció fundamentalmente a China, además de otros países.

En el contexto de la renegociación comercial (T MEC) México hasta el 2020 parecía tener más claras las oportunidades de crecer en la proveeduría y recepción de inversiones directas en manufactura, toda vez que se restringía a otros países a participar en el circuito de la producción. Sin embargo, está por ver si la administración Biden sigue la política de su predecesor de restringir China en EU y en otros países, o bien, decide una política de apertura e integración como la de los predecesores de Trump. También está por ver si la industria automotriz; la de mayor importancia en las manufacturas de México, va a seguir vigente. En suma, está por verse si se privilegiará una mayor convergencia e integración industrial y comercial con México, o en el peor de los casos, se siga un camino a una relación de pobre cooperación y conflicto.

La nueva administración de EU se ha reincorporado al Acuerdo de Cambio Climático de Paris y coloca así a las energías limpias como una prioridad de su gobierno. En ese sentido, las energías convencionales no tienen trato preferencial a juzgar por decisiones tales como cancelar el proyecto Keystone de Canadá y posponer los permisos para exploración de petróleo en Nuevo México, así como anunciar la intención de comprar vehículos eléctricos oficiales a la compañía Tesla. Con estas acciones algunos gobiernos estatales y sectores empresariales asociados al gas, petróleo, carbón, refinerías y sectores afines han manifestado su absoluto repudio.

Esto último no será una cuestión sencilla para Biden, pues se alistan acciones legales para contrarrestar sus medidas, ya que ponen en riesgo de perder empleos e ingresos a más de 10 millones de trabajadores y sus familias. La sustentabilidad económica de comunidades y regiones que han dependido de este tipo de industrias se halla en riesgo con dicha agenda energética. Cabe

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señalarse que esta política energética del gobierno de Biden tampoco será fácil de impulsar en México, dadas las prioridades del gobierno de López Obrador (2018-2024) en cuanto a mantener inversiones en las energías convencionales, pues ahí se advierten inversiones en la construcción y modernización de refinerías, oleoductos, exploración de pozos, generación de energía eléctrica y demás.

2.2. Las remuneraciones y condiciones laborales

Entre los desafíos presentes que México encara deben citarse a las bajas remuneraciones y las condiciones laborales adversas del grueso de los trabajadores. Para México las inversiones foráneas han sido beneficiosas en lo general, aunque los ingresos laborales no han experimentado progresos importantes durante mucho tiempo. De los diversos sectores económicos importantes que se encuentran en el país, destaca el automotriz por ser este considerado de alcance internacional. Este ha adquirido relevancia, pues el mismo genera una mayor contribución al producto nacional y emplea a un número creciente de trabajadores de las manufacturas.

Se trata del sector más pujante de México, del cual el 71 % va dirigido a EU. En su momento la administración Trump consideró que México tomó indebidamente ventajas de este sector a expensas de la pérdida de empleos e ingresos de los trabajadores estadounidenses. La queja de los líderes sindicales de las armadoras estadounidenses era que no había forma de competir con los bajos salarios manufactureros de México, los cuales se ubican ahora mismo en $3.91 en promedio la hora, contra los $39.03 de ese país según se observa en la tabla 3.

Tabla 3 Costos de remuneraciones en la manufactura de México y EU (en USD)

	1997	2011	2019
EU	23.00	37.81	39.03
México	2.62	4.38	3.91

Fuente: Elaborado por los autores en base a Conference Board (2020).

El bienestar del trabajador, considerando el salario promedio, presenta diferencias significativas; aun cuando México y EU buscan continuamente mejorar su relación de vecinos y socios. Las remuneraciones promedio de un trabajador, ya sea de Alemania, EU o Canadá son

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significativamente mayores a las de un mexicano. El PIB per cápita de México se halla muy lejos de alcanzar al de los países desarrollados.

De acuerdo con el sitio Tetakawi, México figura como un país adecuado para la manufactura por las siguientes razones:

> Es la octava economía manufacturera más grande del mundo y ocupa el séptimo lugar en el mundo en el cálculo del índice competitivo de Deloitte. Las competencias de los empleados en la manufactura y una alta disposición a trabajar se están convirtiendo rápidamente en dos de las ventajas notables de México sobre otros países industrializados. Cuando se combinan costos más bajos, mayores habilidades y una actitud mejorada de los empleados, los fabricantes experimentan más productividad, mayor eficiencia y, en última instancia, clientes más satisfechos. Ésta es la ventaja competitiva de México (Tetakawi, 2021: 1).

De hecho, la situación económica prevaleciente en Europa, EU y demás países ha implicado un deterioro en las condiciones de trabajo, con lo cual se advierte estancamiento en las remuneraciones, mayor desempleo, así como una reducción en las prestaciones empresariales. De este modo, el panorama para los trabajadores y sus familias se complica ante la insuficiencia de los ingresos. La brecha existente revela que se trata de una crisis de tipo económico, social y, por supuesto, política. Para revertir esta situación se hace indispensable promover la calidad del empleo y el bienestar social, lo que implica fortalecer las instituciones a fin de inspirar la confianza entre los agentes económicos y sociales (Peralta, 2014).

La gráfica 2 muestra que el crecimiento del PIB per cápita de México apenas si experimentó un modesto cambio al pasar de 7896 USD en 1994 a 9567 en 2019. Por su parte el PIB per cápita de EU pasó de 37171 a 53056 USD en el periodo referido. Con ello se muestra que el crecimiento del ingreso del grueso de la población de México no obtuvo mejoría en el ingreso en el proceso de liberalización comercial; en este caso, la adhesión al GATT, al TLCAN y demás acuerdos comerciales.

Con la *Gran Recesión* de 2008, el desempleo creció en prácticamente todos los países. En el caso de EU, el impacto observado fue más inmediato, aunque luego se comenzó una recuperación modesta, mientras que en México dicha recuperación ha sido más lenta y, desafortunadamente la actual contingencia sanitaria de la Covid 19 ha estancado su crecimiento.

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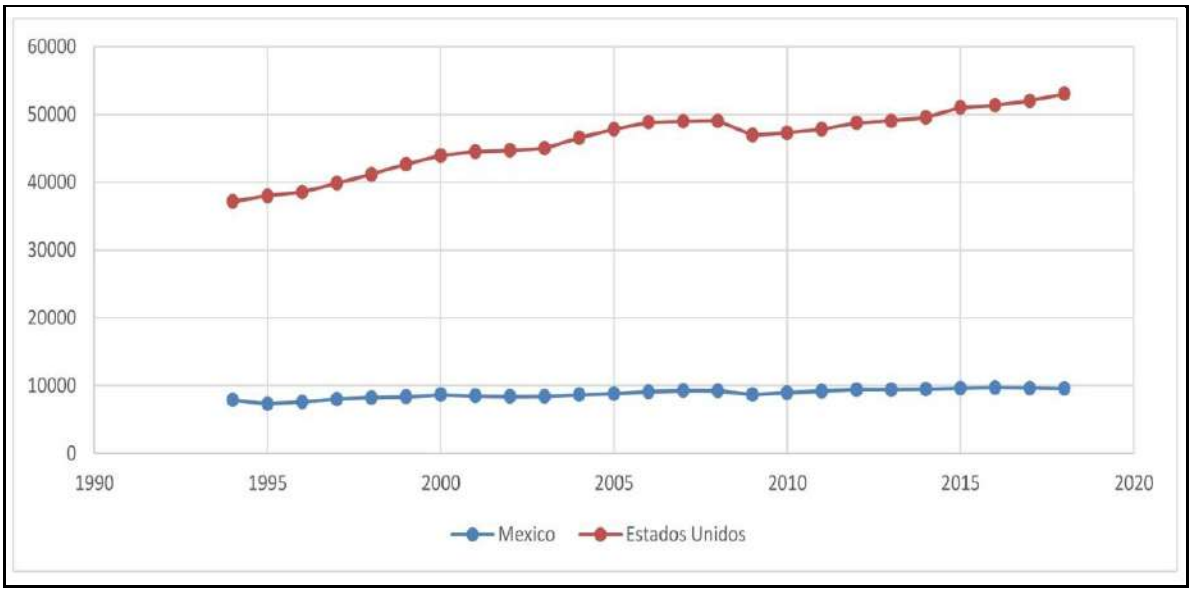
Gráfica 2: Crecimiento del PIB per cápita de México y EU (1993-2019)



Fuente: World Bank (2020).

Por otro lado, en el sector agrícola, existe la autorización de trabajadores temporales mediante el programa H-2ª, lo cual ha permitido a mexicanos el trabajar en EU, una vez que el empleador ha cumplido el requisito de buscar previamente mano de obra local y no encontrarla. De este modo, el trámite y la aprobación suele ser más expedita. Aunque esto puede verse como una gran oportunidad para los trabajadores mexicanos, se ha encontrado la existencia de ciudadanos estadounidenses desempleados que desearían trabajar en el campo. Sin embargo, los bajos salarios y las largas jornadas los mantienen lejos de estos oficios. Se advierte, pues, una práctica de discriminación laboral hacia los trabajadores temporales, tanto en salarios como en jornadas extenuantes (Palacios, 2010).

Debe, adicionalmente, considerarse el aumento de personas con ambas nacionalidades y con derechos para trabajar, para lo cual se requiere de las instancias fiscales el homologar la recaudación de impuestos para no incurrir en la doble fiscalización para el mismo trabajo, o que el trabajador pague impuestos en el sistema del cual no obtiene los beneficios de protección social (Martin y Mejía, 2009).

2.3. Los Derechos Humanos

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En este apartado debe señalarse que el gobierno mexicano ha establecido reiteradamente su compromiso de defender los derechos humanos como política de Estado. El mismo ha reconocido que no se han advertido avances significativos hacia su cumplimiento; por el contrario, se ha visto disminuido ante el aumento de las violaciones de estos, los cuales se llegan a conocer públicamente. Las denuncias de violaciones a los Derechos Humanos de mexicanos en suelo estadounidense siguen al alza. Sin embargo, les ocurre lo mismo a los ciudadanos de otros países en el suelo mexicano. Ello debe obligar a la autoridad competente a actuar en consecuencia y no dar lugar a situaciones de impunidad.

Desafortunadamente, esta condición social es asimilada por las nuevas generaciones de jóvenes como una cultura "normal" de violencia, corrupción e impunidad. El estatus de México, por tanto, se califica como "*parcialmente libre*" (65 en escala de 100). En el año 2016 la Libertad de Prensa se calificó como "*no libre*", y la Red como "*parcialmente libre*". Esta calificación se confirma al conocerse, en el presente 2017, de las prácticas del gobierno contra las comunicaciones privadas. En contraste EU, por su parte, se califica como "*libre*" en los tres apartados, con un puntaje de 89 (*Freedom House*, 2017).

En el caso de los menores de edad e hijos de indocumentados mexicanos, los Derechos Humanos deberán respetarse, considerando el bien superior de la familia. En ese sentido, ambos gobiernos requieren aplicar una política migratoria que ofrezca mecanismos legales de reunificación familiar más expeditos, informando oportunamente a los deportados. Muchos padres deportados no inician un proceso de reunificación por ignorancia o temor, provocando una separación familiar definitiva (Kline, 2013). La situación en México ha movido a organizaciones defensoras de los derechos humanos a buscar un diálogo con la presidencia de México para apoyar en concretar soluciones (*Amnistia Interncional*, 2020).

2.4. Seguridad fronteriza y cooperación contra el crimen

De acuerdo con el entonces presidente de Estados Unidos, Donald Trump (2016-2020), la seguridad fronteriza se constituyó en una prioridad de su gobierno. De hecho, fue uno de los temas de su campaña electoral y la convirtió en una promesa que buscó hacer realidad en su gestión, dados los reclamos de su base electoral. Para el gobierno en cuestión la seguridad

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fronteriza requirió la conjunción de recursos a partir de la tecnología, la infraestructura fronteriza del personal y todo el apoyo gubernamental. La continuación de la construcción del muro en la frontera con México y demás acciones de vigilancia y reforzamiento territorial fueron parte de la estrategia implementada para detener los flujos de drogas, de indocumentados, de terroristas y demás amenazas para la seguridad nacional. Los entonces adversarios políticos de la administración de Trump consideraron la percepción de amenaza a la seguridad del país como una sobredimensión del problema y, que no requería de la aplicación de recursos extraordinarios. La renegociación del TLCAN, a petición expresa de Trump, debió verse en el contexto de *hacer grande América otra vez*, lema fundamental de su campaña política a la presidencia.

En materia de seguridad fronteriza la nueva administración de Joe Biden (2021) ha tomado acciones y ha ordenado detener las deportaciones masivas, frenar la construcción del muro, además de prometer considerar un eventual alivio migratorio. Sin embargo, estados de la Unión Americana como Texas, Arizona, Florida, además de otros, han tomado acciones legales para impedir que se materialicen estas órdenes ejecutivas, pues ninguna de estas puede colocarse por encima de lo establecido por la Constitución. Por otro lado, en el sur de México ocurre una presión extraordinaria de parte de las caravanas de migrantes dado su empeño en llegar a EU. Esta posición coloca al gobierno mexicano en una situación incómoda dadas las acusaciones de violaciones de los derechos humanos y de incurrir en contradicciones con la realidad, pues se cuestiona que el gobierno mexicano haya firmado el Pacto Mundial de Migración y en ese sentido deba velar por el interés de los migrantes.

Tanto México como EU, son origen, tránsito y destino de hombres, mujeres y niños víctimas de tráfico de personas. En el ataque al delito de tráfico de personas, se espera de México una mejora significativa, pues el país ha permanecido en el mismo nivel de clasificación desde 2010. Se ha reconocido la complicidad de autoridades en el ilícito, principalmente a nivel local, lo cual es un problema serio no resuelto. El tráfico de personas es favorecido por el crimen organizado y el turismo sexual en ambos países. Aunque el gobierno de los EU cumple completamente los estándares mínimos para la eliminación del tráfico de personas, se ha recomendado acentuar su trabajo en el área de la explotación laboral y sexual. El Departamento de Estado de EU considera que existe una fuerte cooperación con las fuerzas del orden de

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México, lo cual ha permitido arrestos de traficantes de personas operando en ambos países (US Departament of State, 2020).

Según el Banco Mundial (Enamorado et al., 2013) se ha encontrado evidencia de una relación negativa entre el crecimiento económico y el nivel de crimen organizado asociado al tráfico de drogas; en tanto que este mismo efecto no se detecta para el denominado crimen común. La migración de mexicanos hacia territorio estadounidense se ha encontrado correlacionada positivamente al aumento en criminalidad en los municipios fronterizos, pero negativamente en otras comunidades. A partir de 2005, los migrantes mexicanos hacia el EU, son en general menos pobres y mayormente educados (Escobar Latapí et al., 2013).

En México organismos como la Comisión Nacional de Derechos Humanos y *Human Right Watch*, entre otros, han denunciado al gobierno de la 4T por sus acciones de política migratoria, aun cuando este se ha comprometido a invertir en el sur de México y a dar un trato de justicia al migrante. Es pertinente destacar que el gobierno de EU desde hace varias décadas ha presionado al de México para *poner orden en la casa* y enfrentar a las bandas criminales, pero también a restringir, en lo posible, el ingreso de indocumentados por el sur. Al no poder llegar a EU miles de personas se han quedado a vivir en México. Esto último muestra que son enormes los riesgos que conllevan los flujos migratorios, todo lo cual requiere de acciones conjuntas de los países involucrados para impulsar políticas de desarrollo regional.

2.5. Migración

La crisis de la migración en las fronteras norte y sur de México, agravada por las caravanas de indocumentados de Centro América y de otros países es un claro ejemplo de lo que se señala en líneas anteriores. En el contexto del Pacto Global de Migración del 2018 y la política migratoria de Biden, se ha dado un aliento al fenómeno, creándose así una crisis humanitaria sin precedente. Cientos de miles de inmigrantes, y las mismas autoridades encargadas de resguardar la frontera encaran una situación complicada (Harshbarge, 2021).

En la administración de Trump, EU se inició un cambio en la política de migración cuyo propósito fundamental se circunscribe en el reforzamiento de las fronteras y en la intención de liberarse así de las imposiciones de los organismos internacionales. En la agenda del Pacto

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Mundial de Migración se pretende impulsar las fronteras abiertas con el argumento de la solidaridad e inclusión racial.

Sin embargo, se ha documentado la existencia de grupos de interés que impulsan y financian con la intención de introducirse de forma indocumentada en EU, creando una alteración de las buenas relaciones entre estos países, los cuales habían permitido hasta ahora una convivencia respetuosa y productiva. En el área legislativa debe tenerse presente que quienes impulsan el cambio de sistema político actual en México presentaron una nueva política migratoria como propia, cuando en realidad solo era el plan de la Organización de las Naciones Unidas (ONU) en el tema migratorio aprobado en Marrakech. Debe tenerse presente que EU no firmó este Acuerdo Migratorio, buscando con ello conservar su soberanía en cuanto a quién y cómo se autoriza la entrada a su país.

EU desde antes de la "crisis humanitaria" propuso fortalecer la protección de la frontera con la guardia nacional y, como es normal en toda vivienda en México que se precie de proteger a una familia y sus bienes, construir un muro para mejorar la protección del país. El hecho de que México realizó lo que EU ya antes había propuesto, y sostenido por su presidente Trump de impedir el paso ilegal por la frontera, y que esa misma acción ahora México la repite con el gobierno actual de EU, manifiesta que la política de EU con Trump en ese entonces fue correcta en lo referente a protección fronteriza.

Ahora la política de Biden de abrir las fronteras de EU ha generado un caos migratorio; y aunque la reunión diplomática entre EU y México para tratar el problema concluyó haciendo una declaratoria pública del lema de la ONU de "garantizar una migración segura y ordenada", la acción del gobierno de México enviando 12,000 elementos de su Guardia Nacional a su frontera sur, refleja que en realidad el gobierno de EU urgentemente requirió del apoyo de México para frenar la avalancha que su oferta de apertura fronteriza ha generado.

En el contexto del análisis actual debe tenerse presente que México ha iniciado un cambio gubernamental hacia una economía social, la cual ha mostrado con creces sus limitaciones para hacerla realidad de éxito, pues a través de la historia se ha constatado su limitado avance en los temas de libertades esenciales como el emprendimiento, la innovación, la libre expresión y de respeto por los derechos humanos.

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Los procesos migratorios han existido siempre y son diversas las razones por las cuales se siguen reproduciendo. En el siglo pasado y en el presente la migración se ha asociado al fracaso de políticas económicas adoptadas por gobiernos en los diferentes continentes. En América Latina desde la década de las ochenta dichas políticas se significaron por una reducción en los niveles de bienestar derivado de un proceso de desmantelamiento del Estado de bienestar y de fuerte concentración de la riqueza. En general, estas políticas fueron adversas para el grueso de la población, de modo tal que millones de personas experimentaron la migración del medio rural al urbano en sus respectivos países, pero también hacia los EU, Canadá, Europa, Japón, por mencionar los principales destinos.

El crecimiento de la migración debe explicarse, adicionalmente, al fracaso de no contener la violencia, el narcotráfico, las pandillas y el empobrecimiento de vastas regiones del Continente. Igualmente se advierte las dificultades para que en estos países se pueda experimentar la movilidad socioeconómica a través de la educación formal y empleos bien remunerados.

El asunto migratorio está vigente y aun se refuerza, pues desde 2016 se han observado oleadas de caravanas de ciudadanos procedentes de Haití, Cuba, Centroamérica, pero también de la India, Bangladesh y demás países de África. Estas caravanas tenían como destino a los EU, pero su paso obligado es a través de México. Ello ha significado la permanencia de migrantes en las zonas fronterizas del sur, del interior y del norte de México. De hecho, una nueva crisis migratoria de 2018, 2019 y 2021 ha sido motivo para presionar al gobierno mexicano a fin de que coopere con mayor determinación en la contención de dichas caravanas.

De acuerdo con la gráfica 3 la población indocumentada en EU ha crecido y tiene mayor presencia a lo largo del periodo. En lo que concierne a deportaciones y retornos, de nueva cuenta se observa un crecimiento importante. Llaman la atención algunos años, como el de 2008 con el gobierno de Bush, ya en el contexto de la Gran Recesión. También es notorio el periodo en el que gobernó Obama, considerado *el campeón de las deportaciones*. Su retórica en favor de reforma migratoria contrastó con una situación de deportaciones sin precedentes. Esta situación pone de manifiesto dos cosas: La primera, el deterioro constante de la economía de México, Centro América y el Caribe, además de otras naciones y, segundo, el atractivo de EU como nación que

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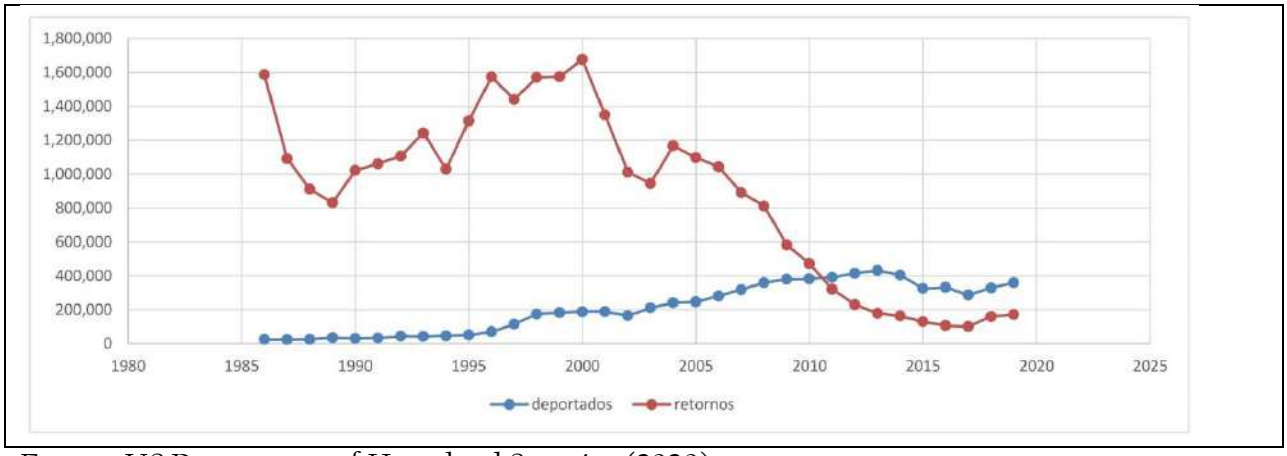
puede aliviar la situación de millones de personas agobiadas por adversidades económicas y políticas.

Gráfica 3: Población deportada y retornada de Estados Unidos (1986-2019)



Fuente: US Department of Homeland Security (2020).

Nota: [1]Las deportaciones son el movimiento obligatorio y confirmado de un extranjero inadmisible o deportable fuera de los Estados Unidos basado en una orden de deportación. [2] Los retornos son el movimiento confirmado de un extranjero inadmisible o deportable fuera de los Estados Unidos que no se basa en una orden de expulsión.

Con la llegada de D. Trump a la presidencia de EU las órdenes ejecutivas en materia de migración consideraron sujetos a deportación inmediata individuos en los siguientes casos: Convictos de un crimen; acusados de una falta penal, aun cuando el caso no ha sido resuelto; comisión de una acción que constituye una ofensa criminal; comisión de fraude o presentación falsa ante una agencia de gobierno; abuso de algún programa de beneficios públicos; tráfico de drogas o trata humana, prostitución, lavado de dinero; con una orden de deportación o es un riesgo para la seguridad pública o nacional, comisión de delitos considerados graves como terrorismo, espionaje, sedición, abuso doméstico o a un menor de edad, así lo considere el agente de inmigración.

Para estos ciudadanos el retorno a sus países plantea escenarios de oportunidades en el mejor de los casos. Si el deportado ahorró dinero o se preparó para esta situación puede emplearse de manera formal. La informalidad es una salida; de hecho, la más común. No obstante, en términos realistas prevalecen en la mayoría de los casos pobreza, crimen y dificultades para

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la reinserción en el país de origen. La cuestión es que regresar a EU parece lo más atractivo, dadas las acciones favorables hacía los migrantes de la administración Biden y de organizaciones no gubernamentales: estímulos económicos, viaje gratuito al interior de EU desde la frontera, hospedaje en hoteles, liberación de las autoridades migratorias aún sin una cita futura para comparecer ante la corte y una alta posibilidad de obtener en el futuro la ciudadanía.

El trayecto hacia los EU significa riesgos y costos elevadísimos dada la existencia de 'coyotes', crimen organizado, vigilancia de autoridades migratorias y demás obstáculos para los migrantes. La situación de que haya migrantes que no logran cruzar a EU plantea un incremento importante de solicitudes de asilo y refugio en México. Sin embargo, en el país no se tiene la capacidad para dar respuesta oportuna a estos demandantes.

Por otro lado, debe señalarse el que las deportaciones se anuncian con tiempo y las redadas se planifican y ocurren en lugares que el gobierno considera de interés estratégico. Con estas acciones se pretende disuadir a los nuevos entrantes de la no conveniencia de aventurarse en territorio estadounidense. Quienes viven de manera indocumentada en EU están muy conscientes de su elevado riesgo y que la deportación es algo que, eventualmente puede ocurrir.

Ante lo anteriormente expuesto, los consulados y embajadas recomiendan a estas familias tener documentos a la mano a fin de protegerse, en lo posible. Se debe prever que se haría en casos de detenciones y deportaciones. El gobierno mexicano no debe dejar a esta población a la deriva, pues en muchos casos tienen hasta 30 años de vivir en los EU. Estas familias pueden poseer propiedades, empleos estables, deudas, activos, formación educativa, expectativas y, por tanto, viven en constante zozobra e incertidumbre.

Sería muy deseable que el gobierno de México tenga una política que le otorgue el acompañamiento necesario a los retornados a fin de disminuir, en lo posible, la incertidumbre que significa esta realidad. Esta población deportada se halla expuesta a ser atrapada incluso por el crimen organizado. Estas personas retornadas han contribuido con sus remesas al desarrollo de sus comunidades o ciudades. Requieren ser atendidos debidamente y tener una valoración social y gubernamental de aquellas naciones de origen.

De acuerdo con el documento "Políticas Multinivel para el retorno y la (re) inserción de migrantes mexicanos y sus familias" de Cruz y Hernández (2018), se asienta la ausencia de

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coordinación gubernamental a fin de atender los perfiles de estos ciudadanos retornados. Deseable es apoyarles en los trámites de identificación y demás necesidades como la atención médica, cuando se requiere esta. Entre los aspectos que debe implementar el gobierno en su política de atención a migrantes en retorno es la de la política de inclusión a la sociedad, además de los apoyos legales y económicos indispensables para llevar su vida con mayor certidumbre.

Por otro lado, las bajas remuneraciones y las deficientes condiciones laborales en México empobrecen a los trabajadores, y a la vez, limitan el crecimiento de la clase media. Dicha condición propicia la agudización de los problemas que encaran los ciudadanos desesperados que buscan en otro(s) país(es) lo que su tierra les niega. La historia muestra que la inmigración es un fenómeno explicado por la necesidad de mejorar las condiciones de vida, al mismo tiempo de escapar de las guerras y de violencia agobiante. En el desarrollo de las naciones resulta fundamental el respeto a las libertades civiles y el apego al Estado de derecho; no hacerlo entraña sufrimiento y es, por tanto, una tragedia social costosa.

México y EU deben revisar los acuerdos migratorios a fin de agilizar la participación laboral a los ciudadanos fronterizos y reducir así la incertidumbre en la que viven millones de personas. Un arreglo migratorio ordenado reduciría la incertidumbre de los migrantes y sus familias. Traería beneficios para las partes, al proveerse fuerza de trabajo a los EU y mejorar las condiciones de ingresos económicos de las regiones pobres de México y de otros países. Ello, aunque es deseable, se ha visto que no es un asunto simple. Sin embargo, debe seguirse en la agenda en cuestión, sin que ello implique que el gobierno mexicano renuncie a su obligación de invertir en desarrollo social. A fin de reducir estos rezagos, la política económica de México deberá ser más inclusiva en lo social, pero estratégica en lo comercial.

Otros problemas que México enfrenta lo constituyen el deficiente sistema de salud y educación pública, el limitado capital financiero para trabajar, el déficit en la infraestructura para el desarrollo regional, entre otros. De hecho, los indicadores de bienestar revelan que los bajos ingresos se asocian con la pobreza y la falta de oportunidades para mejorar las condiciones de vida material del grueso de la población. Dentro de las acciones a seguirse se halla el fortalecer las instituciones del mercado laboral y promover la formalidad y el empleo digno, con lo cual se

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traería consigo mayor cantidad de aportantes y así sustentar a largo plazo el modelo de seguridad y de acceso al bienestar en la edad de jubilación (Martínez et al., 2015).

Conclusiones

En este trabajo se ha planteado el objetivo de analizar la agenda de comercio y desarrollo binacional entre México y Estados Unidos (EU), en lo que concierne a los apartados comercio bilateral, remuneraciones y relaciones laborales, derechos humanos, seguridad fronteriza y cooperación contra el crimen, así como migración. Para México es un imperativo mejorar sus acuerdos comerciales existentes y a la vez diversificar su comercio exterior, especialmente en la coyuntura de proteccionismo latente. Se han señalado aspectos relativos a las remuneraciones y condiciones laborales. Se ha destacado la seguridad fronteriza y la cooperación contra el crimen por ser estos aspectos indispensables. La agenda de la migración cobra relevancia ahora mismo y debe abordarse buscando colocar el interés de México en la misma.

Los tratados comerciales requieren de una continua revisión a fin de encontrar vías de mejoramiento, pues no solo debe privilegiarse los aspectos comerciales. En ese sentido, no es ocioso insistir en una agenda de desarrollo social y de cooperación respetuosa, para lo cual es preciso reducir los conflictos de índole comercial de aquellos que se hallan presentes en toda la vasta geografía del mundo.

Debe señalarse que la inversión extranjera de EU en México ha venido creciendo significativamente, de modo que ya son muchas las empresas adquiridas por parte de grandes corporaciones nacionales y extranjeras. Destacan bancos, cadenas comerciales, manufactureras, empresas de servicios especializados, entre otros. Existen, además de inversiones crecientes en sectores diversos como el turismo, aviación, minería, energía, gas, petróleo, por mencionar algunas.

De igual modo, se espera que las políticas estadounidenses tengan como fin mejorar la relación con México más allá de los aspectos estrictamente comerciales, tomando en cuenta las acciones de otros países como China y los miembros de la Unión Europea. Está claro que ningún país tiene todo por ganar en el CI; por tanto, se plantea la necesidad de adecuarse a la dinámica compleja que entrañan las relaciones binacionales.

Entre los asuntos de la agenda bilateral deben señalarse que merecen priorizarse, entre otros, los siguientes: 1). La petición de sectores mexicanos para que el gobierno de EU reduzca los subsidios a su sector agrícola; 2) los retrasos y complicaciones que sufren los transportistas mexicanos en las aduanas estadounidenses; 3) la cooperación para frenar la causa de la migración de México y de otros países; 4) la violación a Derechos Humanos y la incertidumbre respecto al futuro de mexicanos en territorio estadounidense; 5) el contrabando de armas y demás bienes en forma ilegal hacia México; 6) el tráfico de personas y de drogas hacia EU; 7) la resolución expedita de controversias comerciales.

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Caracterización física y sensorial de almendras de plantas de cacao elite (*Theobroma cacao* L.) en Bagua, Perú

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RESUMEN

El trabajo de investigación tuvo como objetivo caracterizar física y sensorialmente las almendras de cacao (*Theobroma cacao* L.) de 20 plantas elites en fincas de los distritos Copallín y La Peca en la provincia Bagua, Perú. Se determinó la calidad física (índice de grano, peso de grano y prueba de corte) y sensorial (atributos básicos y específicos). Se obtuvo valores de humedad de las almendras (6,5 a 7,7%) dentro los valores aceptables (menor a 8%); el promedio de índice de grano y peso de grano indicaron un manejo agronómico y empleo de material genético adecuados; el índice de grano (1,20 a 1,80) en 18 árboles de cacao elites fueron valores comerciales. Sensorialmente los atributos básicos se acentuaron en las almendras de Copallín; mientras que los atributos floral, frutal y cacao resaltaron más en almendras de La Peca. Las almendras estudiadas son aptas para la obtención de chocolate de fino aroma.

PALABRAS CLAVE: Producto vegetal; producto agrícola; Economía agraria; cacao; Perú.

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El artículo presenta los resultados centrales de un Trabajo de Grado en la Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas, Perú.

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Physical and sensory characterization of almonds from elite cacao plants (Theobroma cacao L.) in Bagua, Peru

ABSTRACT

The objective of the research work was to physically and sensorially characterize the cacao almonds (Theobroma cacao L.) of 20 elite plants on farms in the Copallín and La Peca districts in Bagua province, Peru. Physical (grain index, grain weight and cutting test) and sensory quality (basic and specific attributes) were determined. Moisture values of the almonds (6.5 to 7.7%) were obtained within acceptable values (less than 8%); the average grain index and grain weight indicated adequate agronomic management and use of genetic material; the bean index (1.20 to 1.80) in 18 elite cacao trees were commercial values. Sensorially, the basic attributes were accentuated in the Copallín almonds; while the floral, fruity and cocoa attributes were stood out in La Peca almonds. The studied almonds are suitable for obtaining fine aroma chocolate.

KEYWORDS: Plant products; Agricultural products; Agricultural economics; cocoa; Peru.

Introducción

El cacao (*Theobroma cacao* L.) es nativo de regiones tropicales húmedas. Hay cuatro grupos genéticos comúnmente reconocidos: forastero, criollo, trinitario y un cuarto grupo referido a la variedad Nacional que crece en Ecuador. Los forasteros son los más cultivados por su alta resistencia a enfermedades; mientras que los trinitarios tienen resistencia a enfermedades y alta productividad, pero en sabor son de menor calidad para la producción de chocolates (Castro-Alayo et al. 2019; Ramos, et al. 2020). Los granos de cacao criollo resaltan debido a sus atributos sensoriales especiales de aroma floral y afrutado; mientras que los otras variedades abarcan a los granos de cacao forastero y su híbrido, trinitario (buena calificación), donde se aprecia que el sabor de cacao fino está siendo requerido por las industrias mundiales de chocolate de sabor fino; el atributo sensorial de calidad más importante durante su comercialización es el aroma del grano de cacao; este aroma está formado por compuestos volátiles que son percibidos en la cavidad nasal (Chire et al. 2016; Qin et al. 2017; Wickramasuriya & Dunwell, 2018; Castro-Alayo, 2019).

La calidad de las almendras de cacao se debe básicamente a sus compuestos aromáticos, siendo el genotipo el factor de mayor relevancia; así mismo, las condiciones

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agroclimáticas en las que se desarrolla el cultivo, los procesos de cosecha, fermentación, secado y procesamiento, son factores relevantes en la formación de componentes volátiles que definen la calidad del producto final. Es tendencia estandarizar la calidad en el manejo postcosecha en los granos que permitan realizar una serie de transformaciones físicas y químicas que permitan desarrollar su calidad exigida por el mercado y los agronegocios (Peláez et al. 2016; García & Muñoz, 2017; Quevedo et al. 2018; Moreno-Martínez et al. 2019).

Debido a los requisitos exigidos de la calidad de las almendras de cacao, el estudio de cacao elites es primordial por sus características morfológicas y de productividad, así como se deben mejorar las semillas y plantaciones (Vera et al. 2019). Estos requisitos se expresan en términos de características físicas. Según García & Muñoz (2017) y Quevedo et al. (2018), se deben considerar la apariencia, prueba de corte, índice de grano, humedad, tamaño del grano, mohos, insectos, enfermedades, entre otros.

En estudios previos sobre la calidad física del grano de cacao, García & Muñoz (2017) y Gutiérrez & Gonzales (2018) mencionan que los granos fermentados y secos de cacao criollo presentan colores castaños y cotiledones agrietados productos de un buen beneficio del cacao; comparativamente variedades como trinitario y forastero tienen colores pardo oscuro con cotiledones agrietados; además, el cacao criollo presenta más rendimiento en peso comparado con las otras variedades restantes; esto último se debe básicamente a un adecuado manejo postcosecha.

García & Muñoz (2017), Machado et al. (2018) y Barrientos et al. (2019) afirman que la calidad sensorial del cacao es esencial para el consumo; los procesos postcosecha que se realizan en las almendras y posiblemente la presencia de polifenoles en su composición, determinan el perfil sensorial en el cacao con aroma y sabores amargo, ácido, astringente y a nueces.

En el presente trabajo de investigación se intenta caracterizar física y sensorialmente almendras de cacao (*Theobroma cacao* L.) élites, cultivados en la provincia de Bagua, región Amazonas, Perú. Con los resultados encontrados se busca seleccionar los plantones elites de cacao y cultivar en otras fincas de pequeños productores cacaoteros para obtener una alta producción y mejor calidad de grano exigido en la comercialización con el mercado externo.

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1. Materiales y métodos

La investigación se llevó a cabo en las fincas cacaoteras de productores de los distritos de Copallín y La Peca, provincia de Bagua (Perú) en los años 2018 a 2020. Se recolectaron frutos maduros de plantas de cacao nativo elites de 20 fincas cultivadas entre los 888 msnm y 1133 msnm; se consideraron muestras por triplicado, siendo codificadas con las iniciales de los nombres de los productores. Para la selección de árboles elites se tuvo en cuenta lo mencionado por Ballesteros (2011), como árboles mayores de 15 años de edad, el número de frutos que tenga el árbol 2 meses antes del pico de la cosecha sea mayor a 80 frutos por árbol, índices de mazorca por debajo de 18 por kilo de cacao seco, e índice de semillas mayores de 1,5 gramos por grano, además de alta tolerancia a plagas, enfermedades, estrés de sequía y humedad.

Para determinar la humedad se empleó la técnica descrita por Intriago et al. (2019), se pesó y trituró 10 gramos de almendras usando mortero hasta obtener un tamaño de partícula de hasta 5mm; luego, en una balanza de humedad se determinó la humedad por diferencias de pesos. Para el peso del grano se determinó el número de granos en 100 gramos y el peso promedio por grano (índice de grano-IG) según lo descrito por Vallejo et al. (2018); para IG se calculó la relación de peso de almendras entre número de almendras. Para la prueba de corte se siguió lo descrito por Vallejo et al. (2018), se seleccionaron al azar 50 almendras, después se cortó con un estilete por la mitad cada una de las almendras, siendo colocadas en una superficie plana con fondo de color blanco para tener mejor apreciación de la coloración de los granos cortados; posteriormente se clasificaron las almendras según su fermentación en los siguientes niveles: bien fermentados, levemente fermentados y pizarrosos.

1.1. Calidad sensorial

Para determinar el perfil sensorial se consideró la metodología descrita por Vallejo et al. (2018), con tal fin se pesó 300 g de cacao de cada muestra y se tostaron en horno de secado (120°C, 25 min) por convección natural de aire. Luego se obtuvo el licor de cacao, con tal fin se procesaron en un molino, hasta obtener partículas entre 20-25 µ de tamaño. Los licores se colocaron en recipientes herméticos, rotulados con los datos de cada muestra y se almacenaron a 7°C. Los principales atributos sensoriales en las almendras: básicos (dulce, amargo, astringente y ácido) y específicos (afrutado, cacao, floral, nueces y crudo) fueron

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evaluados por catadores. Para la intensidad de degustación sensorial se tuvo como referencia la siguiente calificación y puntaje: ausente (0), bajo (1 a 2), medio (3 a 5), alto (6 a 8) y muy fuerte (9 a 10).

1.2. Análisis estadístico

El análisis de las variables y datos de estudio se llevó a cabo empleando la estadística descriptiva. Se elaboraron tablas y figuras para ilustrar los datos. Asimismo, para la evaluación sensorial realizada se empleó análisis de componentes principales (PC) para analizar la dispersión de las variables cuantitativas agrupadas según sus atributos sensoriales de almendras de cacao elites.

2. Resultados y discusión

2.1. Determinación de las características físicas de almendras de cacao élites

Las características físicas de almendras de árboles de cacao elites se presentan en la Tabla 1. Se observa la humedad en las almendras del total de árboles elite (20), la cual fluctuó en un rango de 6,5% a 7,7%. Al respecto García & Muñoz (2017), Guimac (2017) y Machado et al. (2018) establecen que el contenido de humedad del grano de cacao en la fermentación es de 60% y luego al secarse puede llegar hasta 6% al 7%. Así mismo, los valores de 06 muestras estuvieron dentro del rango requerido (ABL-01, ABL-02, DTM-02, JBB-02, MRC-08 y SCF-01) y las restantes fueron superior al 7%, valores considerados como aceptables (menor al 8%); estos valores bajos de humedad mantenida en las almendras favorecería a la preservación y comercialización debido a la menor susceptibilidad al ataque de patógenos (García & Muñoz, 2017). También, Botella-Martínez et al. (2021) al evaluar el efecto del tamaño de partícula en la composición química de harinas de semillas de cacao reportaron humedades promedias de grano de cacao rangos de 6,79 a 7,05% comprendidos en lo obtenido en las semillas de cacao provenientes de Copallín y La Peca. Además, el promedio global de número de granos, 100 gramos de granos seleccionados, fue de 95,8, valor similar a lo reportado por Vera et al. (2019); estos valores, Fuentes (2016) lo atribuye a un manejo adecuado de prácticas agrícolas y procedencia del material genético durante la selección de árboles elites de cacao.

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Tabla 1. Características físicas de almendras de cacao de árboles elites

Distrito	Codificación	Humedad (%)	Número de granos en 100 gramos	Peso de grano (IG) g
Copallín	MRC – 08	7,0	82	1,4
Copallín	MRC – 05	7,2	106	1,5
Copallín	ABL-03	7,3	86	1,4
Copallín	ABL-01	7,0	114	1,2
Copallín	MRC-06	7,7	98	1,3
Copallín	VVA-02	7,3	94	1,2
Copallín	SBL-03	7,3	106	1,4
Copallín	FPG-02	7,3	69	1,4
Copallín	MRC-02	7,3	106	1,4
Copallín	MRC-10	7,1	106	0,9
Copallín	ABL-02	6,5	109	0,9
Copallín	SCF-01	6,7	93	1,8
Copallín	DTM-02	6,7	74	1,4
.Copallín	MRC-04	7,3	62	1,6
La Peca	JBB-04	7,2	126	1,6
La Peca	JBB-02	7,0	78	1,2
La Peca	JCC-06	7,4	88	1,2
La Peca	SCHB-01	7,4	95	1,2
La Peca	ARC-02	7,7	120	1,3
La Peca	JCC-02	7,3	103	1,4

De los resultados obtenidos, 02 muestras de árboles élites de Copallín presentaron índice de grano por debajo de 1,0 (ABL-02 y MRC-10 fueron 0,9), pero en 18 muestras de Copallín y La Peca (90% de los árboles elites) fue mayor a 1,0 similar a lo reportado Vera et al. (2019) quienes mencionan que el índice debe ser superior al 1,0 tanto desde el punto de vista filogenético e industrial, descartando valores menores a 1,0. También estos valores de índice de grano (0,9 a 1,2) están dentro de los encontrados por Marca & Maldonado (2018) en cacao nacional boliviano, siendo valores de índices productivos. Las 20 muestras presentaron un índice de grano promedio de 1,34 similar a lo hallado en árboles élites con valores de 1,50 a 1,88 según Nieves & Angulo (2017) y de 1,19 a 2,0 según Vera et al. (2019). También, Fuentes

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(2016) refiere que valores altos de IG están atribuidos a condiciones edáficas del suelo y un buen manejo agronómico, evidenciándose en mayores rendimientos de frutos del árbol.

Respecto a los resultados obtenidos en la prueba de corte, las muestras de almendras ABL-01 y JCC-02 tuvieron 45 granos bien fermentados que representaron un 90%. Asimismo, en 11 muestras los granos bien fermentados tuvieron valores en el rango de 64 al 90% (Figura 1), lo cual está dentro lo reportado por Fuentes (2016) que establece valores entre 62,2% y 75%; esto significaría que el material recolectado evidenció árboles elites con una alto porcentaje de almendras fermentadas, lo cual influye directamente en la calidad sensorial (Vallejo et al. 2018).

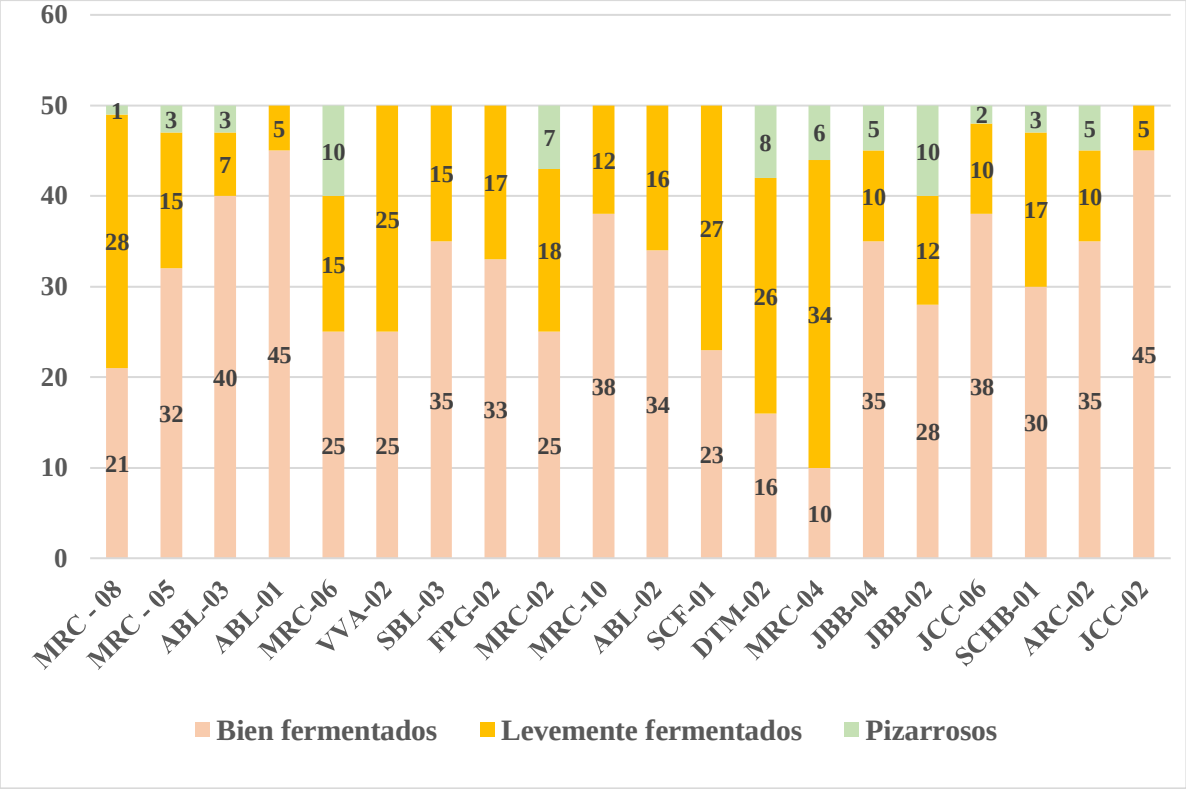

Figura 1. Prueba de corte en almendras de cacao elite

En la Figuran 2 se presentan los atributos básicos. El atributo dulce de la almendra tuvo una mayor percepción en ABL-01 (4,0) en comparación a la ausencia de dulzura percibido en la SCF-01, provenientes de Copallín; en cuanto a la amargura, en las almendras de seis árboles elites de Copallín solo se percibieron dicho atributo (ABL-02, DTM-02, FPG-02, MRC-04, MRC-10 y SCF-01), pero no en las almendras con origen La Peca; la astringencia tuvo valores comprendidos entre 1,0 y 4,4 de puntos, y en tres muestras presentaron puntajes mayores a

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4,0 (ABL-02, MRC-04, SCF-01); paralelamente, la acidez estuvo en un rango de puntuación de 1,0 a 4,2 (FPG-02 mostró el puntaje más alto). Sin embargo, los puntajes en todas las plantas de cacao elite guarda relación con lo reportado por Solórzano et al. (2015) y con los valores intermedios de acidez, astringencia y amargura de cacaos venezolanos (Ramos et al. 2013).

2.2. Determinación del perfil sensorial de atributos básicos y específicos de cacao nativo elite

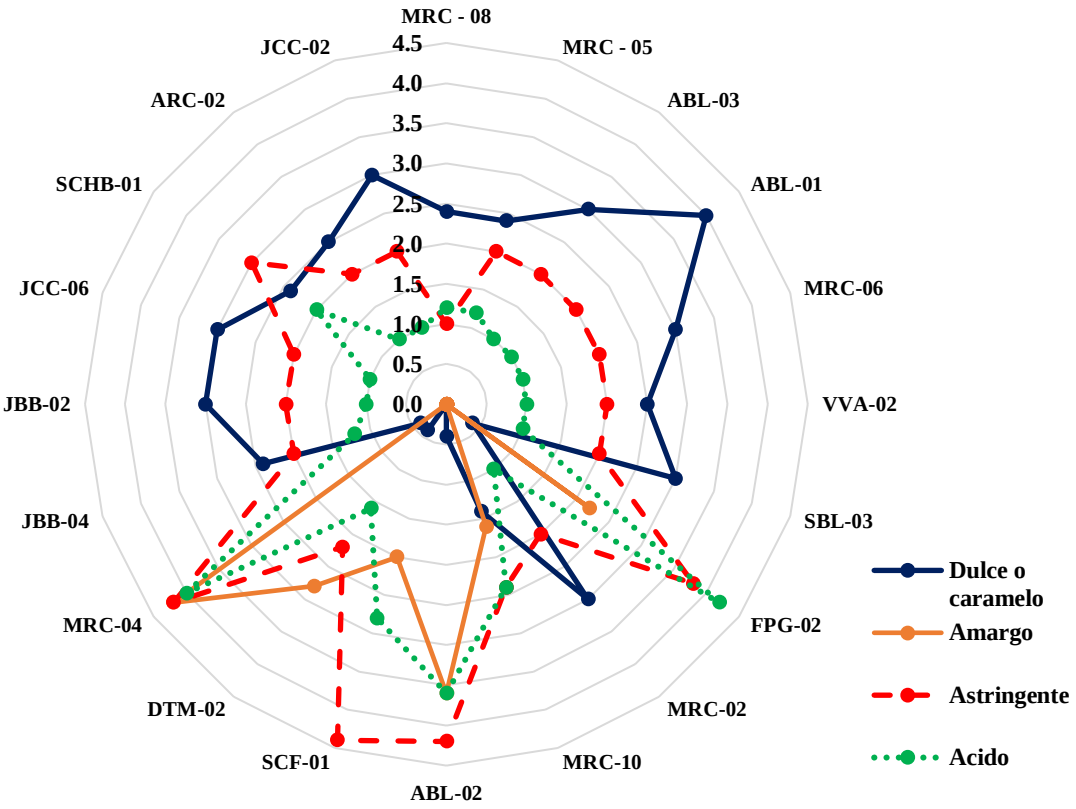

Figura 2. Perfil sensorial de los atributos básicos de las almendras de cacao elite

Respecto a los atributos específicos evaluados, en la Figura 3 se aprecia que sensorialmente el cacao tuvo calificaciones en un rango de 2,6 a 6,0 donde las almendras del árbol SBL-03 (Copallín) fue del sabor a cacao característico y ABL03 (Copallín) resaltó respecto a los demás en su sabor a nueces. En los granos de cacao, su atributo floral, la mayor puntación fue para MRC-08 (Copallín); en general dicho atributo en los cacao elites según su procedencia su puntaje fluctuó desde 1,0 a 4,0; al respecto, es importante lograr una mayor intensidad sensorial percibida de los atributos específicos (cacao, frutal, herbal, floral, y

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nuez); los aromas y sabores específicos son generados por reacciones enzimáticas durante la poscosecha del grano de cacao y pueden influenciar en la calidad organoléptica (Ramos et al. 2013; Marca & Maldonado, 2018). También, se evidencia que los atributos de floral, frutal y cacao son percibidos con mayor intensidad al analizar sensorialmente el cacao que según Vallejo et al. (2018) son atributos específicos requeridos para obtener un chocolate fino.

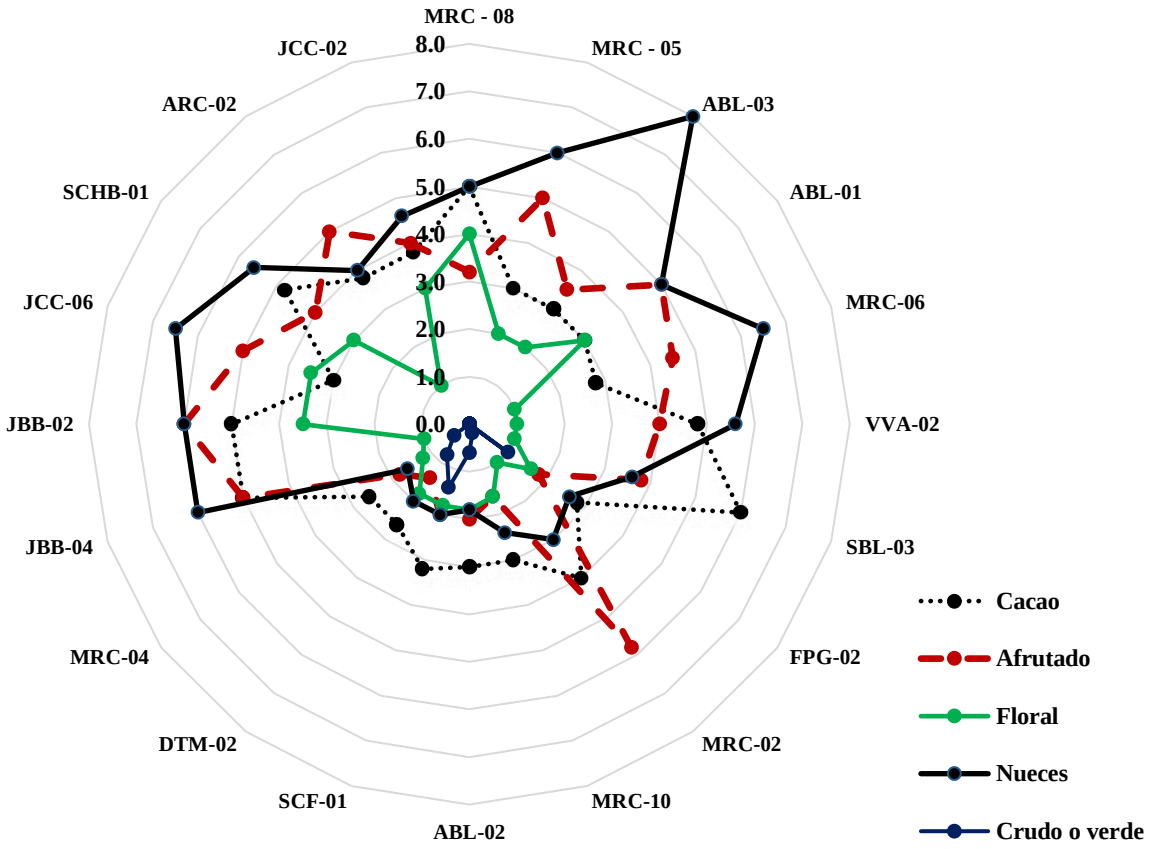

Figura 3. Perfil sensorial de los atributos específicos de las almendras de cacao élite

En la Figura 4 se observa que los atributos sensoriales dulce, afrutado y nueces se correlacionan positivamente más en el primer componente principal (PC1); es así que las almendras de cacaotales provenientes de La Peca resaltan más en los atributos floral, nuez y dulce y en menor nivel en sabor a cacao; paralelamente las almendras provenientes de Copallín se acentúan sus atributos de sabores básicos (amargo, ácido y astringente) y en sabor a cacao. Las almendras de la muestra DTM-02 tuvo una mayor correlación para los atributos de crudo y amargo; mientras la muestra MRC-10 reportó una tendencia a una mejor astringencia y acidez. El primer componente principal (PC1) representó el 66,1% de la

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varianza total, valor por debajo al componente principal de los atributos sensoriales (85,4%) encontrado por Machado et al. (2018). Por otra parte, respecto a los atributos que se correlacionaron más con el PC1 fueron los sabores de dulce (0,39), afrutado (0,35) y nueces (0,34); estos valores son similares a lo reportado por Solórzano et al. (2015) respecto a los atributos frutales, y nueces que tuvieron una alta correlación; sin embargo, no coincidieron con los valores de atributos cacao, amargor y nuez. Solórzano et al. (2015) y Coronado-Jorge et al. (2016) y Vallejo et al. (2018) mencionan que el mayor amargor en las almendras es debido a una fermentación deficiente, mientras que la acidez sería señal de la presencia de ácidos (volátiles y no volátiles) y en varias almendras de árboles elites (Figura 3) donde se ha presentado sabores a cacao, afrutado, floral, amargor y astringencia moderados.

Conclusiones

En cuanto a la calidad física del grano, la humedad que contiene las almendras cacao de los árboles elites (6,5% a 7,7%) están dentro de lo requerido (menor a 8%), los números de granos en 100 gramos con valor promedio global (95,8) indican un manejo agrícola y un origen del material genético adecuados; y referente al índice de grano (1,20 a 1,80) en 18 árboles elites son valores aceptables para comercializarlos. Así mismo, los valores de la prueba de corte expresan un alto porcentaje de almendras fermentadas lo que influye directamente en la calidad sensorial.

La calidad sensorial en las almendras de los árboles elite estudiados respecto a sus atributos básicos de amargor, astringencia y acidez obtuvo una alta intensidad de percepción sensorial en las almendras de las plantas de cacao MRC-04 (Copallín). Por otra parte, las almendras provenientes de La Peca resaltan más en los atributos floral, afrutado y dulce respecto a Copallín, donde es más para los atributos básicos. Por último, los atributos básicos y específicos de estas almendras elites son muy requeridos para la producción de chocolate con fino aroma.

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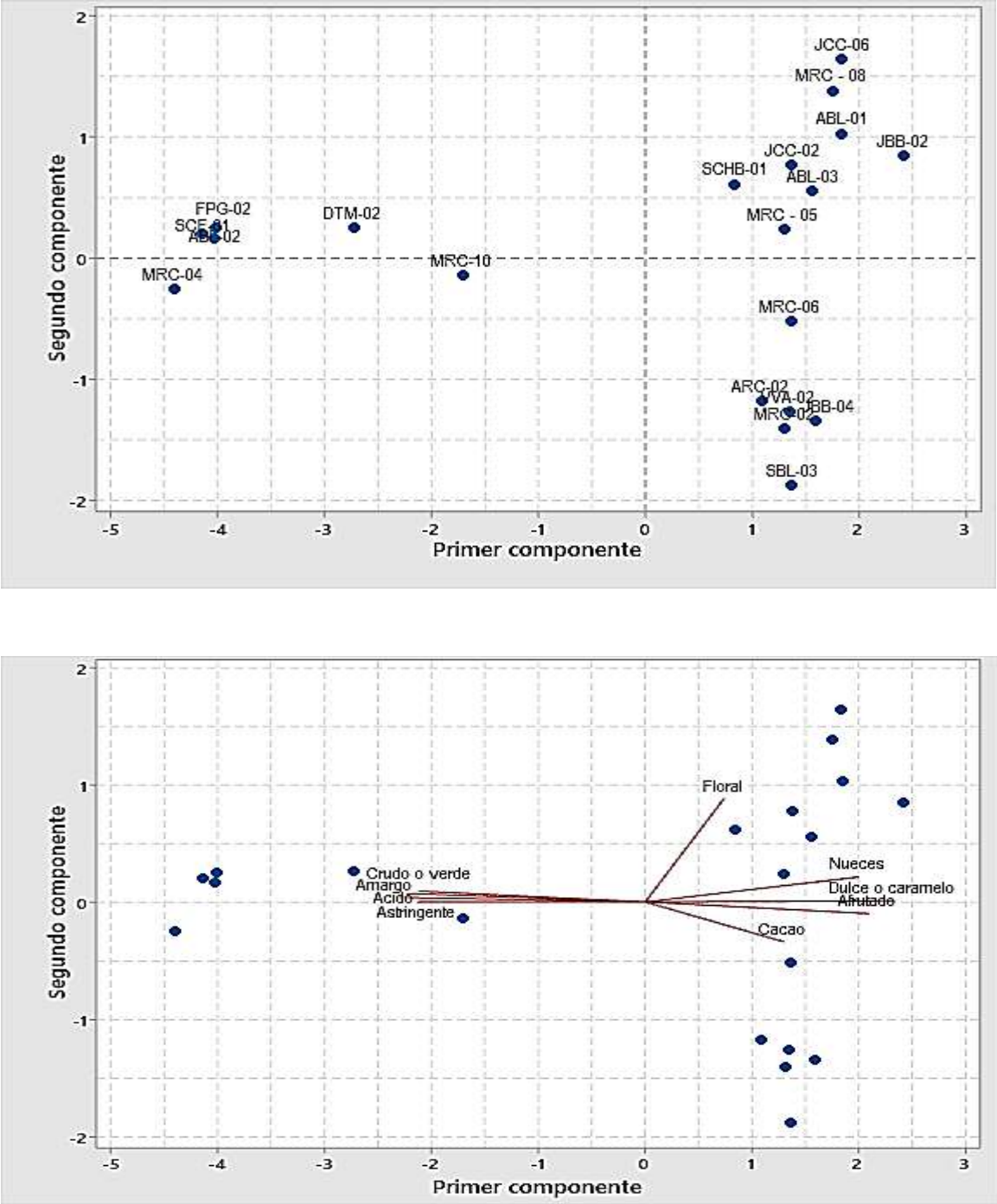

Figura 4. Análisis de componentes principales de los atributos sensoriales en almendras de cacao elites

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Efecto de un recubrimiento a base de quitosano y extracto de cebolla sobre la vida útil y las características sensoriales de filetes de dorado en refrigeración

Dolores Betún Beltrán *
Gustavo Elías Martínez Valenzuela **
Génesis Nathaly Cantillo Holguín ***

RESUMEN

Los productos pesqueros son altamente susceptibles al deterioro por diversas causas; el crecimiento bacteriano es el principal factor que limita su vida útil. La presente investigación evaluó el efecto de un recubrimiento a base de quitosano y extracto de cebolla sobre la vida útil y características sensoriales de filetes de dorado. El recubrimiento de mayor aceptación sensorial fue T6 elaborado con 3% de quitosano y 1% de extracto de cebolla, el cual obtuvo valores por debajo de los rangos permisibles en la norma legal vigente hasta los 21 días en refrigeración (29,12 mg N/100 g). El análisis microbiológico evidenció ausencia de aerobios mesófilos hasta el séptimo día de almacenamiento en refrigeración, incrementando gradualmente su conteo hasta los 21 días ($1{,}9x10^3$ UFC/g), cumpliendo con lo establecido en la normativa legal vigente ($1x10^5$ UFC/g); de igual manera se comprobó la ausencia de Coliformes totales y *E. coli* durante el tiempo establecido.

PALABRAS CLAVE: alimento; industria alimentaria; agroindustria; tecnología alimentaria.

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El artículo contiene los aportes del trabajo de titulación presentado como requisito para la obtención del título de Ingeniero Agrícola Mención Agroindustrial, en la Universidad Agraria del Ecuador.

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Effect of a coating based on chitosan and onion extract on useful life and sensory characteristics of Mahi-Mahi fillets in cooling

ABSTRACT

Fishing products are highly susceptible to deterioration due to various causes, bacterial growth is the main factor that limits their useful life. The present investigation evaluated the effect of a coating based on chitosan and onion extract on the useful life and sensory characteristics of Mahi-Mahi fillets. The coating with the highest sensory acceptance was T6 made with 3% chitosan and 1% onion extract, which obtained values below the permissible ranges in the current legal standard up to 21 days in refrigeration (29.12 mg N / 100 g). The microbiological analysis showed the absence of mesophilic aerobes until the seventh day of storage in refrigeration, gradually increasing their count until 21 days (1.9x103 CFU / g), complying with the provisions of current legal regulations (1x105 CFU / g), likewise, the absence of total coliforms and E. coli was verified during the established time.

KEYWORDS: Food; Food industry; Agroindustry; Food technology

Introducción

Los productos pesqueros son altamente susceptibles al deterioro por lo que se encuentran dentro de los alimentos perecederos; si bien pueden alterarse por diversas causas, el crecimiento bacteriano es el principal factor que limita su vida útil (Condori, 2014).

Después de la captura y muerte del pescado, éste sufre inmediatamente un deterioro, debido que la velocidad de degradación es más elevada que la de otros tipos de carnes; este proceso de degradación es llevado a cabo en una primera etapa, por enzimas propias del músculo del pescado y posteriormente por enzimas producidas por los microrganismos que ingresan al músculo (Oliveira, Dragonetti y Friss, 2001).

La industria alimentaria demanda tecnologías emergentes para aumentar la vida útil del pescado y ofrecer productos seguros y de calidad; por esta razón la aplicación de recubrimientos o películas en filetes de dorado representa una alternativa útil para su conservación, pues gracias a las propiedades que estas presentan, como: barrera de gases, vapor de agua, agentes antimicrobianos y antioxidantes naturales, permiten incrementar la calidad, seguridad y estabilidad del producto pesquero. Es decir, crea una barrera entre el producto y la atmósfera que lo rodea, de esta manera, se protege al alimento evitando la

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pérdida de humedad, reducción de la oxidación de las grasas, controlar el pardeamiento y verificar la calidad y propiedades del producto final (García, 2014).

Las películas y recubrimientos comestibles protegen de los daños físicos causados por impacto mecánico, presión, vibraciones entre otros. Las películas deben ser resistentes a la rotura y abrasión y además deben ser flexibles para adaptarse al alimento. Además, pueden incorporarse ingredientes funcionales como: antioxidantes, antimicrobianos, saborizantes o colorantes que ayuden a evitar la posible deformación del alimento a recubrir (Cadena, 2018).

El interés comercial del quitosano, se debe a las características biológicas favorables que posee, incluyendo la biodegradabilidad, biocompatibilidad y no toxicidad, propiedades que le otorgan un uso fundamental en las industrias farmacéuticas, biomédicas y alimentarias (Valenzuela y Arias, 2012). El objetivo de la presente investigación fue evaluar el efecto de un recubrimiento a base de quitosano y extracto de cebolla sobre la vida útil y las características sensoriales de filetes de dorado en refrigeración

1. Materiales y métodos

1.1. Materia prima

El pescado dorado con escama fue adquirido en el mercado "La Caraguay" en la ciudad de Guayaquil, el cual cuenta con un pequeño muelle donde llegan embarcaciones artesanales con la pesca del día. El pescado fresco fue colocado rápidamente dentro de un cooler, cubierta con capas de hielo, para mantener una temperatura menor a 4 ºC con el fin de evitar la degradación prematura. La norma NTE INEN 1896 (2013: 3) señala que: "El olor, color y sabor deben ser los característicos del producto. No se permiten olores y sabores objetables persistentes e inconfundibles que sean signo de descomposición".

Una vez retirado las escamas, se realizó el eviscerado mediante un corte ventral con un cuchillo hasta la abertura anal, con la finalidad de permitir el fácil acceso a la cavidad abdominal para retirar completamente las vísceras, luego de lo cual se realizó un lavado con el fin de eliminar restos de vísceras, escamas y sangre. Una vez limpio el pescado se procedió a realizar los filetes de aproximadamente 1 cm de espesor, formando filetes homogéneos de aproximadamente 12 x 4 cm.

1.2. Procedimiento del extracto de cebolla

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Se realizó un corte en ambos extremos de las cebollas y retira la capa exterior. Posterior se añadió los pedazos en el extractor durante 5 minutos. Una vez cernido y obtenido el extracto, se colocó en un recipiente plástico de cierre hermético.

1.3. Proceso de elaboración del recubrimiento a base de quitosano y extracto de cebolla

Se preparó 1 litro de solución de quitosano 1 % p/v en ácido acético 1 % v/v., luego se colocó en una placa de calentamiento (40 °C/450 rpm) durante 24 horas. Una vez solubilizado la solución se incorporó 10 ml de glicerol y el extracto de cebolla agitando por 2 horas.

1.4. Aplicación del recubrimiento

El recubrimiento se aplicó en 1 kg de filetes de dorado mediante el método de inmersión y se dejó reposar por 5 minutos. Luego de la aplicación del recubrimiento, se colocó en mallas los filetes para eliminar el exceso del mismo. Los filetes estuvieron expuestos a temperatura de refrigeración 4 ± 1 °C.

En este trabajo se evaluaron dos factores de estudio: el Factor A correspondió a las concentraciones de quitosano (1 y 3%), y el Factor B las concentraciones de extracto de cebolla (0; 0,5 y 1%).

1.5. Características sensoriales

Se escogió un panel sensorial de 30 jueces semi-entrenados para el análisis de color, olor, sabor y textura de las muestras de cada uno de los tratamientos en estudio, para lo cual se utilizó una escala hedónica de 5 puntos, donde 1 equivale a muy malo y 5 significa muy bueno.

Para realizar la prueba sensorial se sometieron los filetes a cocción en una plancha caliente por 2 minutos aproximadamente, sin agregar ningún condimento para evitar que interfiera en los resultados de la prueba. Las muestras fueron servidas a cada juez identificando cada uno con números aleatorios

El tratamiento que tuvo mayor aceptación sensorial por parte del panel de jueces fue analizado a los 7, 14 y 21 días conservado en refrigeración (‹4 °C)

1.6. Contenido de bases nitrogenadas

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La norma NTE INEN 1896.2013 menciona que el contenido de bases nitrogenadas volátiles totales (NVBT) no debe superar 30 mg N/100 g muestra.

La concentración de NVBT se calculó en base al procedimiento establecido en la norma NTE INEN 182. Se pesa de 5 a 10 g de la muestra preparada y se transfiere cuantitativamente al balón de destilación. Se agrega sobre la muestra 300 cm3 de agua destilada, 1 a 2 g de óxido de magnesio y unas gotas de alcohol octílitico para evitar la formación de espuma. Se conecta inmediatamente el balón al condensador y se destila por 25 minutos. El extremo de salida del condensador debe estar sumergido en 50 cm3 de la solución valorada de ácido sulfúrico 0,1 N contenido en el Erlenmeyer de 250 cm3, a la cual se debe agregar unas gotas del indicador rojo de metilo. Una vez terminada la destilación, comprobada con papel indicador, se procede a titular el exceso de ácido contenido en el matraz Erlenmeyer con la solución de hidróxido de sodio 0,1 N. Se debe realizar un ensayo en blanco con todos los reactivos siguiendo el mismo procedimiento anteriormente descrito. La valoración del destilado recogido, mediante la siguiente ecuación:

$$\text{mg N/100 gramos de muestra} = \frac{(V_m - V_b) * 0.14 * 2 * 100}{m}$$

1.7. Vida útil

El análisis microbiológico, se realizó a la muestra de mayor aceptación en laboratorios externos de acuerdo a los requerimientos establecidos en la Norma INEN 1896: 2013. Los criterios microbiológicos analizados fueron: Recuento de microorganismos mesófilos (ufc/g), mediante el método de ensayo estipulado en la AOAC 990.12; Coliformes totales y *E. coli* (ufc/g) utilizando el procedimiento establecido en la AOAC 998.08

1.8. Análisis estadístico

El diseño de investigación empleado fue un diseño en bloques al azar con arreglo factorial (2 x 3). Los datos proporcionados por los jueces quienes conformaron la fuente de bloqueo fueron sometidos a un análisis de varianza (ANOVA) con el fin de establecer diferencias significativas entre los tratamientos para cada variable: color, olor, sabor y textura. Para la comparación de medias se utilizó la prueba de Tukey al 5% de error tipo 1 ($p<0,05$), para lo cual se empleó el software Infostat.

2. Resultados y discusión

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La tabla 1 muestra los resultados del análisis sensorial efectuado en los filetes de pescado dorado con el recubrimiento a base de quitosano y extracto de cebolla. El tratamiento de mayor aceptación sensorial fue el Tratamiento 6, con la combinación de a 2: quitosano 3% y b3: extracto de cebolla 1%., el mismo que fue el mejor calificado en cada uno de los atributos sensoriales.

Tabla 1. Promedios de análisis sensorial

Nº	Factor A	Factor B	Color	Olor	Sabor	Textura
1	a1: Quitosano 1 %	b1: extracto de cebolla 0 %	4.3 ab	4.4 a	4.3 a	4.1 b
2	a1: Quitosano 1 %	b2: extracto de cebolla 0.5 %	4.5 a	4.4 a	4.3 a	4.1 ab
3	a1: Quitosano 1 %	b3: extracto de cebolla 1 %	4.6 a	4,3 a	4.3 a	4.4 ab
4	a2: Quitosano 3 %	b1: extracto de cebolla 0 %	4.3 ab	4.4 a	4.4 a	4.6 a
5	a2: Quitosano 3 %	b2: extracto de cebolla 0.5 %	3.9 b	3.8 b	4.2 a	4.1 ab
6	a2: Quitosano 3 %	b3: extracto de cebolla 1 %	4.4 a	4.5 a	4.5 a	4.6 ab

Betún-Beltrán et al., 2021.

Se puede apreciar que los componentes del recubrimiento no transfieren color, olor o sabores atípicos al producto, debido a que no se observó diferencias significativas entre los distintos tratamientos aplicados, salvo pequeñas excepciones, estos resultados coinciden con los obtenidos por Montaño Cota (2016), quien estudió el efecto de un extracto etanólico obtenido a partir de la planta de tomate (*Olanum lycopersicum*) incorporado en un recubrimiento comestible a base de quitosano sobre la frescura, calidad y vida de anaquel del filete de sierra (*Scomberomorus sierra*) almacenado en hielo, donde se evidenció que no existieron diferencias significativas entre los tratamientos en estudio

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El contenido de bases nitrogenadas volátiles totales se realizó al tratamiento de mayor aceptación (T6: Quitosano 3% y extracto de cebolla 1 %). La tabla 2 muestra los miligramos de nitrógeno obtenidos por cada 100 gramos de producto durante el almacenamiento en refrigeración a los 7, 14 y 21 días.

Tabla 2. Contenido de bases nitrogenadas volátiles totales

Días de refrigeración	Volumen consumido en la titulación	mgN/100g
7	4,2 ml	10,92
14	6,9 ml	18,48
21	10,7 ml	29,12

Betún-Beltrán et al., 2021.

El tratamiento 6: quitosano al 3 % y extracto de cebolla al 1 %, obtuvo valores por debajo de los rangos permisibles según lo estipulado en la normativa legal vigente NTE INEN 182 (30 mg N/100 g) hasta los 21 días en refrigeración: 10.92 mg N/100 g (7 días), 18.48 mg N/100 g (14 días) y 29.12 mg N/100 g (21 días). Mero y Valencia (2018) evaluaron un recubrimiento comestible para filetes de tilapia roja (*Oreochromis* sp) a partir de almidón de yuca (*Manihot esculenta* crantz) y aceite esencial de romero (*Tosmarinus officinalis*), el análisis estadístico demostró, que la media del testigo es ligeramente mayor que la del filete con recubrimiento, el testigo presenta una mayor varianza, y al llegar al décimo día de almacenamiento alcanza un valor máximo de 33.83 mg N/100g similar al recubrimiento; por esta razón se asumió que no hay diferencia alguna entre los grupos sin recubrimiento y con recubrimiento a base de almidón de yuca y aceite esencial de romero. Por otra parte, Raeisi (2014) elaboró un recubrimiento a partir de carboximetil celulosa enriquecido con aceite esencial *Zataria multiflora* y extracto de la semilla de uva para filetes de trucha arcoíris; la muestra de control dio una concentración inicial de 12.67 mg/100g de NBVT, mientras que las muestra sin recubrimiento tuvieron un valor de 11.34 mg/100g de NBVT. Luego de un plazo de 20 días de almacenamiento lograron valores de 52.00 mg/100 g y 40.30 mg/100g.

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En la tabla 3 se muestran los resultados del análisis de vida útil, de aerobios mesófilos, coliformes totales y *E. coli* realizado al tratamiento de mayor aceptación sensorial, a los 7, 14 y 21 días de almacenamiento en refrigeración (3 ± 2 °C).

Tabla 3. Tiempo de vida útil

Parámetros	Tiempo natural: 7 días	Tiempo natural: 14 días	Tiempo natural: 21 días	UNIDAD
Aerobios Mesófilos	‹10	8×10^2	1.9×10^3	UFC/g
Coliformes Totales	‹10	‹10	‹10	UFC/g
E. coli	‹10	‹10	‹10	UFC/g

Betún-Beltrán et al., 2021.

Los resultados del análisis de vida útil evidenciaron que hasta el séptimo día de almacenamiento se mantuvieron ausentes (‹10 UFC/g), luego se observó un incremento a los 14 y 21 días de almacenamiento en refrigeración de 8×10^2 y 1.9×10^3 UFC/g respectivamente; dichos valores están dentro de los rangos establecidos en la normativa legal vigente (1×10^5 UFC/g), por lo tanto, se demuestra la eficacia del recubrimiento aplicado. Al respecto, Suárez y Martínez (2018) mencionan que el quitosano, aunque es una sustancia antimicrobiana natural, tiene una limitación en la difusión en un medio de agar, de modo que solamente los microorganismos en contacto directo con los sitios activos de quitosano son inhibidos y podría ser necesaria la adición de otro antimicrobiano, dicha función se le otorgó al extracto de cebolla. Cabe resaltar que estas películas antimicrobianas, son más efectivas frente a las bacterias Gram-positivas que frente a las bacterias Gram-negativas (Otero, 2019).

Por su parte, Mero y Valencia (2018) evidenciaron que la media de ambos grupos (grupo 1: sin recubrimiento y grupo 2: con recubrimiento de almidón de yuca y aceite esencial de romero) presentan una diferencia mínima, teniendo una varianza casi idéntica, pero se recurrió a la prueba paramétrica, con la que se obtuvo un resultado del 31.73%, cumpliendo con la hipótesis nula, es decir que no existe diferencia alguna entre ambos grupos. Sin embargo, en un estudio realizado Song (2011) con un recubrimiento a partir de alguinato y antioxidantes aplicados a filetes de brema (*Megalobrama amblycephala*), la cantidad de aerobios

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total para todas las muestras empezó en 3 log_{10} UFC/g, pero después de un periodo de 18 días de almacenamiento la muestra con recubrimiento logró un valor de 5.54 log_{10} UFC/g, mientras que la prueba de control en el día 17, ya había sobrepasado los 8 log10 UFC/g.

Conclusiones

El uso de quitosano y extracto de cebolla no influyó en la calidad sensorial del producto, los tratamientos no mostraron grandes diferencias en sus características organolépticas. Sin embargo, el recubrimiento de mayor aceptación sensorial fue T6 elaborado con 3 % de quitosano y 1 % de extracto de cebolla.

El análisis de bases nitrogenadas volátiles en el tratamiento de mayor aceptación sensorial (T6: quitosano al 3 % y extracto de cebolla al 1 %) obtuvo valores por debajo de los rangos permisibles según lo estipulado en la normativa legal vigente NTE INEN 182 (30 mg N/100 g) hasta los 21 días en refrigeración: 10.92 mg N/100 g (7 días), 18.48 mg N/100 g (14 días) y 29.12 mg N/100 g (21 días).

El análisis microbiológico evidenció que hasta el séptimo día de almacenamiento los aerobios mesófilos se mantuvieron ausentes (‹10 UFC/g), luego de lo cual se observó un incremento de 8 x 102 UFC/g a los 14 días y 1.9 x 103 UFC/g a los 21 días de almacenamiento en refrigeración; dichos valores están dentro de los rangos establecidos en la normativa legal vigente (1 x 105 UFC/g). Así mismo, se comprobó la ausencia de Coliformes totales y E. coli durante el tiempo establecido.

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Management of agricultural crops production depending on land quality and intensification factors

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ABSTRACT

The article analyzes the methods of managing the production of agricultural products based on the quality of the land and the intensification factors. The purpose of this article is to determine the main factors that affect the production of agricultural products, develop recommendations to improve the management and analysis of crop production. The objectives of the study are: identification of the main factors that affect the efficiency of production of agricultural products; development of recommendations for the formation of self-sufficient segments of crop production in agricultural organizations and evaluation of the effectiveness of their operation; determination of an algorithm for the analysis and identification of deviations in crop yields due to intensification factors, organizational and management measures and land quality (soil) of cultivated areas. The introduction and use of economic methods to manage agricultural production requires the restructuring and formation of self-sufficient activity segments in medium and large agricultural organizations, which must operate on the principles of independence in matters of control, administration and evaluation of the recovery of the investment. The model (scheme) for the management of the self-sufficient segments of crop production is substantiated, the internal calculation prices are determined to evaluate the products produced by these segments and the net operating income of their activities.

KEY WORDS: Agricultural products; Agroindustry; intensification; Agricultural land; grain crops.

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Gestión de la producción de cultivos agrícolas en función de la calidad de la tierra y factores de intensificación

RESUMEN

El artículo analiza los métodos de gestión de la producción de productos agrícolas en función de la calidad de la tierra y los factores de intensificación. El propósito de este artículo es determinar los principales factores que afectan la producción de productos agrícolas, desarrollar recomendaciones para mejorar el manejo y análisis de la producción de cultivos. Los objetivos del estudio son: identificación de los principales factores que afectan la eficiencia de producción de productos agrícolas; desarrollo de recomendaciones para la formación de segmentos autosuficientes de producción de cultivos en organizaciones agrícolas y evaluación de la efectividad de su funcionamiento; determinación de un algoritmo para el análisis e identificación de desviaciones en los rendimientos de los cultivos debido a factores de intensificación, medidas organizativas y de gestión y calidad de la tierra (suelo) de las áreas cultivadas. La introducción y uso de métodos económicos para administrar la producción agrícola requiere la reestructuración y formación de segmentos de actividad autosuficientes en organizaciones agrícolas medianas y grandes, que deben funcionar sobre los principios de independencia en materia de control, administración y evaluación de la recuperación de la inversión. Se fundamenta el modelo (esquema) de gestión de los segmentos autosuficientes de la producción de cultivos, se determinan los precios de cálculo internos para evaluar los productos producidos por estos segmentos y los ingresos operativos netos de sus actividades.

PALABRAS CLAVE: producto agrícola; agroindustria; intensificación; tierra agrícola; cultivos de granos.

Introduction

The globalization of the agricultural economy and agricultural markets requires a significant increase in the efficiency of agricultural activities by significantly increasing the volume of agricultural production, improving its quality at normal costs and labor productivity. Achievement of these strategic objectives of agriculture is possible by considering all factors of agricultural production and prudent use of material, biological, land, labor, and financial resources in agricultural production. In addition, it is necessary to pay special attention to the development trends and issues of improving the organization of production, labor and payment in crop production and animal husbandry. All this requires the rationalization of the agricultural management system through the introduction and use of economic methods of production management.

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The introduction and use of economic methods for managing agricultural production requires restructuring and formation of self-supporting segments of activity in medium and large agricultural organizations, which should function on the principles of independence in matters of control, management, and evaluation of return on budget costs.

At the present stage of agricultural development, it is of great importance to significantly increase the volume of agricultural production, improve its quality, and increase production efficiency (Alborov et al., 2019).

In modern market conditions, the fundamental for effective development of the activities of any economic entities is to change the production management system through the widespread use of economic methods (Endovitsky et al., 2018). The main task of the management system is the development and implementation of management decisions (Ostaev, Suetin, et al., 2020).

The transition of farms at the end of the last century to the market led to the need to adapt production and management mechanisms to the requirements of the external environment, which first of all required the preservation and strengthening of labor discipline, independence, and initiative of management in setting and solving current and future problems (Kondratiev et al., 2020).

The main indicators of efficiency of agricultural production are crop yields and cost of the products obtained from them, as well as labor productivity, capital return, material efficiency, net operating income, etc. (Kontsevaya et al., 2020). There is an inverse relationship between yield of agricultural crop and unit cost of given agricultural crop (Ostaev, Shulus, et al., 2020). With an increase in yield per 1 hectare of given agricultural crop, the cost price of 1 centner of the product obtained from this crop decreases and, conversely, with a decrease in yield per 1 hectare of given agricultural crop, the cost price of 1 centner of production of this agricultural crop increases (Alborov et al., 2017).

A variety of technological, organizational, managerial, and other factors influence the efficiency indicators of agricultural crop production (Molchan et al., 2020). These factors include:

a) intensification factors: increasing the equipment of crop production with means of production; increasing the level of mechanization and automation of crop production processes; introduction of the most advanced active-adaptive technologies for production of

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agricultural crops; carrying out reclamation measures and cultural and technical works to artificially improve the fertility of land; improving quality of production capacities (machines, tractors, combines) by updating them and replacing physically and morally obsolete means of labor (fixed assets); use in the production process of the best categories of seeds, planting material, high-yielding varieties of agricultural crops, required quantity and quality of fertilizers according to special cartograms and crop rotation systems.

b) organizational and managerial factors (conditions): organization of rational placement and use of material and labor resources in crop production; application of the most progressive forms of organization of production process, labor, and payment in crop production; improvement of production management system by increasing the efficiency of its planning and prognostic, accounting and analytical, control and evaluation functions.

c) abiotic factors (conditions): light; heat; air (its composition and movement); moisture (precipitation, soil moisture, air).

d) edaphic factors: mechanical and chemical composition of the soil; physical properties of soil, its quality in general according to bonitet scores; relief of land (arable land, hayfields, etc.).

In addition to all the above factors and conditions, the level of yield and cost of agricultural crops largely depends on the observance of the time period for carrying out agrotechnological works in crop production (Karagodin, 2014).

Therefore, agrotechnological work (processes) in the production of agricultural crops must be performed in a strict sequence in accordance with the technological maps of agricultural crops (crop groups) and system of scientifically substantiated alternation in time and space (placement in the fields) in the field of crop rotation adopted in the organization. (Selezneva et al., 2020).

Timely implementation of all agrotechnological works in crop production will contribute to an increase in the efficiency of all factors (intensification, abiotic, edaphic) affecting the level of yield and unit cost of agricultural crops (Karagodin, Tsyguleva, 2021). To increase the effectiveness of the influence of organizational and managerial factors on the yield and self-cost of agricultural products, in our opinion, it is necessary to change the current semi-administrative system for managing crop production in agricultural

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organizations by gradually switching to economic methods of internal management (Frantsisko et al., 2020).

The introduction of economic methods of internal management requires its certain decentralization, in this case, in the crop production industry (Kokonov et al., 2019). In other words, it is necessary to transfer part of the internal management functions (planning and prognostic, accounting and analytical, control and evaluation) to the primary (structural) divisions of crop production. At the same time, preliminary work should be carried out on restructuring of crop industry and creation of self-supporting segments of activity in this sector of agricultural organizations, which should be as independent as possible, function on the principles of self-government, self-control, and self-sufficiency. The remuneration of employees in these self-supporting segments of activity should depend not only on the established categories of employees and prices for production unit and unit of work performed in crop production, but also on the operational financial results (operating net income) of production, performance of work in specific self-supporting segments of activities. All this will contribute to an increase in the material and moral interest of employees in self-supporting segments of activity, an increase in their stimulation to an increase in labor productivity, rational use of material, labor, and financial resources in crop production (Kontsevoi et al., 2020).

1. Methodology

The methodological basis of the study is to determine the main factors affecting the production of crop products. The study is based on materialistic dialectics, which determines the study of a phenomenon in any specific area of practice and scientific knowledge. The study is based on the works of domestic scientists and personal observations on the problems of using material, biological, land, labor, and financial resources in agricultural production. In addition, theoretical and practical factors of intensification, organizational and managerial, abiotic, and edaphic factors affecting the efficiency of production of agricultural products are studied.

The study proposes ways to rationalize the agricultural management system through the introduction and use of economic methods of production management. During the study, general scientific and special research methods were used: analysis, synthesis, modeling, methods of systematization and generalization of the results obtained.

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The new provisions are substantiated by the results of study and observations obtained by the indicated methods. The purpose of the study is to determine the main factors affecting the production of agricultural products, to develop recommendations for improving the management and analysis of the production of crop products. The object of the study is agricultural organizations, the subject of the study is the issues of production management and analysis of factors affecting the productivity of agricultural crops.

The significance of the study lies in the substantiation of indicators with the help of which it is possible to assess the quality of the intensification of crop production, the management of the efficiency of this production, as well as the impact of abiotic and edaphic factors on the yield of agricultural crops in quantitative terms.

2. Results and discussion

In the crop production industry, agricultural organizations are recommended to create one self-supporting segment of auxiliary production and several self-supporting segments of production as needed (Figure 1).

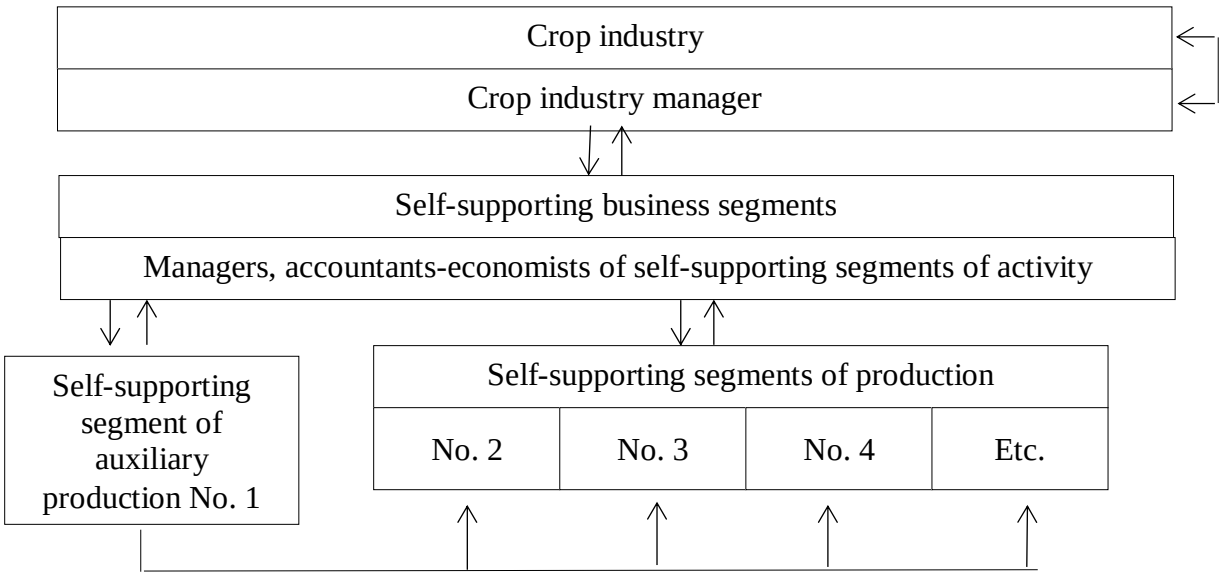

Figure 1. Management scheme for self-supporting crop production segments

The self-supporting segment of auxiliary production (machine and tractor brigade) performs all field mechanized work (plowing, pre-sowing soil cultivation, sowing, fertilization, crop care, harvesting, transportation work in crop production, etc.). Employees of this self-supporting segment will control their costs and the volume of work, as well as the

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final financial results of this self-supporting segment, that is, the received operating net income.

Self-supporting segments of production (crop production teams) grow crops and produce crop products (grain, potatoes, hay, green mass, root crops, vegetables, etc.). Employees of these self-supporting segments control their costs, the volume of product types received, their quality and the final financial result of production (operating net income).

At the end of each reporting year, the gross volume of work performed by the self-supporting segment of auxiliary production and the gross volume of products received, considering its quality, by each self-supporting segment of production is estimated at the internal estimated prices. By subtracting from the cost of the gross volume of work performed by the self-supporting segment of auxiliary production, the amount of costs for performing these works is determined by the operating net income of this self-supporting segment. By subtracting the costs of its production from the cost of gross product in each self-supporting segment of production, the operating net income is determined. At the same time, in our opinion, the basis for the development of internal settlement prices should be the variable cost of works and products, which includes all variable costs (depending on the volume of production, work performance) of given self-supporting segment of activity and its general production (variable) costs ... Thus, the internal estimated price per unit of work, unit of production of the corresponding self-supporting segments of activity can be determined by the formula:

$$\text{Iep} = \frac{Vpc}{Tpc} \times \text{Amv},$$

where Iep -is the internal estimated price per unit of work performed by the self-supporting segment of auxiliary production, unit of products received by the self-supporting segment of production, rubles.

Vpc– is the variable production cost per unit of work performed by the self-supporting segment of auxiliary production, units of products received by the self-supporting segment of production, rubles.

Tpc– is the total production cost per unit of work performed by the self-supporting segment of auxiliary production, unit of products received by the self-supporting segment of production, rubles.

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Amv– is the average market value of unit of work performed by the self-supporting segment of auxiliary production, units of products received by the self-supporting segment of production, rubles.

Using the internal settlement prices, the operating net income of the corresponding self-supporting segment of activities is calculated using the formula:

$$Oni = (Iep \times Qvwp) - \Sigma Cav,$$

where Oni is the operating net income for the volume of work performed by the self-supporting segment of auxiliary production, for the volume of production received by the self-supporting segment of production, rubles.

Qvwp is the volume of work performed by the self-supporting segment of auxiliary production, the volume of products received by the self-supporting segment of production, hectares of reference plowing, centners.

ΣCav is the cost amount for the volume of work performed by the self-supporting segment of auxiliary production, for the volume of products received in the self-supporting segment of production, rubles.

If any self-supporting segment receives operating net income from its activities, then this amount of operating net income should be used to accrue remuneration to employees of this self-supporting segment of activities for the final results based on the work results for the year.

Of great importance in increasing the efficiency of each self-supporting segment and crop production in general is the analysis and assessment of the influence of all of the above factors of production on the yield of agricultural crops, since everything depends on the level of yield of these crops: unit cost of the products received, productivity of labor, labor intensity of the products received and amount of operating net income from its production.

We will conduct such an analysis and assessment using the example of agricultural organizations of the Udmurt Republic, attributed to the zone of risky agriculture in Russia with a sharply continental climate, in terms of the yield of one of the main agricultural crops - grain crops (Table 1).

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Table 1. Assessment and analysis of grain crop yields by agricultural organizations of the districts of the Udmurt Republic

District names	Amount of grain harvest per 1 hectare for 2005-2019, c	Average actual grain yield per hectare, c	Soil bonitet score	Average normal grain yield per 1 hectare, c	Deviation of grain yield per 1 hectare:	
					Due to factors of intensification, organization and management, c	Due to the quality of land, c
	ΣHip	**Hfip**	**Bip**	**Hnip**	**Δ Hfipи**	**Δ Hnipb**
1. Alnashsky	286.5	19.1	81	15.9	+3.2	+1.6
2. Balezinsky	187.1	12.5	73	14.3	-1.8	-
3. Vavozhsky	383.4	25.6	67	13.1	+12.5	-1.2
4. Votkinsky	241.2	16.1	64	12.5	+3.6	-1.8
5. Glazovsky	205.9	13.7	73	14.3	-0.6	-
6. Grakhovsky	270.3	18.0	79	15.5	+2.5	+1.2
7. Debesky	214.9	14.3	75	14.7	-0.4	+0.4
8. Zavyalovsky	242.4	16.2	82	16.1	+0.1	+1.8
9. Igrinsky	213.7	14.2	70	13.7	+0.5	-0.6
10. Kambarsky	89.9	9.0	65	12.7	-3.7	-1.6
11. Karakulinsky	225.7	15.1	85	16.7	-1.6	+2.4
12. Kezky	165.8	11.1	71	13.9	-2.8	-0.4
13. Kiznersky	190.7	12.7	64	12.5	+0.2	-1.8
14. Kiyasovsky	203.4	13.6	76	14.9	-1.3	+0.6
15. Krasnogorsky	156.6	10.4	69	13.5	-3.1	-0.8
16. Malopurginsky	249.9	16.7	78	15.3	+1.4	+1.0
17. Mozhginsky	289.4	19.3	73	14.3	+5.0	-

18. Sarapulsky	228.5	15.2	79	15.5	-0.3	+1.2
19. Seltinsky	185.3	12.4	65	12.7	-0.3	-1.6
20. Yumsinsky	196.1	14.0	63	12.3	+1.7	-2.0
21. Uvinsky	222.0	14.8	65	12.7	+2.1	-1.6
22. Harkansky	239.1	15.9	76	14.9	+1.0	+0.6
23.Yukamensky	171.0	11.4	72	14.1	-2.7	-0.2
24. Akshur-Bodyinsky	128.6	10.7	68	13.3	-2.6	-1.0
25. Arsky	190.8	12.7	72	14.1	-1.4	-0.2
Σ У25р	5378.3	-	-	-	-	-
Average	У = 14.3		73	14.3	-	-

The indicators given in table 1 are determined according to the following calculation formulas:

Hfip = ΣHip: 15 years

Hnip = H: 73 × Bip.

Δ Hfipи = Hfip – Hnip.

Δ Hnipb = Hnip – У.

У = ΣУ25р: (25×15) = 5378,3: 375 = 14,3 с.

The data in column 6 of Table 1 (that is, Δ Hfipи) show the deviation of the actual grain yield per 1 hectare on average over the past 15 years for agricultural organizations of the districts due to intensification factors, as well as organizational and managerial measures.

In such districts as Alnashsky, Vavozhsky, Votkinsky, Grakhovsky, Igrinsky, Zavyalovsky, Malopurginsky, Mozhginsky, Syumsinsky, Uvinsky and Sharkansky agricultural organizations received an increase in grain yield per 1 hectare of sowing due to more effective use of intensification factors and organizational and managerial measures.

In other districts, such as Balezinsky, Glazovsky, Debessky, Kambarsky, Karakulinsky, Kezsky, Kiznersky, Kiyasovsky, Krasnogorsky, Sarapulsky, Seltinsky, Yukamensky, Yakshur-Bodyinsky and Yarsky agricultural organizations due to

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intensification factors, organizational -management measures have received less grain harvest. In the agricultural organizations of these areas, there is a lower level of intensification, weak use of intensification factors and organizational and managerial measures.

The data in column 7 of Table 1 (Δ Hnipb) show the deviation of the actual grain yield per 1 hectare of crops on average over the past 15 years for agricultural organizations in the districts due to the quality of the land.

In agricultural organizations of Alnashsky, Grakhovsky, Debessky, Zavyalovsky, Karakulinsky, Kiyasovsky, Malopurginsky, Sarapulsky and Sharkansky districts, they received an increase in grain yield per 1 hectare of sowing due to the higher fertility of the land.

Agricultural organizations of Balezinsky, Glazovsky and Mozhginsky districts did not receive any increase in grain yield per 1 hectare of sowing due to the coincidence of the quality of the land with its average level in all districts.

Agricultural organizations of Vavozhsky, Votkinsky, Igrinsky, Kambarsky, Kezsky, Kiznersky, Krasnogorsky, Seltinsky, Syumsinsky, Uvinsky, Yukamensky, Yakshur-Bodinsky and Yarsky districts received less grain harvest per 1 hectare of sowing due to the low quality of the land (below the average for all districts). Therefore, agricultural organizations in these areas should in the future take measures to increase the soil fertility of arable land (arable land).

Of the intensification factors, the yield of agricultural crops, in this case, grain crops, is most influenced by the amount of organic and mineral fertilizers applied to the soil, considering the quality of the land. In this regard, to improve the quality of the land (soil fertility) and the yield of grain crops per 1 hectare of sowing, as well as to optimize the doses of fertilizers applied to the soil, it is necessary to determine the quantitative parameters of the influence of these factors (doses of fertilizers in the soil, soil quality) for grain yield per 1 hectare of sowing. In addition to these two factors, the grain yield per hectare of sowing depends very much on the abiotic (climatic) conditions of growing grain crops.

Conclusion

In general, in the Udmurt Republic, the climate is characterized as sharply continental with large fluctuations within the given subject in the regions. Therefore, it is necessary to

establish the factor of the year for each district (that is, the effect of abiotic - climatic conditions of the year on crops yield).

This is necessary when conducting a factor analysis of crop yields using the correlation and regression method. In this case, the factor of the year, in our opinion, can be set (measured) in qualimetric units of measurement (coefficients or points). With the help of qualimetric indicators, it will be possible to quantify the quality of intensification of crop production, efficiency management of this production, as well as the impact of abiotic and edaphic factors on agricultural crop yields.

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Results of the Russian State policy in the field of increasing food availability

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ABSTRACT

The purpose of the study was to assess the impact of the Russian state policy on agricultural production and food availability in the context of food security. Using methodological tools, statistical data about production, consumption and prices of food products were processed. In the course of the work, it was determined that the agriculture of Russia shows a fairly high rate of development. The positive aspect is that this growth is provided mainly by intensive factors. The sale prices of agricultural producers show high growth rates, which negatively affects the availability of food for the country's population. In general, Russia's agriculture, under the conditions of the food embargo and economic sanctions, shows good results. It is proposed that the State changes the emphasis from state support from grain and pig farming to growing vegetables, growing fruits, and raising livestock, including milk products. Increasing support to these areas will increase the volume of agricultural production of high value-added goods, which will have a positive impact on the development of rural areas and the diversification of exports. At the same time, state support should be left in the direction of the production of class 1 and 2 cereals and the processing of pork.

KEY WORDS: production; supply-side economics; public administration; macroeconomics; agricultural industries; economic policy, Russia.

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Resultados de la política del Estado ruso en el ámbito del aumento de la disponibilidad de alimentos

RESUMEN

El propósito del estudio consistió en evaluar el impacto de la política del Estado ruso sobre la producción agrícola y la disponibilidad de alimentos en el contexto de la seguridad alimentaria. Utilizando herramientas metodológicas, se procesaron datos estadísticos sobre producción, consumo y precios de productos alimenticios. En el curso del trabajo, se determinó que la agricultura de Rusia muestra una tasa de desarrollo bastante alta. El aspecto positivo es que este crecimiento es proporcionado principalmente por factores intensivos. Los precios de venta de los productores agrícolas muestran altas tasas de crecimiento, lo que afecta negativamente la disponibilidad de alimentos para la población del país. En general, la agricultura de Rusia, bajo las condiciones del embargo alimentario y las sanciones económicas, muestra buenos resultados. Se propone que el Estado cambie el énfasis del apoyo estatal de la cría de cereales y la cría de cerdos hacia el cultivo de hortalizas, el cultivo de frutas y la cría de ganado, incluidos los productos lácteos. Aumentar el apoyo a estas áreas incrementará el volumen de producción agrícola de bienes de alto valor agregado, lo que tendrá un impacto positivo en el desarrollo de las áreas rurales y la diversificación de las exportaciones. Al mismo tiempo, el apoyo estatal debe dejarse en la dirección de la producción de cereales de clase 1 y 2 y el procesamiento de carne de cerdo.

PALABRAS CLAVE: producción; economía del lado de la oferta; administración pública; macroeconomía; industrias agrícolas; política económica; Rusia.

Introduction

The struggle to keep Ukraine in Russia's sphere of influence led to the adoption of economic sanctions by the United States, Canada, Australia, and the European Union countries, which had a strong impact on the economic situation in the country. Since the adoption of the sanctions, the World Bank has not approved a single decision on investment in projects within Russia. The supply of high-tech goods was restricted, and the supply of dual-use goods, goods that can be used in both civil and military projects, was completely prohibited. The economic chains between the enterprises of Ukraine and Russia were completely destroyed. Trade turnover between Russia and the countries that have adopted sanctions has dropped significantly. All these factors, as well as the fall in oil prices, have led to significant damage to the country's economy, as well as to the population.

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In response, Russia introduced a food embargo in 2014 that was a ban on the supply of food products to the country, the country of origin of which are the countries participating in the sanctions pressure. As a result of the food embargo, a significant market share turned out to be free, the diversification of import supplies in 2014 and even in 2015 was not completely possible to implement, and, therefore, Russian food producers had the opportunity to increase their share in the domestic market. Together with the import ban, the liberation of the market part from competitors, there was an increase in food prices, profitability increased by 5-10 points for some food products. However, an increase of food prices, devaluation of the national currency, and reduction of budget spending on social projects endangered the country's food and economic security.

Food security is determined by the totality of food production and availability. On the one hand, rising prices and embargo stimulated food production, on the other hand, there was a decrease in the availability of food. The components of economic security are reflected in the aspect of the development of labor resources and the sustainability of the functioning of agricultural entities. Without affordable and high-quality food, it is impossible to develop labor resources, as well as to ensure population growth. The low stability of agricultural production entities is manifested in the instability of the conditions of the internal and external environment. The lifting of restrictions on the food embargo may lead to the fact that the investment projects in the agro-industrial complex will lose profitability or become unprofitable. In addition, the devaluation of the national currency and high inflation have determined costs' increase. Prices for seeds, fertilizers, fuels and lubricants, machinery, equipment have increased significantly under the influence of the factors presented above.

Thus, the relevance of the study is determined by the need to assess the impact of the country's state policy on ensuring food and economic security.

The purpose of the study is the need to assess the impact of government policy on agricultural production and food availability in the context of ensuring food security.

Achieving the study purpose required solving the following tasks:

- to analyze changes in the volume of production of food products and raw materials for its production;

- to assess the impact of the extensive factor on the production of food products and raw materials for its production;

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- to assess the impact of the intensive factor on the production of food products and raw materials for its production;

- to analyze the prices of agricultural producers;

- to analyze the consumption of basic food products by the population of the country.

Public-private relations regarding the production, processing and consumption of food products are identified as the object of the study. The subject of the study is the country's food security.

The hypothesis of the study is the scientific assumption that the Russian food embargo did not sufficiently ensure the development of agriculture, which led to an increase in food prices and negatively affected the volume of its consumption by the population.

1. Theoretical basis

The theoretical basis of the study is formed on the basis of scientific works of Russian and foreign scientists, published in leading peer-reviewed scientific journals, presented in monographs, educational publications, dissertations, collections of conference proceedings for the issues under study.

The issues of state regulation of agricultural production in order to ensure food security are widely considered in the works of such scientists as C.G. Brown, S.R. Johnson, J. Vik, X.D. Guo, P. Lung, J.L. Sui, R.P. Zhang, C. Wang, R. Beluhova-Uzunova, K. Hristov, M. Shishkova, D.J. Pannell, R. Claassen, O. Ecker, P.L. Hatzenbuehler, E. Calegari, E. Fabrizi, G. Guastella, F. Timpano.

S.R. Johnson in the study “How nutrition policy affects food and agricultural policy” identifies the importance of food production and availability for labor resources development, which corresponds to one of the areas of economic security (Johnson, 1994). In his work, he does not distinguish between agriculture and food consumption, he considers these areas as a complex. He also pays great attention to the quality of food products. S.R. Johnson believes that modern food and agricultural policy should ensure the quality of the produced food.

In the work "The agricultural policy trilemma: On the wicked nature of agricultural policy making. Land use policy" J. Vik considered agricultural policy as a complex, multidimensional activity based on mutually exclusive goals (Vik, 2020). Using the example of agriculture in Norway, he conducted a study of the trilemma of agricultural policy. In the

course of his work, he identified three tasks of agricultural policy, shifting the focus to solving only one of them can lead to disastrous consequences.

X.D. Guo, P. Lung, J.L. Sui, R.P. Zhang, and C. Wang in the work "Agricultural Support Policies and China's Cyclical Evolutionary Path of Agricultural Economic Growth" analyzed the development of agricultural production in China, which allowed them to distinguish three production cycles (Guo et al., 2021). An important achievement was the assessment of the probability of changing production cycles in the country's agricultural sector. The work carried out made it possible to determine that active government support has ensured sustainable growth dynamics. However, China's agriculture development will lead to the decrease of growth rates that is natural and determined by the established scale of the industry.

R. Beluhova-Uzunova, K. Hristov and M. Shishkova in the published study "The common agricultural policy post 2020 - farmers' perception and policy implication" analyze the state of agriculture, and also determine the place of the state in its development (Beluhova-Uzunova et al., 2020). The basis of their study was the analysis of 74 agricultural producers, according to the results of which it became clear that state support is more effectively provided for large farms, and small enterprises are in less advantageous conditions. The authors give data that government support is mainly directed to support animal husbandry and cultivation of crops with high added value. In conclusion of the study, it was determined that support should be implemented in a targeted way, and not in a general one.

Targeted support for agricultural producers was also supported by C.G. Brown. In his work "Removing redundant regulation in the reform of agricultural policies - the case of the common agricultural policy of the EC", he revealed that, despite the development of government support mechanisms, administrative and bureaucratic barriers to its receipt and use increase (Brown, 1994). C.G. Brown believes that removing administrative and bureaucratic barriers, as well as unnecessary control, will give a new impetus to the development of agriculture in Europe.

D.J. Pannell and R. Claassen in their work "The Roles of Adoption and Behavior Change in Agricultural Policy" focused on the interaction of agriculture and the environment (Pannell, Claassen, 2020). The authors consider state support of agriculture as a stimulating

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tool for the modernization of production, the use of new ways of conducting and organizing the economy that meets the modern environmental agenda.

O. Ecker and P.L. Hatzenbuehler in the article "Food consumption-production response to agricultural policy and macroeconomic change in Nigeria" assess the impact of state agricultural and macroeconomic policies on food production and consumption (Ecker, Hatzenbuehler, 2021). Nigeria, like Russia, is a developing resource-oriented country. As in Russia, the country has an unstable national currency. Nigeria is heavily dependent on export foreign exchange earnings and imported labor. The negative macroeconomic phenomena in Nigeria have led to the fact that households increased food production for their own consumption, and large companies for export. However, rational state policy has made it possible to reduce the negative impact of crisis phenomena in the national economy.

E. Calegari, E. Fabrizi, G. Guastella and F. Timpano contributed to the theory and practice of state regulation of food production. In the work "EU regional convergence in the agricultural sector: Are there synergies between agricultural and regional policies?" the authors analyze the common agricultural policy of the EU countries (Calegari et al., 2021). The authors argue that agricultural policy has recently acquired significant regionalism, which contradicts the unity of Europe. In the course of the study, the authors concluded that in the EU countries with a low level of agricultural development, a unified agricultural policy leads to negative consequences, and in agrarian developed countries, on the contrary.

Among Russian agricultural scientists, such scientists as E.B. Razuvaeva, B.A. Voronin, I.P. Chupina, Ya.V. Voronina, V.V. Drokin, A.S. Unravel, N.V. Rodnina and others made a significant contribution to the development of food economics, but the prominent agricultural economist, academician of the Russian Academy of Sciences A.I. Altukhov deserves special attention.

The fundamental work of A.I. Altukhov "The food security paradigm of Russia" (Altukhov, 2019) can be considered an anthology of food security and regulation of agricultural production. This work covers the methodology of assessment, risks, threats, challenges, government regulation, as well as territorial aspects of food security.

The sphere of scientific interests of E.B. Razuvaeva is economic security and the impact of food security on it. In his work "Food security as an important component of ensuring the economic security of the country" the author substantiates the need to provide

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food for the population from the perspective of the policy of economic security formation (Razuvaeva, 2020).

The issues of agroecology, agricultural land management, food security are reflected in the works of B.A. Voronin. So, in the work "Conditions for the development of the market for organic products in Russia as a factor of compliance with food security", the importance of organic production for ensuring food security is determined, and the Russian food market is analyzed (Voronin et al., 2020).

A significant contribution to the study of agri-food systems was made by V.V. Drokin. In his works, the scientist examines the territorial features of agricultural production, its competitiveness, government regulation, as well as food security itself. In the work "On the food security of the rural population of the regions of Russia" the authors examine the level of food security of the rural population of Russia, the population, which itself is a source of food. At the end of the study, V.V. Drokin and A.S. Zhuravlev came to the disappointing conclusion that the quality of nutrition of the rural population is inferior to the urban one, both in quantitative terms and in terms of the balance of nutrients (Drokin, Zhuravlev, 2020).

Another agricultural scientist who made a significant contribution to the development of scientific provisions of food security is N.V. Rodnina. It is worth noting her work "Food Security Doctrine: Regional Aspect", in which the author examines the regional features of ensuring food security (Rodnina, 2021). N.V. Rodnina in her works tries to cover all the factors that form food security, from natural conditions to human resources and fixed assets.

Despite significant developments in the field of regulation of agricultural production, a fairly large number of issues remain debatable, namely, a rational state policy for ensuring food security, the impact of state policy on the food availability and agricultural production volumes, and others.

2. Methodology

The study materials were formed on the basis of statistical data from the Federal State Statistics Service, the Ministry of Agriculture of the Russian Federation, electronic library systems: "Scientific Electronic Library" and "National Electronic Library", as well as modern professional databases: "Electronic library of dissertations of the Russian State Library "," Web of Science "and" Scopus ".

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The methodological study tools included such general scientific methods as analysis, synthesis, horizontal analysis, the method of graphic interpretation of statistical information, the empirical method and other scientific methods that solved the study objectives.

Within the framework of the study, the purpose, objectives, and hypothesis of the study were determined. To achieve the stated purposes, it is necessary to determine the volume of agricultural production in Russia and its change under the influence of extensive and intensive factors. Extensive factors in the framework of this study should be understood as a change in the area of crops and perennial plantings for the crop industry and change in the number of farm animals and number of bee colonies for animal husbandry. The intensive factor is determined by the efforts of agricultural producers to obtain better results. In crop production, these efforts are related to investments in seeds, assortments, mineral fertilizers, plant protection products, equipment, new forms of production organization, etc. In animal husbandry, these efforts are manifested in the acquisition of more productive breeds of animals, construction and re-equipment of farms, development and improvement of feed base, acquisition of veterinary drugs and feed additives, etc. The simplest indicators of the impact of intensive factor on food production are yield of agricultural crops and productivity of farm animals.

The availability of food is influenced by its price and income of the population. To assess food availability, data on the average annual food consumption can be used. This study uses producer prices, i.e., prices at which agricultural enterprises sold food products and raw materials for their production. This choice is justified by the purpose of the study, namely the activities of commodity producers and consumers of food. Margins, logistics costs and other selling costs are not related to food production. The exception was the prices for granulated sugar and honey, as there were no data on the sale prices of sugar beets for processing plants in open sources. For honey, the situation is different. Most of the product is produced by the population, therefore, sales prices are not recorded.

The interval of 2013-2018 was defined as the study period. The comparison of 2018 was carried out since 2014. The choice of interval is determined by the need to investigate economic processes before the outbreak of the pandemic, which had a negative impact on both the economy and population. Comparison of 2018 with 2014 is carried out in order to see the changes taking place in the conditions of economic sanctions and food embargo.

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3. Results

Wheat is the main agricultural crop of the country. Its high importance is determined by food and feed value, as well as significant export potential. According to table 1, it can be seen that wheat production in Russia for 2013-2018. showed an increase of 20.8%. Since the embargo, the volume of production has increased by 12.4 million tons. Wheat exports take central place in the export of food products.

The situation is multidirectional for the rest of the grain and leguminous crops. Corn production for grain showed a weak 0.9% growth. Buckwheat production increased 1.4 times, and leguminous production increased 1.5 times. Buckwheat production showed high volatility, so in 2014 the volume of production amounted to only 662 thousand tons, and reached 1.5 million tons by 2017, then in 2018 it decreased to 932 thousand tons. The production of rye, triticale, barley, oats, millet, and rice showed a decrease from 10 to 56%. The smallest decrease in production volumes is observed for rice – 1% (Table 1).

Industrial crops show an increase in production volumes. During the study period, the production of sugar beets increased by 8.6 million tons, soybeans by 1.7 times, and sunflower seeds by 1.5 times. In 2014, compared to 2013, the production of all industrial crops, except for soybeans, decreased.

The production of vegetable and melon crops shows weak growth dynamics, except for potatoes, the volume of production of which decreased by 7.8%. The production of vegetables increased by 7%, or only by 0.9 million tons, and food melons by 33.3%, which corresponds to an increase of 500 thousand tons.

The production of fruit and berry products shows a positive growth trend. For 2013-2018 the gross harvest of fruits and berries increased by 557 thousand tons, which corresponds to an increase of 20%, and grapes by 58 thousand tons, or 10.2%. In general, the production of fruit and berry products develop at a fairly high rate, however, they are insufficient to cover the volumes of products prohibited for import from Europe.

Livestock production shows an increase in pigs, sheep, goats, poultry and milk, and a decrease in cattle and honey. The highest growth rates were shown by the production of pig meat (26.3%), and the smallest was milk production (2%). In general, it can be noted that the growth rate of milk production is insufficient to cover the country's needs, and the same can be noted for cattle meat and honey.

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As noted earlier, the cultivated area and livestock population were chosen as indicators of the extensive factor. Therefore, based on the data in Table 2, it is necessary to analyze the change in cultivated area / livestock, which will determine what caused the increase or decrease in production.

Table 1 - Production volumes of food products and raw materials for its production in Russia for 2013-2018

Culture	2013	2014	2015	2016	2017	2018	Change (+, -) from 2018 to 2014	Trend	Growth rate (%) from 2018 to 2014
Crop production, million tons									
Wheat	52.1	59.7	61.8	73.3	86	72.1	12.4	▲	120.8
Rye (winter)	3.4	3.3	2.1	2.5	2.5	1.9	-1.4	▼	57.6
Corn for grain	11.6	11.3	13.1	15.3	13.2	11.4	0.1	▲	100.9
Triticale	0.6	0.7	0.6	0.6	0.5	0.4	-0.3	▼	57.1
Barley	15.4	20.4	17.5	18	20.6	17	-3.4	▼	83.3
Oats	4.9	5.3	4.5	4.8	5.5	4.7	-0.6	▼	88.7
Millet, thousand tons	419	493	572	629	316	217	-276	▼	44.0
Buckwheat, thousand tons	834	662	861	1187	1525	932	270	▲	140.8
Rice, thousand tons	935	1049	1110	1081	987	1038	-11	▼	99.0
Legumes	2	2.2	2.4	2.9	4.3	3.4	1.2	▲	154.5
Sugar beet	39.3	33.5	39	51.3	51.9	42.1	8.6	▲	125.7
Sunflower seeds	10.6	8.5	9.3	11	10.5	12.8	4.3	▲	150.6
Soybeans, thousand tons	1636	2371	2716	3143	3622	4027	1656	▲	169.8
Potato	30.2	24.3	25.4	22.5	21.7	22.4	-1.9	▼	92.2
Vegetables	14.7	12.8	13.2	13.2	13.6	13.7	0.9	▲	107.0
Food melons	1.4	1.5	1.8	1.9	1.8	2	0.5	▲	133.3
Fruits and berries, thousand tons	2942	2780	2676	3056	2683	3337	557	▲	120.0
Grapes, thousand tons	439	570	520	601	580	628	58	▲	110.2
Livestock products, million tons									
Livestock and poultry for slaughter in slaughter weight, thousand tons: cattle	1633	1621	1617	1589	1569	1608	-13	▼	99.2
Pigs	2816	2964	3083	3355	3516	3744	780	▲	126.3
Sheep and goats	190	203	204	213	219	224	21	▲	110.3
Poultry	3831	4164	4541	4622	4941	4980	816	▲	119.6
Milk	30.5	30	29.9	29.8	30.2	30.6	0,6	▲	102.0
Eggs, billion pcs.	41.3	41.7	42.5	43.5	44.8	44.9	3.2	▲	107.7
Honey, thousand tons	68	74	67	69	65	65	-9	▼	87.8

* Compiled by the author on the basis of the Agriculture in Russia, (2019) http://gks.ru/bgd/regl/b19_38/

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Table 2 - Assessment of the impact of the extensive factor on the production of food products and raw materials for its production in Russia for 2013-2018.

Culture	2013	2014	2015	2016	2017	2018	Change (+, -) from 2018 to 2014	Trend	Growth rate (%) from 2018 to 2014
Cultivated area / area of perennial plantations, thousand hectares									
Winter wheat	12334	12155	13364	14041	14954	15296	3141	▲	125.8
Spring wheat	12729	13103	13463	13668	12969	11968	-1135	▼	91.3
Rye (winter)	1831	1876	1291	1262	1180	978	-898	▼	52.1
Corn for grain	2450	2677	2762	2887	3019	2452	-225	▼	91.6
Triticale	240	237	235	212	160	138	-99	▼	58.2
Winter barley	392	584	521	560	522	480	-104	▼	82.2
Spring barley	8628	8771	8344	7762	7488	7845	-926	▼	89.4
Oats	3324	3258	3047	2860	2887	2853	-405	▼	87.6
Millet	470	506	595	435	265	260	-246	▼	51.4
Buckwheat	1096	1008	957	1205	1692	1045	37	▲	103.7
Rice	190	197	202	208	187	182	-15	▼	92.4
Legumes	1979	1595	1587	1752	2221	2754	1159	▲	172.7
Sugar beet	904	917	1021	1107	1198	1127	210	▲	122.9
Sunflower	7271	6911	7013	7607	7994	8160	1249	▲	118.1
Soy	1532	2012	2131	2237	2636	2949	937	▲	146.6
Potato	2138	1599	1562	1441	1350	1325	-274	▼	82.9
Vegetables	671	563	563	551	535	526	-37	▼	93.4
Food melons	154	157	181	170	152	140	-17	▼	89.2
Fruit and berry plantations	502	472	467	460	462	466	-6	▼	98.7
Vine plantations	62	90	89	91	91	94	4	▲	104.4
Livestock inventory, thousand heads of cattle									
Cattle (without cows)	10903	10657	10506	10380	10343	10209	-448	▼	95.8
Cows	8661	8263	8115	7966	7951	7943	-320	▼	96.1
Sheep and goats	24337	24445	24606	24717	24389	23129	-1316	▼	94.6
Bird, million heads	495	524	544	550	556	541	17	▲	103.2
Bee colonies	3341	3446	3425	3317	3182	3094	-352	▼	89.8

* Compiled by the author on the basis of the Agriculture in Russia, (2019) http://gks.ru/bgd/regl/b19_38/

The data in Table 2 confirm that one of the growth factors in the production of wheat, buckwheat and legumes was the increase in the cultivated area, i.e., the extensive factor, and

for corn, it is safe to say that the growth in production was provided by the intensive factor. The production of industrial crops increased primarily due to an increase in the cultivated area. With regard to potatoes, vegetables, and food melons, we can say that the impact of the extensive factor on the production volume is quite strong. Perennial plantations showed a decrease in area, with the exception of an increase of 4 thousand hectares of vineyards.

The production of livestock products showed dependence on the extensive factor only for poultry, the number of which has increased, for cattle and honey, the reduction in production of which was accompanied by a reduction in the number of livestock and number of bee colonies.

Thus, the impact of the extensive factor is most fully traced in cereals and leguminous crops, with the exception of corn and industrial crops. For livestock products, the impact of the extensive factor is most strongly traced in cattle and poultry meat, as well as in honey.

The result of efforts to increase the efficiency of agricultural producers is the yield of agricultural crops and the productivity of animals. These indicators show the final impact of intensive factors (Figure 3).

The values presented in Table 3 indicate that Russian agricultural producers actively invest in improving production efficiency.

There is a tendency of yield growth in almost all agricultural crops. The largest increase in yield was shown by sunflower (22.1%), and the smallest by winter wheat (0.3%). This situation is a consequence of the achieved maximum possible level of yield under existing conditions. At the same time, the relatively high rate of sunflower yield growth is caused by the relative novelty of the crop, in contrast to the rest, which are traditional. Organizations have not yet fully worked out the cultivation technology, they continue to experiment with varieties, select the most suitable for specific conditions. The yield's decrease in 2018 compared to 2014 was shown by spring barley, millet, and leguminous crops. This decrease, as well as the change in the yield of other agricultural crops, should be attributed to volatility under the influence of natural and climatic conditions. As noted above, the existing yield is a probable maximum under the current climatic conditions, forms, and conditions of production organization. Volatility at the level of 10, possibly more, will take place under the influence of weather conditions and beyond.

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Table 3 - Assessment of the impact of intensive factors on the production of food products and raw materials for its production in Russia for 2013-2018.

Culture	2013	2014	2015	2016	2017	2018	Change (+, -) from 2018 to 2014	Trend	Growth rate (%) from 2018 to 2014
Productivity, c / ha									
Winter wheat	29.9	35.1	32	37.6	41.7	35.2	0.1	▲	100.3
Spring wheat	14.2	14.7	15.5	15.7	18.9	16.8	2.1	▲	114.3
Rye (winter)	18.9	17.7	16.7	20.3	21.7	20.1	2.4	▲	113.6
Corn for grain	50.1	43.6	49.3	55.1	49	48.1	4.5	▲	110.3
Triticale	24.1	26.4	23.1	27.8	29.1	27	0.6	▲	102.3
Winter barley	40.3	35.9	40	39.5	41.9	38.8	2.9	▲	108.1
Spring barley	18.1	21.8	20	20.8	25.2	20.5	-1.3	▼	94.0
Oats	16.4	17.1	16	17.3	19.6	17.3	0.2	▲	101.2
Millet	11.8	12.3	12.9	15.4	13.4	11.6	-0.7	▼	94.3
Buckwheat	9.2	9.3	9.5	10.6	10.2	9.5	0.2	▲	102.2
Rice	49.5	53.6	55.8	53	53.1	57.6	4	▲	107.5
Legumes	12.1	14.6	15.9	17.5	20.1	13	-1.6	▼	89.0
Sugar beet	442	370	388	470	442	381	11	▲	103.0
Sunflower	15.5	13.1	14.2	15.1	14.5	16	2.9	▲	122.1
Soy	13.6	12.3	13	14.8	14.1	14.7	2.4	▲	119.5
Potato	145	153	164	158	163	170	17	▲	111.1
Vegetables	214	219	226	229	241	243	24	▲	111.0
Food melons	105	104	109	119	127	147	43	▲	141.3
Fruits and berries	77.1	77.3	77.3	88.4	77.9	96	18.7	▲	124.2
Grapes	93.6	78.1	77.8	86.6	84.9	91.9	13.8	▲	117.7
Productivity, kg									
Production of livestock per head (yield, growth, weight gain): Cattle	146	149	152	150	154	155	6	▲	104.0
Pigs	191	200	209	203	208	208	8	▲	104.0
Milk per cow	3893	4021	4134	4218	4368	4492	471	▲	111.7
Average annual egg production of laying hens, pcs.	305	308	310	308	311	305	-3	▼	99.0
Honey	20	21	20	21	20	21	0	▼	97.8

* Compiled by the author on the basis of the Agriculture in Russia, (2019) http://gks.ru/bgd/regl/b19_38/

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On the positive side, it is necessary to assess the level of development of animal husbandry, the productivity of which grows both in meat and milk. The dynamics of productivity decline was shown by poultry farming focused on egg production, as well as beekeeping. The decrease in egg production is insignificant and, in general, may correspond to the level of 2013. The situation with beekeeping is ambiguous, since the statistics considered all bee colonies, even those who suffered and did not recover from poisoning with plant protection products. In addition, beekeeping in Russia is the production of the population, i.e., it is difficult to talk about the results of investments in breeding work, modernization of production forms and production technologies.

Thus, we can conclude that agriculture in Russia develops predominantly in an intensive way, which is a positive factor. However, agricultural producers, together with the state, need to determine development directions that take into account the minimization of the impact of weather conditions. In animal husbandry, it is advisable for the state to direct additional resources to the development of the industry since the existing growth rates are insufficient to achieve full self-sufficiency of the country in animal products in the near future.

Having determined the nature of the development of agricultural production, let us consider the average producer prices, as an element that forms the level of food availability for the country's population (Table 4).

Analysis of changes in food sales prices showed an increase in all products of plant and animal origin, with the exception of buckwheat, potatoes, food melons. Buckwheat is characterized as a highly volatile crop. High variability is shown by the yield, and, consequently, volume of production and selling price. The decrease of prices for potatoes and food melons does not exceed 3%, which is insignificant considering the study period. Among other agricultural crops, millet, sunflower seeds, fruits, and berries, as well as grapes showed the highest sales price increases (Golovin, 2020c).

Considering the prices for livestock products, the largest price increase is for cattle meat, for 2014-2018 and amounted to 33.8%, as well as to sheep and goats (26.5%). Prices for poultry meat, milk, chicken eggs and honey showed increase of 10%. The lowest growth rates were shown by pork in 2014-2018 as it increased in price by only 5.8%.

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In general, the increase in prices for food products and raw materials for their production does not contribute to the increase in the food availability, however, it provides a payback for agricultural producers, which means it ensures the economic security of the country and the industry.

Table 4 - Average prices of agricultural producers in Russia for 2013-2018.

Culture	2013	2014	2015	2016	2017	2018	Change (+, -) from 2018 to 2014	Trend	Growth rate (%) from 2018 to 2014
Crop production, thousand rubles / t									
Wheat	6.7	6.8	8.8	8.8	7.3	8.5	1.7	▲	124.6
Rye (winter)	4.9	4.7	5.2	6.1	5.6	5.6	2.1	▲	136.4
Corn for grain	6.6	5.8	7.9	8.3	7.0	7.9	2.1	▲	120.2
Barley	6.4	5.5	7.3	7.7	6.8	8.1	2.6	▲	147.1
Oats	5.8	5.0	5.5	6.4	6.5	6.0	1.0	▲	120.2
Millet	5.2	5.6	7.4	6.4	5.1	11.8	6.2	▲	210.1
Buckwheat	7.2	8.4	20.1	25.9	15.7	7.5	-0.9	▼	89.8
Legumes	8.4	8.5	13.1	16.7	12.3	9.5	1.1	▲	112.9
Sugar beet	32.3	45.0	52.1	48.8	36.8	46.2	1.3	▲	102.8
Sunflower seeds	12.0	11.5	20.3	21.9	17.0	17.8	6.2	▲	154.1
Soy beans	15.0	17.0	19.0	23.5	21.1	22.6	5.6	▲	133.1
Potato	9.4	12.9	13.2	10.2	11.6	12.5	-0.3	▼	97.3
Vegetables	31.5	36.3	45.5	45.2	47.0	45.1	8.8	▲	124.1
Food melons	2.9	8.5	5.8	5.3	6.4	8.4	-0.1	▼	98.8
Fruits and berries	26.5	27.1	44.2	47.3	45.6	39.5	12.4	▲	145.5
Grapes	16.5	16.8	22.0	24.7	29.9	29.9	13.1	▲	178.0
Livestock products, thousand rubles / t									
Livestock and poultry (live weight): cattle	72.1	74.4	93.3	96.6	97.6	99.5	25.1	▲	133.8
Pigs	71.7	94.1	103.0	94.0	96.5	99.6	5.5	▲	105.8
Sheep and goats	74.3	71.0	79.7	85.8	89.4	89.8	18.8	▲	126.5
Live poultry	54.4	63.7	71.3	72.3	68.1	70.8	7.2	▲	111.3
Raw milk	15.9	19.6	20.6	21.8	24.5	22.9	3.2	▲	116.5
Fresh chicken eggs in shell, 1000 pcs.	3.2	3.4	4.2	4.2	3.6	3.9	0.5	▲	114.4
Honey	404.7	415.9	442.2	462.3	468.2	454.7	38.7	▲	109.3

* Compiled by the author on the basis of the Agriculture in Russia, (2019) http://gks.ru/bgd/regl/b19_38/

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In conclusion of the study, let us assess the consumption of basic food products by the population of Russia (Table 5).

Table 5 - Assessment of consumption of basic food products by the population of Russia for 2013-2018.

Culture	2013	2014	2015	2016	2017	2018	Change (+, -) from 2018 to 2014	Trend	Growth rate (%) from 2018 to 2014
Food products of plant origin, kg / person / year									
Consumption of bread products	118	118	118	117	117	116	-2	▼	98.3
Potato consumption	94	93	91	90	90	89	-4	▼	95.7
Consumption of vegetables and food crops	102	102	102	102	104	107	5	▲	104.9
Consumption of fruits and berries	63	63	60	60	59	61	-2	▼	96.8
Sugar consumption	40	40	39	39	39	39	-1	▼	97.5
Vegetable oil consumption	13.7	13.8	13.6	13.7	13.9	14.0	0	▲	101.4
Food products of animal origin, kg / person / year									
Consumption of meat and meat products	75	74	73	74	75	75	1	▲	101.4
Consumption of milk and dairy products	245	239	233	231	230	229	-10	▼	95.8
Consumption of eggs and egg products, pcs.	271	271	273	277	282	284	13	▲	104.8
Consumption of fish and fish products in live weight (raw weight)	27.3	25.7	22.3	22.3	22.9	20.2	-6	▼	78.6

* Compiled by the author on the basis of the Agriculture in Russia, (2019) http://gks.ru/bgd/regl/b19_38/ and Consumption of basic food products by the population – 2020, https://rosstat.gov.ru/storage/mediabank/vqBMi2zc/Potr20.rar

Table 5 shows that the consumption of bread products, potatoes, sugar, fruits, and berries decrease. According to nutritionists, the decrease in the consumption of potatoes, bread products and sugar can be attributed to a positive trend, while the decrease in the consumption of fruits and berries can be assessed from the negative side. The consumption of vegetable oil, vegetables and food crops shows a similar ambiguous dynamic. Nutritionists agree that the consumption of vegetable oil should be reduced, but in our case, it increases. The increase in consumption of vegetables and food melons and gourds can be unambiguously assessed on the positive side (Golovin et al., 2020d).

The consumption of animal products increases for meat, meat products, eggs and egg products and decreases for milk, dairy products, fish, and fish products. These dynamic changes are ambiguous. Thus, a decrease in the consumption of dairy and fish products is a negative trend. At the same time, nutritionists talk about the need to limit the consumption of eggs and egg products, but in our case, their consumption only increases. The relative availability and cheapness of eggs are likely to determine the growth in their consumption. At the same time, the increase in meat consumption is not due to cattle meat, but due to the meat of pigs. There is a significant imbalance in consumption, with pig meat forming the basis of the population's diet, which is negatively assessed by nutritionists (Golovin, 2020b).

4. Discussions

The results obtained make it necessary to determine the state's activity in supporting agriculture as quite effective, but there are several problematic points. So, despite the growth in production volumes, there is a lag in vegetable growing, fruit growing, cattle breeding, as well as milk production. These areas of agriculture form a healthy diet of the population, but at present they are not able to cover the scientifically substantiated needs of the population in these products. Instead, highly profitable, including export-oriented, areas actively develop - grain farming and pig breeding (Golovin et al., 2020a). These areas are important, and not only for obtaining export earnings, but shift of focus towards maximizing income can cause irreparable harm to both food security and land resources.

Any state industry support is aimed at developing industry or specific direction of production to the level where it can maintain its work at the level sufficient for the ongoing development. Such industries were the cultivation of wheat, sugar beets, sunflowers, as well as pig breeding. The feasibility of reducing state support for these areas will free up significant financial resources, which it is advisable to direct into livestock breeding, including dairy, vegetable growing, fruit growing, viticulture. An increase in state support for these areas will increase production, and employment in rural areas, reduce imports and open up new opportunities for the export of goods with high added value. Strengthening government support will help curb the rise in prices for healthy foods included in the set of "proper" nutrition.

The redistribution of state support will create the risk of an increase in prices for bread and pork, but there is some advantage in this. Nutritionists recommend reducing the

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consumption of these foods, which will happen when their prices rise, and they will be replaced by other, healthier foods. However, it is unreasonable to completely deprive grain industry of state support, it is necessary to preserve it in relation to the high-quality grain produced, the development of breeding and seed production, as well as during the implementation of projects to improve the production and logistics infrastructure (Zyukin et al., 2020a). In Russia, the production of wheat of 3 and 4 grades prevails with 5 existing ones, where 1 is the highest. It is necessary to switch to subsidizing the production of grain only 1 and 2 grades and leave the rest of the production without subsidies. The growth in the grain production of 1 and 2 grades will significantly increase the size of export earnings, since the price of wheat of the 1 grade is twice more than 5 of the fifth grade (Zyukin et al., 2020b).

Thus, the need to shift the focus towards supporting the production of vegetables and fruit and berry crops, as well as dairy and beef cattle breeding will help increase the production of food with high added value, curb the rise in prices for these products, form healthier diet of the population, and ensure the availability food. At the same time, shift of focus for supporting the production of grades 1 and 2 will increase export earnings, and the quality of grain products in the country will increase. In pig breeding, the shift of state support from growing to processing will also increase the export of products with high added value.

Conclusions

In the course of the study, the following conclusions were made:

1. The total volume of food production in Russia increases. During the study period, the production of cereals and legumes increased, with the exception of crops such as rye, triticale, barley, oats, millet, and rice. The production volumes of industrial and fruit crops show rather high growth rates. Among vegetable and food melons, only potatoes showed dynamics of production decrease. Production of cattle meat and honey decreased. The rest of the categories of meat, as well as milk and eggs showed an increase in production.

2. Assessment of the impact of the extensive factor on the volume of food production showed that the strongest impact is traced in relation to all cereals, with the exception of corn. The growth in the production of industrial crops also maintains, including due to the extensive factor. Vegetables and melons showed an increase in production volumes with a

decreasing area under crops. The decrease in the production of cattle meat and honey due to the extensive factor.

3. The analysis of crop yields makes it possible to evaluate the efforts of agricultural producers as effective. This estimate is determined by the growing yield of almost all crops, with the exception of spring barley, millet, and legumes. Intensification of livestock production provides an increase in productivity for meat products and milk, and on the contrary, a decrease in eggs and honey. However, even the existing growth rates are insufficient to ensure high profitability of production, and, consequently, for sustainable incoming development.

4. Analysis of the average selling prices of agricultural products by commodity producers indicates a widespread growth, which leads to a decrease in the availability of food. Among the products of plant origin, only buckwheat, potatoes and food melons showed a decrease. There is a decrease in the price of buckwheat and greater return to the current price after a shortage of the product and corresponding increase in prices in 2015-2017. The decrease in prices for potatoes and food melons is more of temporary market changes.

5. Assessment of food consumption has revealed a number of ambiguous trends. Thus, the reduction in the consumption of bread products, potatoes, sugar can be attributed to the positive trend. The increase in consumption of vegetable oil, eggs, and egg products, as well as a decrease in the consumption of dairy and fish products, fruits, and berries, according to doctors, is a negative trend. The situation with an increase in the consumption of vegetables and food melons is undoubtedly positive. The increase in meat consumption is generally positive, but the shift of focus to pork and low consumption of beef and poultry also have a negative impact on public health.

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Análisis proximal y rendimiento de cinco especies nativas con valor forrajero

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RESUMEN

El objetivo del presente estudio fue evaluar el establecimiento, crecimiento, rendimiento y valor nutritivo de cinco especies nativas con valor forrajero (*Cenchrus clandestinus*, *Philoglossa mimuloides*, *Philoglossa* sp., *Trifolium dubium* y *Trifolium repens*). El experimento se realizó en el distrito de Molinopampa (Perú), donde se instalaron parcelas de 30 m^2. La altura de planta se midió mensualmente hasta los 90 días. El material se cortó a nivel del suelo, se pesó, se secó y se determinaron los rendimientos de forraje verde y materia seca. El valor nutricional de las muestras se realizó siguiendo el procesamiento de la AOAC. Los resultados muestran que el porcentaje de establecimiento más alto fue alcanzado por *T. repens* (89,51%). La altura de planta mostró que *P. mimuloides* y *Philoglossa* sp. registraron su mayor crecimiento entre los días 30 y 60 después del establecimiento; y además fueron las especies con mayores niveles forraje verde (7,46 y 8,04 kg/m^2) y materia seca (8,58 y 8,90 t/ha). En términos de valor nutricional, *T. dubium* y *C. clandestinus* registraron los niveles más altos de proteína y fibra, respectivamente; mientras que las especies del género *Philoglossa* tienen mayor digestibilidad.

PALABRA CLAVE: ganado; recursos alimentarios; pastizal; recursos animales.

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Proximal analysis and performance of five native species with forage value

ABSTRACT

The objective of this study was to evaluate the establishment, growth, performance and nutritive value of five native species with forage value (Cenchrus clandestinus, Philoglossa mimuloides, Philoglossa sp., Trifolium dubium, and Trifolium repens). The experiment was conducted in the district of Molinopampa (Peru), where 30 m2 plots were installed. Plant height was measured monthly until 90 days. The material was cut at ground level, weighed, dried and green forage and dry matter performances were determined. The nutritional value of the samples was made following AOAC processing. The results show that the highest percentage of establishment was achieved by T. repens (89.51%). Plant height showed that P. mimuloides and Philoglossa sp. registered their highest growth between the 30th and 60th day after establishment, they were also the species with the highest levels of green forage (7.46 and 8.04 kg/m2) and dry matter (8.58 and 8.90 t/ha). In terms of nutritional value, T. dubium and C. clandestinus recorded the highest levels of protein and fiber, respectively, while Philoglossa species have higher digestibility.

KEYWORDS: Cattle; Food resources; Grasslands; Animal resources.

Introducción

En la alimentación del ganado durante los últimos años se ha extendido el uso de especies forrajeras mejoradas. La popularización acelerada de especies herbáceas no nativas con valor forrajero se debe a su potencial para aportar altos niveles productivos y valor nutritivo (Villalobos y Arce, 2014). Sin embargo, la producción de carne y leche no sólo depende de la calidad del alimento, sino también del adecuado aprovechamiento del forraje y de la selección de la raza. En las regiones donde la ganadería es familiar, la mala gestión de los componentes (especies forrajeras y animales) pueden generar inconvenientes para la actividad al libre pastoreo, ya que casi siempre se desarrolla sin un criterio técnico, existiendo sobrepastoreo y sobrecarga animal (Alegre et al., 2019).

Las especies introducidas o mejoradas requieren de condiciones edafoclimáticas idóneas para expresar su potencial genético. Las condiciones estacionales particulares de cada región influyen significativamente sobre el desarrollo de los pastizales (Fernández et al., 2001). Esto

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implica que las variaciones de temperatura y los cambios en los patrones de lluvia pueden provocar un desbalance en los rendimientos, afectando la disponibilidad de los forrajes (Fernández et al., 2000; Primavesi y Primavesi, 2002). En este contexto, es importante que los ganaderos seleccionen especies aptas para el clima y suelo de cada zona (Primavesi y Primavesi, 2002; Clavero, 2013). Una alternativa importante se encuentra en la diversidad nativa, donde es posible encontrar especies adaptadas a las condiciones agroclimáticas del lugar, de alta productividad y gran valor nutricional (Fernández et al., 2001; Uvidia et al., 2013).

La introducción de especies puede ejercer una presión negativa sobre la diversidad de herbáceas forrajeras nativas (Dresseno et al., 2018). Las perturbaciones ocasionadas por las especies exóticas pueden tener graves consecuencias sobre la composición de la biodiversidad (Pedrini et al., 2018). La competencia por coexistir puede fragmentar el hábitat de los forrajes nativos (Bakker y Wilson, 2001), modificar las interacciones abiótico-bióticas (Godfree et al., 2017), y alterar la estructura y cantidad de nutrientes del suelo (Dresseno et al., 2018). Por ello, para asegurar la sostenibilidad de la ganadería es importante que las personas comprendan la importancia y el comportamiento de las especies nativas con valor forrajero.

Bajo esas premisas es fundamental el estudio de especies locales, dado que la limitada información dificulta la revaloración del potencial de las especies forrajeras nativas que predominan en las cuencas ganaderas de la región Amazonas (Perú) (Oliva et al., 2015a). Por lo anterior, el objetivo del presente estudio fue evaluar el establecimiento, crecimiento, rendimiento y el valor nutritivo de cinco especies nativas con valor forrajero, con posibles potencialidades para la actividad ganadera local.

1. Materiales y métodos

1.1. Área de estudio

El estudio se desarrolló en el distrito de Molinopampa ubicado en la provincia de Chachapoyas, región Amazonas, al norte de Perú; se ubica entre los 06°11′45″ de latitud Sur y 77°38′15″ de longitud Oeste, a una altitud sobre los 2400 m s.n.m. La zona se caracteriza por un clima ligeramente húmedo y templado cálido (sin estaciones climáticas diferencias), con una

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temperatura promedio anual de 14,5 °C y precipitación promedio de 1200 mm/año (IIAP, 2007); entre los meses de noviembre a marzo se registra la mayor intensidad de lluvia.

1.2. Diseño experimental

El ensayo se dirigió bajo un diseño de bloques completos al azar conformado por cinco tratamientos (especies forrajeras nativas) y tres réplicas. Se establecieron parcelas experimentales de 30 m^2, donde a partir de material vegetativo (brotación) se plantó cinco especies de forrajeras nativas: 1) *Cenchrus clandestinus* (Hochst. ex Chiov.) Morrone (Poaceae) (kikuyo), 2) *Philoglossa mimuloides* (Hieron.) H. Rob. & Cuatrec. (siso lapacho), 3) *Philoglossa* sp. (siso menudo) (Asteraceae), 4) *Trifolium dubium* Sibth. (trebolillo) y 5) *Trifolium repens* L. (trébol blanco) (Fabaceae), distanciadas a 20 cm entre surcos y 10 cm entre plantas.

1.3. Establecimiento, crecimiento y rendimiento

Después de 30 días de plantación, el porcentaje de prendimiento (eficiencia de implantación) se determinó contando el número de plantas vivas respecto al número total de plantas instaladas. Además, durante los siguientes 90 días se evaluó su crecimiento (altura de la planta), para lo cual se seleccionaron al azar 30 plantas por tratamiento (10 plantas por repetición).

Para estimar el rendimiento, los muestreos se llevaron a cabo después de 90 días de la plantación (inicio de floración), para lo cual el forraje se cortó a nivel del suelo. La producción de forraje verde (FV) se determinó usando un cuadrante de 1 m^2 y una balanza (precisión 0,1 g). La materia seca (MS) se calculó tomando 1 kg de forraje (muestra representativa y homogénea) que fue secado a 65° C durante 72 horas y luego pesado para estimar la MS por diferencia de peso.

1.4. Análisis proximal

Las muestras se secaron en una estufa a 65 °C durante 24 h y luego se realizó el análisis proximal: humedad (H), proteína cruda (PC), extracto etéreo (EE), fibra cruda (FC) y cenizas (C) por el método descrito por la AOAC (AOAC, 1990), digestibilidad *in vitro* (DIVMS) mediante el método enzimático pepsina-celulasa (Clarke et al., 1982) y extracto libre de nitrógeno (ELN) mediante un cálculo por diferencia [100 – (H + PC + EE + FC + C)].

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1.5. Análisis de datos

Los resultados obtenidos fueron evaluados mediante un análisis de varianza con un 5 % de significancia (α = 0,05); asimismo, fueron sometidos a la prueba de comparaciones múltiples de Tukey ($p \leq 0,05$). Todos los datos fueron evaluados previamente usando la prueba Shapiro-Wilk y Levene para determinar la normalidad y homogeneidad de varianzas. Los datos se analizaron en el programa SPSS v.15 (SPSS Inc, 2006).

2. Resultados

2.1. Establecimiento, crecimiento y rendimiento

Durante el período de evaluación las especies no mostraron diferencias significativas en el prendimiento (%). No obstante, se observó que *T. repens* (89,51 %) y *T. dubium* (88,25 %) presentaron una sobrevivencia numéricamente mayor, principalmente comparado con *P. Mimuloides* (78,98 %).

La altura de planta mostró una dependencia significativa de la edad de plantación, es decir, la mayor altura de planta se alcanzó a los 90 días después del establecimiento. Las especies *P. mimuloides* y *Philoglossa* sp. fueron quienes presentaron los valores más altos para altura de planta (32,34 y 33,89 cm respectivamente) y rendimiento de forraje verde (7,46 y 8,04 kg/m^2 respectivamente). Sin embargo, estas especies tuvieron los porcentajes más bajos de materia (11,50 y 11,07% respectivamente) (Tabla 1). En contraste, *T. dubium*, *C. clandestinus* y *T. repens* alcanzaron menores alturas y rendimientos de forraje verde (Tabla 1). Los rendimientos de materia seca de *P. mimuloides*, *Philoglossa* y *C. clandestinus* fueron superiores a 8 t/ha, mientas que los rendimientos de *T. dubium* y *T. repens* fueron inferiores a 5 t/ha (Tabla 1).

2.2. Análisis proximal

El análisis de varianza y la prueba de comparaciones múltiples de los parámetros nutricionales mostraron diferencias altamente significativas ($P \leq 0,01$) entre las especies (Figura 1). Mediante el análisis de sus componentes nutricionales se observó que P. mimuloides presentó un mayor valor de humedad (7,09%) y ELN (61,68%), T. dubium generó mayores valores de proteína (25,68%) y grasa (extracto etéreo) (2,18%); C. clandestinus registró mayor valor de

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fibra (25,2%) y T. repens alcanzó mayores valores de ceniza (10,52%). En cuanto a la digestibilidad, los valores más altos (71,18 - 73,27%) se registraron en las especies del género Philoglossa.

Tabla 1. Altura de planta, forraje verde y materia seca de cinco especies forrajeras nativas.

Especie forrajera nativa	Altura de planta (cm) en distintas edades de plantación (días)			Forraje Verde (kg/m^2)	Materia Seca (%)	Materia seca (t/ha)
	30	60	90			
Philoglossa mimuloides	9,28 ^{a}	27,92 ^{a}	32,34 ^{a}	7,46 ^{a}	11,50 ^{b}	8,58 ^{a}
Trifolium dubium	5,41 ^{b}	14,87 ^{b}	17,89 ^{b}	2,52 ^{c}	18,37 ^{ab}	4,63 ^{b}
Philoglossa sp.	9,01 ^{a}	27,82 ^{a}	33,89 ^{a}	8,04 ^{a}	11,07 ^{b}	8,90 ^{a}
Cenchrus clandestinus	7,56 ^{a}	15,74 ^{b}	19,25 ^{b}	4,20 ^{b}	20,03 ^{a}	8,38 ^{a}
Trifolium repens	9,58 ^{a}	18,39 ^{ab}	22,41 ^{b}	2,76 ^{c}	17,30 ^{ab}	4,90 ^{b}

^{a,b,c} medias con letras diferentes en una misma columna difieren entre sí, según la prueba Tukey ($p \leq 0,05$).

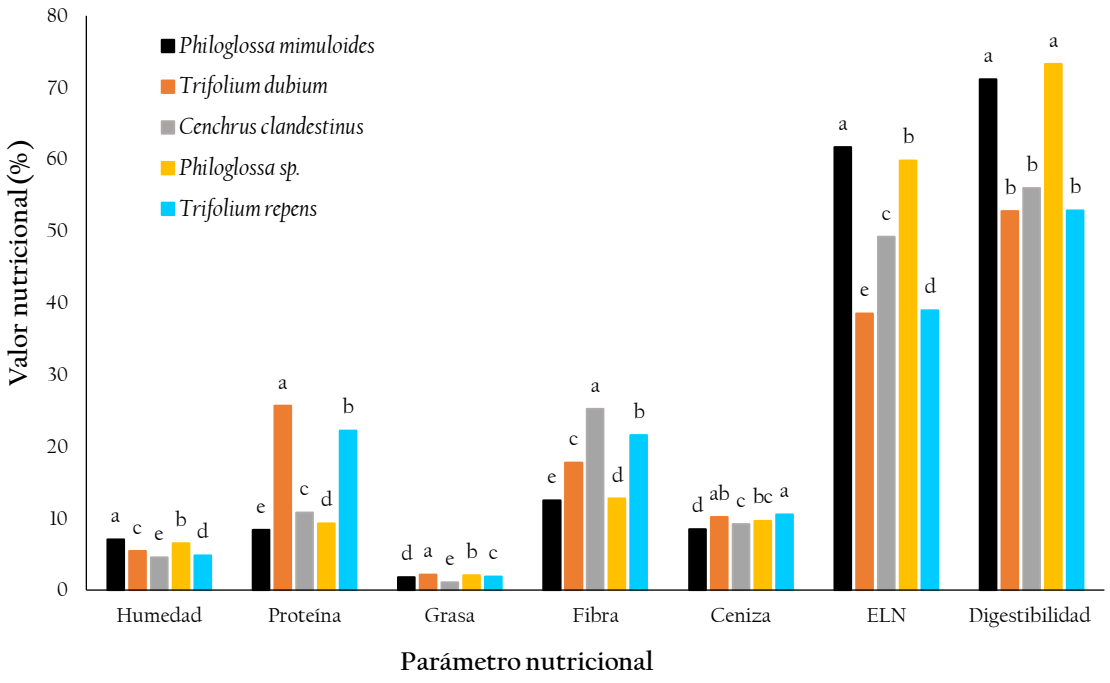

Figura 1. Valor nutricional registrado para cinco especies forrajeras nativas.

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3. Discusión

3.1. Establecimiento, crecimiento y rendimiento

En este estudio, la eficiencia de implantación en cuatro de las especies forrajeras superó el 80%; y aunque las diferencias entre especies no fueron significativas, sus resultados muestran una capacidad de establecimiento que se debe continuar evaluando. Las especies nativas constituyen un recurso importante que puede ser estudiado y utilizado para lograr la cobertura de las áreas de pastoreo (Oliva et al., 2015b), ya que pueden presentar mejor adaptabilidad a las condiciones climáticas particulares de cada región. Las variables climáticas pueden cambiar significativamente a lo largo del año, incluso dentro de la misma área, por lo que se convierten en factores que inciden en el desarrollo del componente forrajero (Gandullo et al., 2013; Velasco et al., 2018). El análisis de la capacidad adaptativa de las especies muestra que el germoplasma puede ser explotado en la zona de estudio y sus áreas circundantes, y proporcionar forrajes para el desarrollo de la actividad ganadera local.

El análisis de la altura de la planta permitió constatar que esta variable (en todas las especies) mantuvo un incrementó constante a partir del día 30 después de plantación. Este comportamiento fue más pronunciado en las especies del género *Philoglossa* (Asteraceae) debido a su mayor tasa de crecimiento (0,38-0,41 cm/día, datos no mostrados), comparado con las otras especies (0,19-0,21 cm/día, datos no mostrados). Sin embargo, es importante tener en cuenta que la diferencia de altura comparado con las especies del género *Trifolium* está más relacionada con la morfología de la planta, debido a que estas mostraron un comportamiento y dinámica de crecimiento típicas de la familia de las leguminosas (Fabaceae) (Wachendorf et al., 2001); ya que la activación de las yemas vegetativas requiere un período de descanso más prolongado antes de que pueden iniciar su crecimiento. En general, la abundancia de estas especies las convierte en una importante alternativa para la producción de forraje en las praderas naturales de la región Amazonas (Oliva et al., 2015a; Oliva et al., 2019).

La evaluación del crecimiento del forraje (altura de la planta) es muy importante porque es un parámetro que presenta una relación proporcional con la acumulación de biomasa (Fernández et al., 2001). En este estudio se observó que las especies del género *Philoglossa* obtuvieron los valores de rendimiento más altos. Un resultado similar fue reportado por Oliva et

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al. (2015b), donde especies de este género presentaron el mayor rendimiento en comparación con otras especies nativas. En cuanto a los niveles de materia seca, Pereira-Crespo et al. (2012) reportaron que el valor de las leguminosas del género *Trifolium* osciló entre 11 a 13 %, siendo resultados similares a lo que este estudio registró para *Philoglossa* sp. y *Philoglossa mimuloides*, pero inferiores los registros de *T. dubium*, *C. clandestinus* y *T. repens*.

Es importante resaltar que tanto el crecimiento como la velocidad de recuperación (rebrote) de las pasturas está influenciada por factores como la acumulación de carbohidratos en sus estructuras vegetativas (Castro et al., 2013; Lemaire y Agnusdei, 2000), la especie y su potencial genético (Castro et al., 2013; Rodríguez et al., 2011; Uvidia et al., 2013). Además, se debe considerar a la temperatura, radiación y la precipitación como factores determinantes en la tasa de crecimiento y la calidad de las especies forrajeras de interés (Fernández et al., 2001; Wachendorf et al., 2001; Velasco et al., 2018).

3.2. Análisis proximal

Los valores de proteína y fibra de los forrajes indican que *C. clandestinus* (proteína: 12,55 % y fibra: 17,62 %), *T. repens* (proteína: 19,90 % y fibra: 14,15 %) y *T. dubium* (proteína: 23,29 % y fibra: 13,34 %) tienen un comportamiento normal para la zona (Oliva et al., 2015b), es decir, el nivel alcanzado es cercano, y puede sugerir que estos parámetros dependen de la especie a cultivar. Estos resultados muestran el potencial forrajero de las especies nativas. Además, las especies del género *Trifolium* también pueden ofrecer una fuente alternativa de nitrógeno para la producción de forraje, adicional a la aplicación de fertilizantes (Egan et al., 2017). Los niveles de ceniza, comprendidas en un rango de 8 a 11 %, son similares a los reportados para especies como *Brachiaria decumbens* Stapf y *Cynodon nlemfuensis* Vanderyst (Poaceae) (Combatt et al., 2015); determinación que es importante por estar relacionado con la disponibilidad de minerales en el forraje (Combatt et al., 2015). Respecto a la digestibilidad, los resultados obtenidos a excepción de la especie *Philoglossa* sp. fueron superiores a investigaciones realizadas con maní forrajero *Arachis pintoi* Krap. & Greg. (Fabaceae), cuyos valores se comprendieron entre 55 a 67 % (Godoy et al., 2012), similar resultado fue reportado para morera *Morus alba* L. (Moraceae), pues el nivel de NDT fue inferior a 60 % (Boschini, 2006). No obstante, Estupiñán et al. (2007) y Godoy et al.

(2012) señalan que la digestibilidad de las pasturas varía según el estado vegetativo de la planta, siendo importante establecer el estado óptimo para su aprovechamiento.

Conclusiones

Las especies *P. mimuloides* y *Philoglossa* sp. obtuvieron los más altos valores de forraje verde (7,46 y 8,04 kg/m^2) y materia seca (8,58 y 8,90 t/ha). Asimismo, se ha comprobado que las especies influyen sobre el nivel de cada componente nutricional, siendo *T. dubium* la especie que presentó el mayor contenido de proteína. Las especies evaluadas presentan condiciones que pueden favorecer la sostenibilidad de la actividad ganadera en la zona de estudio, pero sus posibilidades de cultivo y la gestión equilibrada de cada especie dentro de los pastizales deben continuar evaluándose.

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Adjustment of water demand norms for accompanying crops in rice crop rotations

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ABSTRACT

The relevance of the study is due to the need to save water resources. The purpose of study is to determine microclimatic correction factors for monitoring and adjusting the norms of water de-mand for accompanying crops in rice crop rotations for various zones of natural moistening in Russia. The main study methods are experimental (field) and comparative analysis of the data obtained with theoretical calculations. Study results: Correction factors are presented for calcu-lating evapotranspiration / evaporation of accompanying crops in rice crop rotations, varying in the regions of Russia from Ccr= 0.75 to Ccr = 0.94, respectively, at from Cm 0.2-0.3 to Cm 0.8-1.0 and it is determined that in the rice crop rotation it is necessary to take into account the residual additional productive moisture reserves after rice, which is in the meter soil layer - from 60 mm in regions with Cm = 0.2-0.3 to 84 mm with Cm 0.8-0.1. Practical significance: The use of micro-climatic correction factors for adjusting the norms of water demand for accompanying crops makes it possible to calculate and justify the volume of water for irrigation of these crops in rice crop rotations and to save water resources.

KEYWORDS: water; crops, agricultural products, rice; irrigation.

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Ajuste de las normas de demanda de agua para cultivos acompañantes en rotaciones de cultivos de arroz

RESUMEN

La relevancia del estudio se debe a la necesidad de ahorrar recursos hídricos. El propósito del estudio es determinar los factores de corrección microclimáticos para monitorear y ajustar las normas de demanda de agua para los cultivos acompañantes en las rotaciones de cultivos de arroz para varias zonas de humectación natural en Rusia. Los principales métodos de estudio son el experimental (campo) y el análisis comparativo de los datos obtenidos con cálculos teóricos. Resultados del estudio: Se presentan factores de corrección para calcular la evapotranspiración/evaporación de los cultivos acompañantes en las rotaciones de cultivos de arroz, que varían en las regiones de Rusia desde Ccr= 0,75 a Ccr = 0,94, respectivamente, a Cm 0,2-0,3 a Cm 0,8-1,0 y se determina que en la rotación de cultivos de arroz es necesario tener en cuenta las reservas de humedad productiva adicional residual después del arroz, que se encuentra en el metro de capa de suelo - de 60 mm en regiones con Cm = 0,2-0,3 a 84 mm con cm 0,8-0,1. Importancia práctica: El uso de factores de corrección microclimáticos para ajustar las normas de demanda de agua para los cultivos acompañantes permite calcular y justificar el volumen de agua para riego de estos cultivos en las rotaciones de cultivos de arroz y ahorrar recursos hídricos.

PALABRAS CLAVE: agua; cultivos; producto agrícola; arroz; riego.

Introduction

Rice is one of the most water-intensive agricultural crops, the production of which takes tens of thousands of cubic meters per hectare, therefore, the issues of saving water resources in rice cultivation are relevant all over the world. Saving water resources is possible by various methods: improving irrigation technology (Wu, 2017; Allen, 1998; Belder, 2007; Redwanur, 2014), breeding rice varieties (Victoriano, 2017), organizational measures (Victoriano, 2017; Mom, 2007), etc.

Rational use of water resources in Russia is becoming one of the urgent tasks of irrigated agriculture. One of the ways to save water is the regulation and management of water distribution by substantiating, developing, and approving regional water consumption standards for agricultural crops and water disposal from irrigation systems (Olgarenko, Vasilyev and Balakay, 2019). It is especially relevant for rice irrigation systems, which are the main consumers of water resources, where 20 thousand m^3 or more of irrigation water is

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supplied to each hectare of rice. In rice-growing regions, it is 70–80% of the volume of water supplied for irrigation. In the existing normative document GOST R 58331.3-2019 regulating water consumption by agricultural crops, there are no norms for the water demand of rice and accompanying crops in rice crop rotations.

At the moment, the specialists of the Federal State Budgetary Scientific Institution " Russian Research Institute of Land Reclamation Problems " have determined an approach to calculating the norms of water demand for rice (Balakay, 2018; Vasilyev, 2018) and have proposed these norms for various agro-climatic zones of Russia, but they have not developed norms for water demand for accompanying crops of rice crop rotation, the adjustment of which will give the possibility of saving water resources for rice irrigation systems up to 15–20% by regulating the irrigation regime and operational water distribution, taking into account the norms and, accordingly, reducing the norms of water disposal from them. Thus, the purpose of study is to determine the microclimatic correction factors for adjusting the norms of water demand for accompanying crops in rice crop rotations for various zones of natural moistening in Russia.

1. Materials and methods

Today there are many methods for determining evaporation (potential evapotranspiration). The calculation models of H.L. Penman, L. Turk, and H.F. Blaney - V.D. Kriddle are the most well-known and widespread abroad. In Russia - A.M. and S.M. Alpatyev, N.N. Ivanov, N.V. Danilchenko's modified formula, etc. (Ilyinskaya, 2001).

To determine the total evaporation (evapotranspiration, water demand) of a specific field (ET_j) with a specific crop « j », it is necessary to have indicators of biological (Cb) and microclimatic (Co) coefficients of water consumption of this crop in dynamics from germination to maturation. The total evaporation is proposed to be determined by the equation (Methodological guidelines ..., 1984):

$$ET_j = ET_o \cdot C_b \cdot C_0, \quad (1)$$

where ET_j is the total evaporation (water consumption) of the field, mm.

ET_o is the evaporation from the field, mm.

C_b is the bioclimatic coefficient.

C_o is the microclimatic coefficient.

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The microclimatic coefficient (C_o) considers the change in the microclimate of an agricultural field under the influence of sprinkler irrigation. It depends on the agro-climatic conditions of a particular territory, the size of the irrigated area S_{ir} and the phase of development of field crops.

However, in rice crop rotations, where rice is irrigated superficially by flooding paddies with rice, the use of the same microclimatic coefficients (C_o) to calculate the evapotranspiration of accompanying crops in rice crop rotations leads to large calculation errors.

To be able to calculate the water demand norms for accompanying crops in rice crop rotations during flooding of rice, studies were carried out and correction microclimatic coefficients for these crops C_{cr} instead of C_o were obtained. The microclimatic correction factor C_{cr} differs from the microclimatic coefficient C_o in that it considers the peculiarities of evaporation from the water surface of rice paddies flooded with water and from the fields of irrigated accompanying crops in conditions of rice crop rotations.

C_{cr} is calculated for a certain period as a quotient of the value of evaporation (potential evapotranspiration) of crops from rice crop rotation fields to the evaporation of the same crops in field crop rotations. Calculations of monthly evaporation E_o were determined by the formula of N. N. Ivanov (Norms of water demand ..., 2000):

$$E_0 = 0{,}0018 \cdot (t + 25)^2 \cdot (100 - \alpha), \qquad (2)$$

where t is the average monthly temperature, ° C.
α is the relative humidity of the air, %.

To establish the indicator C_{cr}, instrumental measurements of meteorological parameters were carried out during the growing season of rice for the Petrovsko-Anastasievskaya rice irrigation system of the Krasnodar Territory in five replications. The measurements were carried out using the appropriate equipment, starting from the border of the rice irrigation system from the windward side and with further deepening into the rice system itself in the direction of the wind at various distances - from 200 to 7000 m. The processing of the obtained data was carried out using mathematical analysis of the experiment and mathematical statistics.

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Since it was not possible to conduct such field studies for various agro-climatic conditions in Russia, theoretical calculations of these coefficients were carried out using the analog method for all zones with natural moistening C_m from 0.2 to 1.0 using the meteorological indicators of meteorological stations of specific territories.

2. Results

Analysis of experimental data in rice crop rotations allowed us to establish indicators of changes in microclimatic coefficients C_{cr} during the growing season of various accompanying crops, associated with increased relative moisture in rice crop rotations and, as a consequence, lower air temperature. In this regard, the correction factor C_{cr} also changes during the growing season of crops. For example, the calculations showed that in the Petrovsko-Anastasievskaya rice irrigation system of the Krasnodar Territory in April (on average) C_{cr} was 0.94, and in July - 0.72 (Table 1).

Table 1. Evaporation E_0 in rice and field crop rotations and microclimatic correction coefficient C_{cr} during the growing season of crops.

Month	In rice crop rotations			In field crop rotations			C_{cr}
	T °C	α, %	E_0, mm	T °C	α, %	E_0	
1	2	3	4	5	6	7	8
Experimental data							
April	12.5	63.8	91.6	13.0	62.4	97.7	0.94
May	18.5	61.8	130.1	19.5	59.8	143.3	0.91
June	24.4	63.4	160.7	24.0	52.4	205.7	0.78
July	28.3	65.1	177.8	29.0	53.2	227.5	0.72
August	25.4	44.2	255.0	26.4	35.4	307.2	0.83
Average	21.6	59	177.7	21.4	49	205.0	0.84
Theoretical calculations							
Month	According to the archival data of the meteorological station of the city of Slavyansk-on-Kuban			According to the archival data of the meteorological station of the city of Timashevsk			K_{np} K_{pr}
	T °C	α, %	E_0	T °C	α, %	E_0	
April	11.5	68.9	74.6	12.0	67	81.3	0.92
May	17	72.1	88.6	18.4	69	105.1	0.84
June	22.3	69.0	124.8	23.1	62	158.3	0.79
July	25.1	64.0	162.6	25.7	54	212.8	0.76
August	26	57.0	201.3	26.1	49.8	238.9	0.85
Average	20.3	66.2	130.4	21.1	60.3	158.7	0.83

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Figure 1 shows the relationship between the correction factors established by theoretical calculations and experimental data using meteorological parameters.

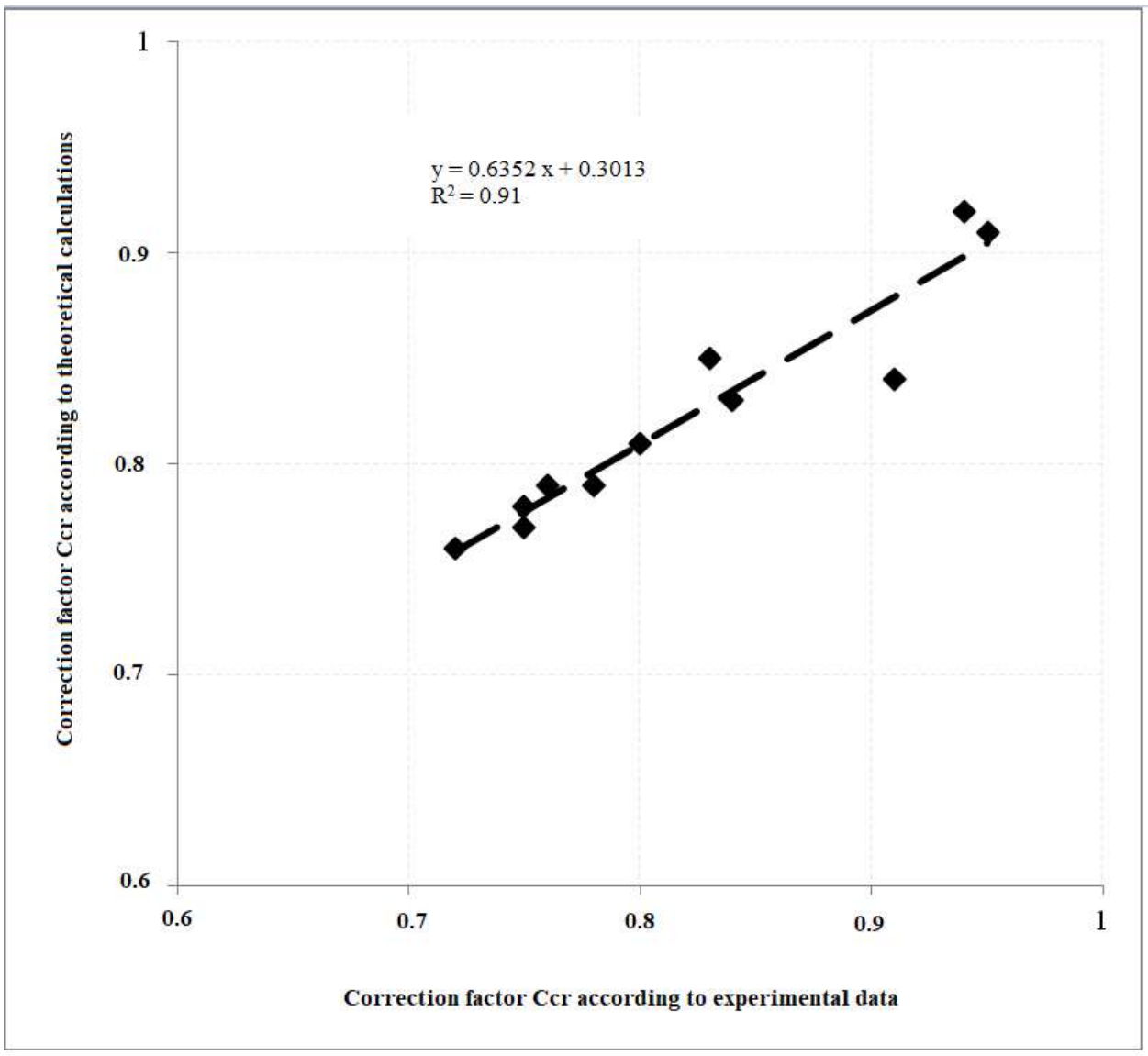

Figure 1. Relationship between correction factors obtained from experimental and theoretical data

The resulting relationship equation y = 0.6352 x + 0.3013 and the approximation coefficient R^2 = 0.91 confirm the reliable convergence of the microclimatic correction coefficients obtained during instrumental field studies of changes in temperature, air humidity and wind speed directly on rice and field crop rotations, as well as correction factors, calculated using the same meteorological parameters, but taken from the archive of meteorological stations in Slavyansk-on-Kuban and Tinashe's of the Krasnodar Territory (electronic resource).

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The close relationship of the obtained microclimatic correction coefficients made it possible by the same analogy method to calculate the microclimatic correction coefficients for accompanying crops cultivated in rice crop rotations for different moistening zones using data from meteorological stations in rice-growing regions with observation periods of at least 35 years (Table 2).

Table 2. Data of C_{cr} obtained by calculation method for various natural moistening zones

Region	Moistening coefficient C_m	Microclimatic correction factor C_{cr}
Astrakhan region	0.2–0.3	0.75
Republic of Kalmykia	0.2–0.3	0.75
Republic of Dagestan	0.3–0.4	0.81
Rostov region	0.3–0.4	0.81
	0.4–0.5	0.83
Krasnodar Region	0.45–0.5	0.83
	0.5–0.6	0.85
Primorsky Krai	0.8–1.0	0.94

The reliability of the microclimatic correction factors obtained by the calculation method for various moistening zones is confirmed by the close relationship between C_{cr} and C_m (Figure 2). The approximation coefficient was 0.87, which indicates a close relationship between these indicators.

In addition, a close relationship (R2 = 87) has been established between the coefficients of natural moistening content Cm and the relative correction factors to the norm of water demand of accompanying crops Crel.cr, equal to (1–Ccr), if we accept the condition that at Cm= 1 there will be a balance between evaporation and precipitation (Figure 3).

Figure 3 shows that the drier the climate, the more water evaporates from flooded paddies (the temperature decreases and the relative humidity of the air increases) and thus this is more reflected in the evaporation and irrigation regime of associated crops, i.e., evapotranspiration and, accordingly, the irrigation rate decreases.

When adjusting the water requirements for accompanying crops in rice crop rotations, additional moisture reserves remaining in the soil after rice cultivation should be considered. As studies carried out in Kalmykia have shown, residual moisture reserves in the spring period are quite large and, regardless of weather conditions in the autumn-winter period, the meter layer contained water from 74.3 to 88% of field moisture capacity and more (Balakay, 2017; Consolidated norms ..., 2013; Kravchenko, 2007).

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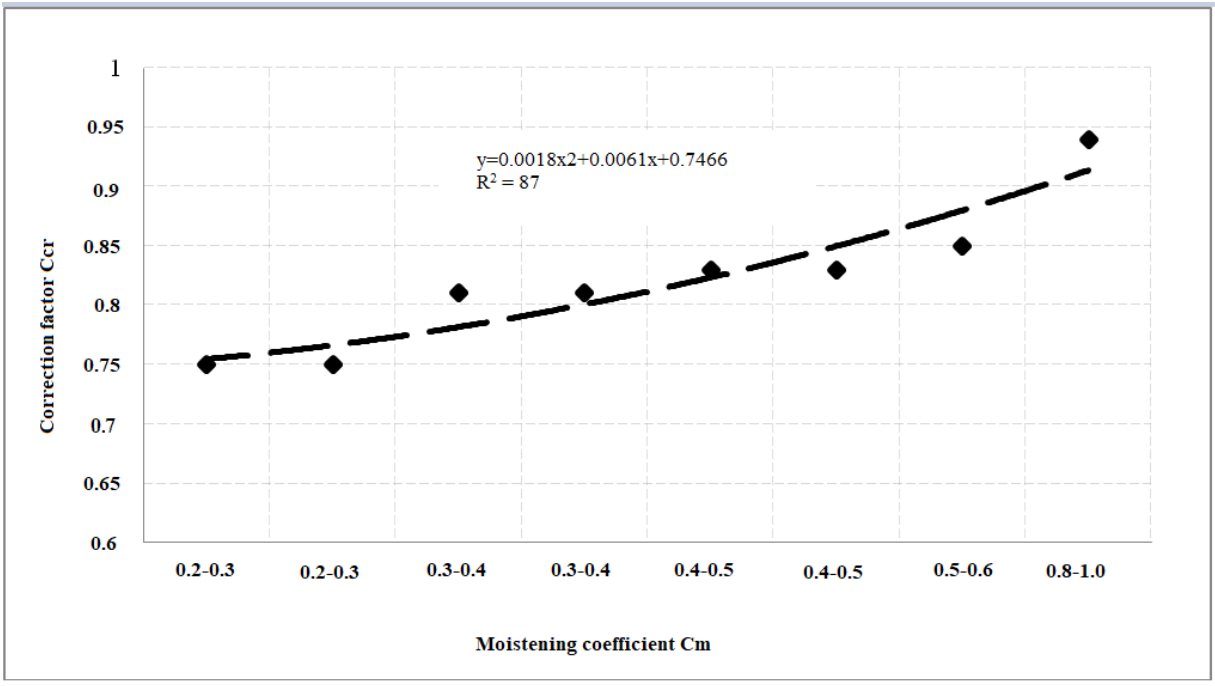

Figure 2. Relationship between microclimatic correction factors and moistening factors for different agro-climatic zones

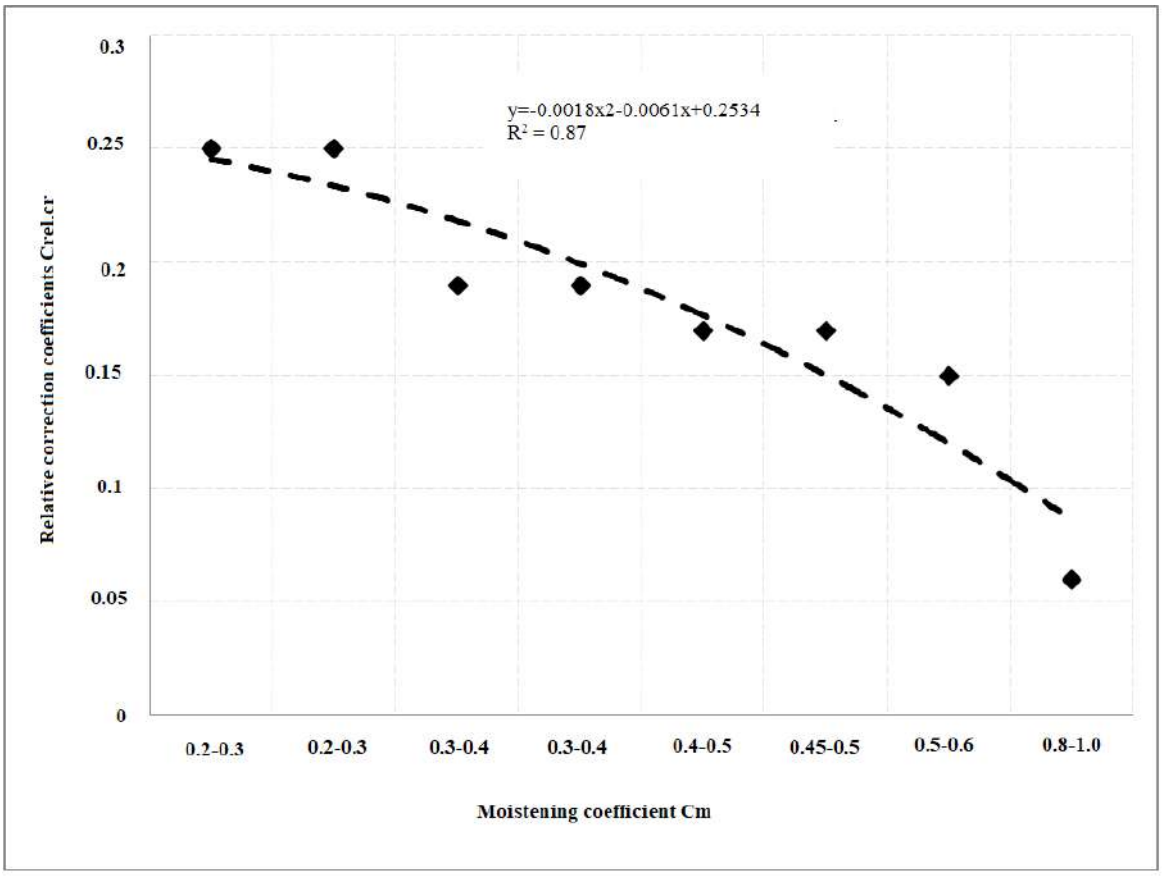

Figure 3. Relationship between natural moisture factors C_m and relative correction coefficients C_{relcr}

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We also carried out studies to establish residual moisture reserves in the soil of paddies in the spring before sowing accompanying crops (Table 3).

Table 3. Moisture and moisture reserves in a meter layer of soil before sowing in paddies after rice cultivation

(n = 5)

Layer, cm	Moisture							Moisture reserves at the beginning of the growing season, mm
	Actual, % abs. dry soil	δ, %	V, %	Field moisture capacity, %	δ, %	V, %	Actual, % from field moisture capacity	
1	2	3	4	5	6	7	8	9
Nizhne-Manychskaya irrigation system, Rostov region C_m= 0.31-0.4								
0–20	21.2	0.68	3.2	26.5	1.10	4.3	80	58.9
20–40	19.1	0.71	3.7	24.5	0.95	3.9	78	53.4
40–60	20.1	0.83	4.3	24.5	1.07	4.4	82	56.5
60–80	22.3	0.74	3.1	26.5	0.95	3.6	84	62.5
80–100	23.8	0.69	2.9	27.6	0.86	3.1	86	66.7
0–100	21.3	0.73	3.4	26.0	0.99	3.9	82	298.0
Petrovsko-Anastasievskaya rice irrigation system, Krasnodar Territory, C_m = 0.45-0.50								

Continuation of table 3

1	2	3	4	5	6	7	8	9
0–20	22.9	0.85	3.7	28.3	1.25	4.4	81	64.3
20–40	22.5	0.90	4.0	28.9	1.18	4.1	78	63.2
40–60	22.8	0.96	4.2	28.8	1.35	4.7	79	64.1
60–80	25.4	1.29	5.1	31.7	1.61	5.1	80	71.6
80–100	26.9	1.05	3.9	32.8	1.24	3.8	82	74.8
0–100	24.1	1.01	4.2	30.1	1.32	4.4	80	338.0

Note δ is the standard deviation, V is the coefficient of variation.

The results showed that under the conditions of the Rostov region in the zone with C_m = 0.31–0.40 on soils with a heavy loamy composition, these moisture reserves in the meter layer amounted to 298 mm or 82% of field moisture capacity, and on clay soils of the Krasnodar Territory in the zone with C_m = 0.45–0.50, respectively, 338 mm or 80% of field moisture capacity. At the same time, the calculations of the standard deviation and the coefficient of variation indicate insignificant variability of moisture and moisture reserves in the soil in the spring after rice in different regions.

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The data obtained allow us to assert that in the spring of the next year, after the cultivation of rice, the moisture in the soil remains equal in volume to at least 80% of field moisture capacity. Based on this, for the main rice-sowing regions, we calculated the residual moisture reserves after rice cultivation before sowing accompanying crops, considering the properties of soils and data of field moisture capacity (Table 4). They ranged from 238 mm in the Astrakhan region to 325 mm in the Primorsky Krai.

Table 4. Residual moisture reserves after rice cultivation

Region	C_{cr}	Soil by granulometric composition	Field moisture capacity, % abs. dry soil	Moisture reserves at field moisture capacity, mm	Moisture reserves at the beginning of the growing season, mm	Productive moisture, mm	Residual moisture reserves, mm
Astrakhan region	0.21–0.30	Medium loamy	22	297	238	178	60
Republic of Kalmykia	0.21–0.30	Medium loamy	23	308	246	185	61
Republic of Dagestan	0.31–0.40	Heavy loamy	25	340	272	204	68
Rostov region	0.31–0.40	Heavy loamy	26	364	298	218	66
	0.41–0.50	Loamy	30	414	331	248	83
Krasnodar Region	0.45–0.50	Loamy	30	423	338	254	84
	0.50–0.60	Heavy loamy	27	367	294	220	74
Primorsky Krai	0.8–1.0	Loamy	29	406	325	244	81

Moisture should remain in the soil at the level of productive reserves of at least 60%, while the share of residual moisture in the total volume of moisture reserves after rice for accompanying crops ranges from 60 to 84 mm or 32–33%.

3. Discussions

For 40 years, the Southern Scientific Research Institute of Hydraulic Engineering and Melioration (Russian Research Institute of Land Reclamation Problems), together with other institutes (All-Russian Scientific Research Institute "Raduga", Central Scientific Research Institute for the Integrated Use of Water Resources), have been studying irrigation

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regimes for agricultural crops by sprinkling in field crop rotations, creating mathematical models for calculating productive moisture reserves for various types soil and in various agroclimatic conditions of Russia, which made it possible not only to develop standards for the water demand of field crops, but also to promptly adjust irrigation regimes according to meteorological parameters, taking into account the agro-climatic conditions of a particular irrigated area (Water demand norms ..., 2000; Ilyinskaya, 2001; Methodological guidelines ..., 1984; Calculation of irrigation regimes ..., 2012; Balakay, 2017).

Based on the data of long-term field studies, the norms of water demand for crops were calculated and regulated depending on the heat and moisture supply of the year according to the integrated indicator C_m - the coefficient of natural moisture in a particular area and provision the year according to the indicator of the water balance deficit (Enlarged norms ..., 2013). Heat and moisture supply of the year was characterized by meteorological parameters: average daily precipitation, temperature, relative air humidity and wind speed. When using office, mathematical and statistical processing of field studies, patterns, dependencies, relationships were established, which made it possible to obtain bioclimatic and microclimatic coefficients, calculate the water demand of plants and develop a regulatory document for the main field crops GOST R 58331.3–2019 - Water demand for irrigation of agricultural crops. However, such studies of the total evaporation of these field crops as accompanying crops under the conditions of rice crop rotations have not been carried out.

The concept of this calculation is based on the fact that moisture evaporation from permanently flooded rice paddies occurs more intensively than from crops of field irrigated crop rotations, where sprinkler irrigation is carried out two to eight times per season and high soil and plant moisture and, accordingly, more evaporation is observed only in the first two or three days after watering. It should be noted that with different irrigation methods on rice systems and in field crop rotations, the main indicators of the microclimate (temperature and relative humidity) change in different ways, which have a significant effect on the evapotranspiration / evaporation rates of plants, this must be considered and appropriate corrections must be made by introducing correction coefficients into the calculation methodology.

It should also be noted that water resources are saved in rice crop rotations due to the use of residual moisture reserves in the soil by accompanying crops that go in the crop

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rotation fields after rice. Residual (after rice) moisture reserves of productive moisture in the soil are highly stable and vary for a layer of 1 m from 155 to 189 mm (Kravchenko, 2007). For example, in the first year of life of alfalfa in the total water consumption, residual moisture reserves after rice amounted to 41% (Smykov, 2005). In Kalmykia, resource-saving technologies, for cultivating dry crops capable of generating high yields without watering due to the use of moisture reserves remaining after rice, are being introduced on rice systems (Melikhov, 2016, Dubenok, 2014; Rakitina, 2017).

Conclusion

Evaporation of moisture from constantly flooded rice paddies occurs more intensively than in crops of field crop rotations irrigated by sprinkler irrigation, where the number of irrigations per season is from two to eight, and high moisture content of soil and plant tissues and, accordingly, greater evaporation is observed only in the first two to three days after watering. In rice crop rotations with flooded paddies, evaporation increases and, accordingly, the microclimate changes, including temperature decrease and relative humidity increase, which have the major effect on plant evapotranspiration.

On the basis of experimental and theoretical studies, correction factors were obtained for calculating evapotranspiration / evaporation of accompanying crops in rice crop rotations, varying in the regions of Russia from C_{cr}= 0.75 to C_{cr} = 0.94, respectively, at C_m from 0.2-0.3 to C_m 0, 8-1.0.

The natural relationship has been established between the correction factors obtained between the experimental data and the theoretical ones, calculated from the meteorological parameters of meteorological stations in the regions, expressed by an equation of the form y = 0.6352 x + 0.3013 with an approximation coefficient R^2 = 0.91.

When calculating the norms of water demand for accompanying crops, it is necessary to consider the residual additional productive moisture reserves in the meter layer of soil from 60 mm in regions with C_m= 0.2–0.3 to 84 mm – with Cm 0.8–0.1.

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Internal control in the economic security system of agricultural and processing organizations

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ABSTRACT

The article reveals the need for internal control in the economic security system of agricultural and processing organizations. The objective of the study is to establish the function of internal control in the economic security system of agricultural and processing organizations, as a mechanism for identifying risks and threats. In accordance with this objective, the main task was determined, to substantiate the theoretical and practical aspects of internal control in the economic security system of agricultural and processing organizations. The work examines the substantive and formal methodological aspects, including the study of laws, theories, the structure of scientific knowledge, the analysis of research methods from the point of view of logical structure and the formalized approaches for the construction of the theoretical knowledge, its truth and argumentation. The classification of internal control in the organization's economic security system is offered. A list of mandatory internal control elements has been determined in the organization's economic security system. The methods and procedures are grouped by functional components in the economic security system.

KEY WORDS: agricultural organization; dairy industry; Organization and management; Business economics.

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Control interno en el sistema de seguridad económica de las organizaciones agrícolas y de procesamiento

RESUMEN

El artículo revela la necesidad del control interno en el sistema de seguridad económica de las organizaciones agrícolas y de procesamiento. El objetivo del estudio es fundamentar la función del control interno en el sistema de seguridad económica de las organizaciones agropecuarias y de procesamiento, como mecanismo de identificación de riesgos y amenazas. De acuerdo con este objetivo, se determinó la tarea principal, fundamentar los aspectos teóricos y prácticos del control interno en el sistema de seguridad económica de las organizaciones agrícolas y de procesamiento. El trabajo examina los aspectos metodológicos sustantivos y formales, incluyendo el estudio de las leyes, las teorías, la estructura del conocimiento científico, el análisis de los métodos de investigación desde el punto de vista de la estructura lógica y los enfoques formalizados para la construcción del conocimiento teórico, su verdad y argumentación. Se ofrece la clasificación del control interno en el sistema de seguridad económica de la organización. Se ha determinado una lista de elementos obligatorios de control interno en el sistema de seguridad económica de la organización. Los métodos y procedimientos se agrupan por componentes funcionales en el sistema de seguridad económica.

PALABRAS CLAVE: organización agrícola; industria lechera; organización y gestión; Economía de la empresa.

Introduction

The aim of the study is to substantiate the function of internal control in the system of economic security of agricultural and processing organizations, as a mechanism for identifying risks and threats.

Many scientists believe that internal control is necessary only in terms of identifying internal risks and identifying deviations reflected in accounting documents. However, many authors focus on internal control as an adaptive mechanism in the context of the economic security of an organization.

The organization's economic security system in modern times should be based on many internal control and analytical, resource and accounting principles and technical and technological approaches (Kontsevaya S. R., 2018).

Control is a universal mechanism and management function of the organization, therefore it should be used with the use of methods of economic analysis of factors of production for making management decisions (Kontsevoi G. R. et al., 2020).

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Currently, the computerization processes of management and accounting are rapidly developing, but together with all their advantages they create a fair number of new problems, challenges and threats in the field of organization's economic security (Endovitsky D.A., et al., 2018). In the process of business functioning, as a result of external influences and changes in the internal state of the organization, situations arise that require an immediate response in the form of internal control (Alborov et al., 2017).

Internal control in the organization's economic security system using an indicative approach, factor analysis, other standard measures help to identify the strengths and weaknesses of the organization considering internal risks and external threats (Ostaev G.Ya., et al., 2020). Internal control in the organization's economic security system should cover all methods and procedures required for the collection of information, both on paper and in electronic and cloud media, its processing and study (Kontsevaya S., 2017). The studied information under internal control in the economic security system determines the essence and importance of the identified negative factors, reveals the problem areas of the organization and sets the course for the study of these areas (Rokotyanskaya V. V. et al., 2018).

Internal control of business processes in the organization's economic security system can be classified depending on the type of the current internal control system; specifics of the tasks being solved; time of commission; sources; coverage volumes; the operation level of the internal control system; applied methods for assessing the internal control system.

The classification of internal control in the organization's economic security system depending on the traits is presented in Table 1.

This classification shows the main classification traits of internal control in the system of economic security of the organization. The proposed classification is compiled considering traditional and special methods for the purpose of ensuring the economic security of the organization.

The reform of internal control in the system of economic security of the organization, in fact, should be aimed at expanding the possibilities of control and analytical actions (Mukhina I.A. et al., 2020).

Reform is the most promising of the possible types of development. Reform essentially means changing the shape of something. The practical application of this

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concept in economics suggests a conscious, purposeful, consistently sparing change in the form of economic relations (Kondratiev D. V. et al., 2020).

Table 1. Classification of internal control in the system of the organization's economic security.

It.No.	Classification trait	Classification element
1	Depending on the type of the current internal control system	1. Non-automated, 2. Automated; 3. Mixed.
2	Depending on the specifics of the tasks to be solved	1. Administrative and managerial; 2. Accounting and analytical; 3. Technical and technological; 4. Tax and legal; 5. Financial and economic, etc.
3	Depending on the execution time	1. Preliminary; 2. Current (operational); 3. Subsequent (final).
4	Depending on the sources	1.Documentary; 2. Computer; 3. Actual;
5	Depending on the scope of coverage	1. Partial or complete; 2. Complex or topical; 3. Solid or selective.
6	Depending on the level of the internal control system action	1. Corporate; 2. By structural divisions; 3. At the level of the technological process.
7	Depending on the methods used for assessing the internal control system	1. Visual and actual control methods; 2. Methods of documentary control using technical and communication technologies; 3. Methods of indicative, factorial, standard and complex control.

* Author's development

Internal control in the organization's economic security system should include such methods as inventory, visual observation, reverse calculation, examination or laboratory research, comparison, arithmetic verification, logical control of documentation, testing or questioning of personnel, audit, monitoring, official investigation, comprehensive analysis of activities, monitoring, forecasting and modeling.

To achieve the assigned tasks, internal control specialists in the organization's economic security system must develop strategies and plans for control measures.

The plans of control measures in the organization's economic security system should cover control and analytical procedures starting from sampling determination, collection and analysis of information to assessing business processes for their effectiveness (Frantsisko O. Yu., et al., 2020). The strategic objectives in planning and conducting internal control in the

economic security system of an organization is to assess the causes of deviations, identified remarks/risks and external threats (Molchan A. S. et al., 2020).

The measures of the internal control system in the organization's economic security system should be aimed at collecting evidence, documenting and forming the final control documents.

Factors affecting economic markets or economic relations are identified (determined) studiesi (Ostaev G.Ya., Kondratyev D.V., et al., 2020).

1. Methodology

The implementation and creation of a workable internal control system for the purposes of the economic security of agricultural and processing organizations is influenced by a number of factors: the complexity of the organizational structure of the organization, the accounting and management programs used, the qualifications of employees, types of activities, etc.

The theoretical and methodological basis of the study was the works of domestic and foreign scientists. The work investigates substantive and formal methodological aspects, including the study of laws, theories, the structure of scientific knowledge, analysis of research methods from the point of view of the logical structure and formalized approaches to the construction of theoretical knowledge, its truth and argumentation.

The article uses a holistic systematic approach that allows us to consider the internal control system for the purposes of the economic security of the organization. This approach allows you to study the problems of the internal control system for the purposes of the economic security of the organization, to determine its main functions, to outline further development prospects.

The methodological framework used in internal control must be adapted to meet specific goals and objectives, taking into account the available resources, budget and capabilities of the economic entity.

To achieve the goal of the study, general scientific and special methods were used: economic analysis, modeling, observation, comparison and generalization.

2. Research results and discussion

For optimal, rational, safe and efficient operation, any system requires internal control.

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The organization's activity as a unified management system is no exception.

Internal control is a process aimed at studying the internal environment of an organization to determine the effectiveness and efficiency of its activities. (Horuzhy L.I., Alborov R.A., 2019).

Internal control should be understood as a process aimed at checking and evaluating one's own work, carried out in their own interests, in order to gain confidence in the effectiveness and constructiveness of their activities (Belozerova L.A. 2019).

The internal control system of the organization must meet the specifics of the financial and economic activities of the organization, operate on an ongoing basis, while the internal documents of the economic entity, which reflect all business processes, are subject to assessment (Kotlyachkov O. V., Denisova N. L. 2014).

The committee of sponsoring organizations of the treadway commission (COSO) has developed a general internal control model against which companies and organizations, including banks, can evaluate their own governance systems.

The elements of internal control according to the COSO system include: control environment; risk assessment; control measures; collection and analysis of information, as well as its transfer to its intended purpose; monitoring and error correction (Internal Control - Integrated Framework, 2013)

Traditionally, all authors and the COSO system attach great importance to the internal environment, while little is paid (do not pay) to the external environment and the economic security of the organization.

It seems to us that internal control in the economic security system of an organization has all the capabilities and controls to assess not only the internal environment, but also to assess external threats, maintain stability, develop and expand prospects.

Currently, economic entities possess high technologies, operate based on high-tech platforms in the field of IT technologies. On high-tech platforms, of agricultural and processing organizations participate in tenders, offer goods (works, services), such a business model is focused on modern business. Accordingly, the requirements, elements, methods, techniques, procedures of internal control in the organization's economic security system are changing.

For the purpose of competent internal control of accounting activities in the of

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agricultural and processing organizations economic security system, the information should be divided into its components presented in table 2.

Table 2. Information for internal control of accounting and managerial activities in the organization's economic security system.

It.No.	Accounting department	Information to be researched
1	Financial information	Information about the registration of completed business transactions and business processes is investigated from the point of view of legality and expediency.
2	Production information	Information on cost accounting, costing of products (works, services), budgeting and planning at the production level is studied from the point of view of arefmeticity, analyticity, cost, profitability, timeliness and expediency.
3	Management information	Information about research aimed at business development is investigated from the point of view of the timeliness of making strategic decisions, cost and profitability.

*Compiled by the authors

With this approach of internal control in the agricultural and processing of agricultural and processing organizations economic security system, all deviations at the places of formation and registration of accounting and managerial information will be identified for the business accounting data.

Internal control of risks and threats in the system of organization's economic security is a set of traditional and special control and analytical measures, techniques and procedures for the purpose of timely management of risks and threats.

The purpose of internal control in the agricultural and processing organizations economic security system for controlling risks and threats should be to provide reasonable confidence in the achievement of the tasks set for the business (Table 3).

Internal control in the agricultural and processing organizations economic security system should include a certain list of mandatory elements, which are presented in Figure 1.

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Table 3. Target settings of internal control in the organization's economic security system to control risks and threats.

It.No.	The target of internal control	Target focus/area
1.	Strategic objectives	Ensuring financial stability and improving the financial condition of the business
2.	Commutative targets	Study of the characteristic features of activities, resources, assets for the purposes of efficient and economic use, as well as ensuring the safety
3	Reporting preparation restructuring objectives	Control over the completeness of accounting (financial), statistical, managerial and other reporting and their reliability
4	Regulatory compliance objectives	Compliance with applicable business laws and regulations

* Author's development

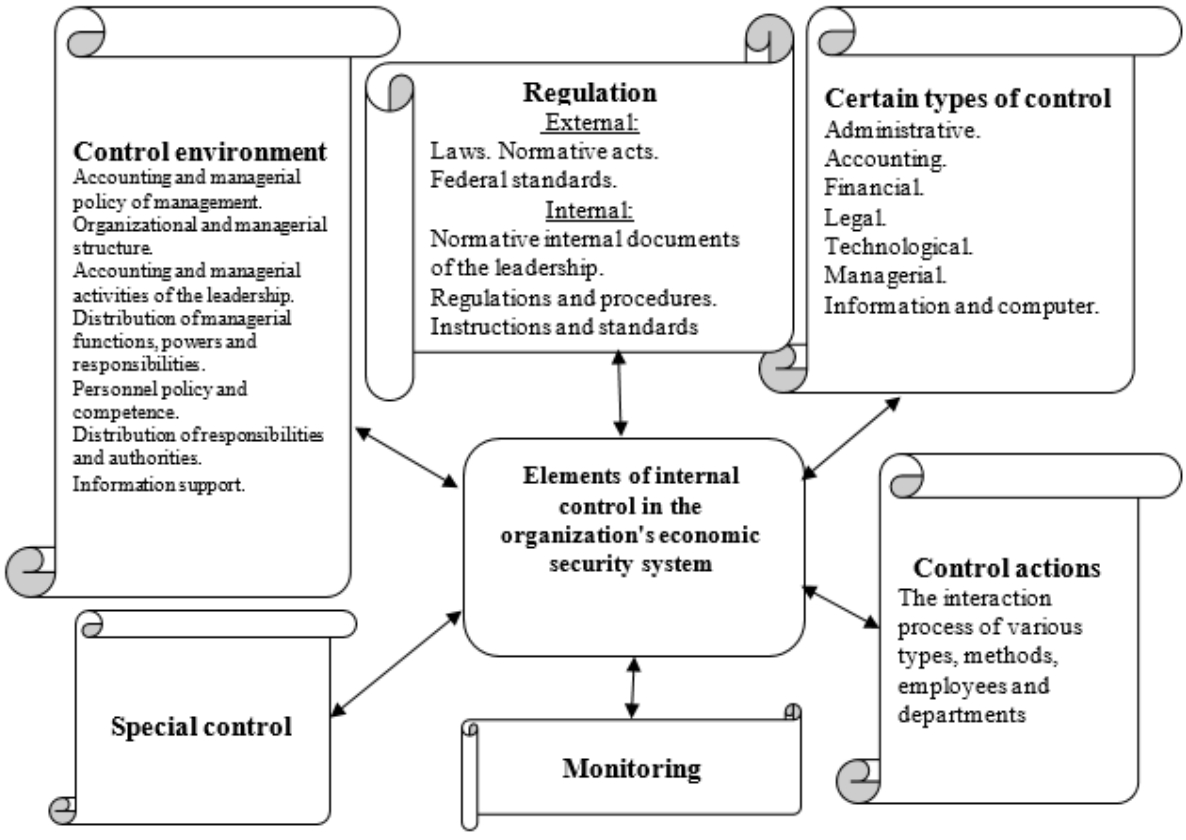

Figure 1. List of mandatory elements of internal control in the economic security system of the agricultural and processing organizations (author's development).

The control environment is the backbone of the agricultural and processing organizations economic security system for the purpose of identifying various accounting deviations,

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internal management and other risks and external threats. The control environment is a foothold for the organization's economic security system covering both the control and accounting system and the organizational and management structure of an economic entity considering the monitoring of the internal and external environment. The internal control apparatus from the point of view of studying the internal environment also reveals the competence of employees considering indicative and other approaches.

Regulatory activity is responsible for the compliance of the internal control system with the regulatory framework of both the agricultural and processing organizations internal (constituent documents, charter, accounting policy and other local regulations) and external environment - compliance with applicable federal legislative acts (federal laws, regulations, provisions, etc.)

Separate types of control, such as administrative, accounting, legal, financial, managerial and informational (computer) make it possible to distribute the workload of the person responsible for organizing internal control (for example, the owner or CEO) in the areas operating within the firm. The purpose of this distribution is to structure the existing internal control regulations in accordance with the specificity of the activities of the organization's departments.

Control actions in the economic security system of an organization in terms of methods, procedures and technologies can be grouped according to certain functional components (Table 4).

Let us consider the practical aspects of internal control in the system of economic security of the organization in terms of the investment business program for the reconstruction of production facilities for milk processing using the example of Megapolis LLC.

Control actions in the organization's economic security system in terms of making an investment decision regarding real investments for Megapolis LLC must be confirmed by functional parameters, which include: production, financial, market, management, etc.

Verification of information using traditional and innovative it-technologies allows for a financial and economic assessment of an investment project. At the same time, all of its functional parameters are checked in value (monetary) terms, which made it possible to obtain an opinion on the organization's investment project.

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Table 4. Grouping of methods and procedures by functional components in the agricultural and processing organizations economic security system.

It.No.	Control action methods and procedures	Direction of control methods and procedures	Study and correction
1	Information verification using traditional and innovative IT technologies	Observation tests, visual and actual control, documentary verification using technical and communication technologies	Study of information for compliance with accounting, economic and managerial indicators considering internal risks and external threats identified using traditional and innovative technologies. Correction of identified discrepancies obtained from internal and external sources of information considering the risks and threats revealed using traditional and innovative technologies.
2	Data processing using traditional and innovative IT technologies	Grouping and processing of information considering the standard and indicative approach using traditional and innovative technologies.	Study of grouped and processed information for compliance considering internal risks and external threats identified using traditional and innovative technologies. Correction of the processed information considering the accuracy of accounting and managerial data, the efficiency of strategic information, internal risks and external threats identified using traditional and innovative technologies.
3	Data analysis using traditional and innovative IT technologies	Factor analysis of indicators, analysis of accounting and managerial documentation, technical and technological analysis using traditional and innovative technologies	Study of information based on the results of documentary and actual inventory, factor analysis considering risks and external threats identified using traditional and innovative technologies. Correction of factor analysis data, technical and technological analysis considering internal risks and external threats identified using traditional and innovative technologies.

* Author's development

In particular, the characteristics of the investment project were studied: the reconstruction of the existing property complex and the organization of the production of

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dairy products. This property complex was acquired by Megapolis LLC under a sale and purchase agreement from Agrosila-Milk LLC on October 30, 2018.

The study revealed that the financing of the project is represented by own and borrowed funds. According to the control information of Megapolis LLC, the company's own funds in the amount of 5.895 million rubles (7.0% of the project cost) were invested in the project in 2019. The total amount of loan funds to finance the project is 80 million rubles, for a period of 10 years with a 1 year deferral of the principal debt payment and an interest rate of 8.5% per annum. The main direction for the development of credit funds is investments in the increase in working capital for the purchase of raw materials (40.0 million rubles) and the purchase of the necessary equipment (40.0 million rubles).

When processing data using traditional and innovative it technologies, the ratio of own and borrowed funds in project financing was studied. The study showed a high degree of dependence of the project on borrowed funds. This project is financially dependent on borrowed resources and has signs of financial instability.

Table 5 - Study of the distribution of investment costs by structure

It.No.	Cost type	Price, million rubles	Share in total costs,%
Capital investments			
1	Equipment	40,0	46,5
2	Investments in the increase in working capital	40,0	46,5
3	Funds previously invested in the project	5,895	7,0
	TOTAL costs	85,895	100,0 %

The study showed that the use of own and borrowed funds is necessary for the functioning and development of Megapolis LLC, which specializes in the production of dairy products. Calculations are presented with an indication of a gradual increase in the rate of production of products and their sales, according to the design annual capacity (table 6).

According to the presented Schedule for the development of the design production capacity and reaching the design capacity in 100% volume, it is planned to be carried out in 2021, i.e. for the 3rd year from the start of the project. Sales volumes, upon reaching full production capacity, will amount to 14,364 tons of products.

Below are the calculations characterizing the cash flows from the sale of products, according to the sales plan (schedule) (table 7).

Table 6 - Study of the plan (schedule) of sales, tons

Sales	Schedule for the development of design capacity, taking into account the volume of sales											
	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029 (3мес.)	Total
1. Resale of milk												
Sales volume for the period (tons)	8 370	11 160	11 160	11 160	11 160	11 160	11 160	11 160	11 160	11 160	2 790	111 600
2. Cheese												
Sales volume for the period (tons)	72	1 403	2 004	2 004	2 004	2 004	2 004	2 004	2 004	2 004	501	18 008
3. Milk												
Sales volume for the period (tons)	48	727	1 200	1 200	1 200	1 200	1 200	1 200	1 200	1 200	300	10 675

Table 7 - Study of indicators of the cash flow of the investment project, mln. rub.

It.No.	Years	Cash flow * by years of project implementation	Cash flow * cumulative
1	2019	2,311	-77,688
2	2020	43,986	-33,701
3	2021	89,772	56,071
4	2022	85,453	141,524
5	2023	81,126	222,650
6	2024	77,061	299,711
7	2025	73,278	372,990
8	2026	69,713	442,703
9	2027	66,123	508,827
10	2028	62 865	571,693
11	2029	15 336	**587,029**

* Cash flow from the point of view of the theory of value

Data processing using traditional and innovative it- technologies showed that the accumulated cash flows for 2019 - 2020. have negative values, which is associated with the gradual development of the maximum possible volume of production (for the 3rd year of the

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organization's work) with the full use of all available resources, as well as with the cost of repaying the loan. The total accumulated flow of the investment project by April 2029 will amount to 587 million rubles. which is 7.3 times higher than the amount of investments, that is, this amount (587 million rubles) of the profit received by the organization at the end of the investment project. We believe that the accumulated volume of cash flow is more expedient to reinvest (invest) in the project (for example, to increase production capacity) in order to obtain additional profit from its implementation.

Data analysis using traditional and innovative it-technologies was aimed at assessing the effectiveness and feasibility of investments (development of a milk processing business) for these purposes, calculations were made to implement the financial model of the project. The main financial indicators are shown in table 8.

Table 8 - Key financial indicators of the project

It.No.	Indicators	Unit rev.	Meaning
1	Net Present Value (NPV)	million rubles	587
2	Internal Rate of Return (IRR)	%	71
3	Payback Period (DPP)	years	2,5
4	Return on Investment Index (PI)	-	7,3

The study showed that project performance indicators are in line with generally accepted standards for project analysis:

- The net present value (NPV) of the project is above 0 and amounts to 587 million rubles (for 10 years). This is the amount of profit (587 million rubles) that the investor will receive from the implementation of this project, taking into account the time value and risks of all monetary investments in the investment project. The indicator has a positive value, therefore, the project is attractive for investment.

- The internal rate of return (IRR) of the project is 71%, which exceeds the value of the discount rate declared at the level of 6.7% (WACC is the average cost of all sources of financing), therefore, the investment project has an internal rate of return that is higher than the cost of its own and borrowed capital.

- The payback period of the project, taking into account the factor of the change in the value of money over time, is 2.5 years, this is the minimum period for which the accumulated income will exceed the amount of the invested funds;

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- The index of return on investment (a relative indicator of investment efficiency) is - 7.3. It shows the level of income received per one ruble of investment, taking into account the time value of money, that is, by 2029, the organization will receive 7.3 rubles of income for each ruble of investment invested.

These indicators indicate that the project is paying off and is able to bring additional profit to the initiators of the project.

The return on sales, as one of the main financial indicators for assessing the effectiveness of the organization, at the time of reaching the design capacity in 2021, will be 9.8%, that is, in every ruble earned, the organization will have about 10 kopecks of net profit. This result will be achieved with the forecasted revenue volume of RUB 1,192.1 million. and profit from production and sales of products in the amount of 116.9 million rubles.

The average profitability of sales from the moment of reaching profit from production and sales of products (from 2021) to the end of the project is 8.6%. In the methods of express analysis, it is established that a net profit margin of more than 10% means successful activity, the level of profitability from 5% to 10% is assessed as a relatively good result, and profitability below 5% or losses are interpreted as failure. According to the results of the project, this indicator characterizes a good work result, but for a more meaningful assessment, let us compare the profitability of the organization (8.6%) with the results of its competitors.

Profitability indicators are higher than the industry average values of competing enterprises, the level of which is determined at 8.2% (food industry) (according to data established by the Federal Tax Service of the Russian Federation, Appendix No. 4 to Order of the Federal Tax Service of Russia No. MM-3-06 / 333 @ dated May 30, 2007). Control actions in terms of methods, procedures and technologies confirmed the viability of the project and, consequently, the economic security of the organization.

The list of measures related to the *monitoring of control means* in the agricultural and processing organizations economic security system includes:

1. Supervision of the internal control apparatus over the implementation of control and analytical, monitoring and evaluation activities within the economic entity;

2. Assessment of the internal control apparatus of accounting and analytical information provided by the economic and accounting department of the organization;

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3. Analysis of employees' competence of an economic entity and the timeliness of their work preparation in accordance with their job descriptions;

4. Supervision over the compliance of accounting, storage of the organization's assets, implementation of contractual relations, internal ethical standards;

5. Assessment of technical means of control, corrective measures considering risks and threats.

Monitoring should cover all internal resources, accounting and management documents, information obtained from internal and external sources.

Special control, being a separate structural unit of control operating in an agricultural and processing organization, is a universal element and an applied tool of the organization's economic security system, which identifies internal risks and external threats.

The main elements of the economic security system in the implementation of the agricultural and processing organizations internal control are shown in Figure 2.

Digital technologies including software products in the work of internal control in the agricultural and processing organizations economic security system allow minimizing risk factors.

Summarizing all the studied information of internal control the facts that revealed considering the measures taken should be used and are fully disc losed.

In the organization's economic security system, internal control is the core of an orderly, systemic, organized and applied element of achieving the efficiency of an economic entity's functioning.

Conclusion

Thus, internal control in the organization's economic security system in a "complex" is a complicated, multifaceted economic phenomenon characterized by many factors and conditions, by analyzing of which it is possible to identify business development trends considering internal risks and external threats.

Despite the complexity and specificity of internal control in the economic security system, agricultural and processing organizations must constantly collect and process information in order to reduce various threats and risks. The problems of internal control in the economic security system are relevant and follow constant and active improvement.

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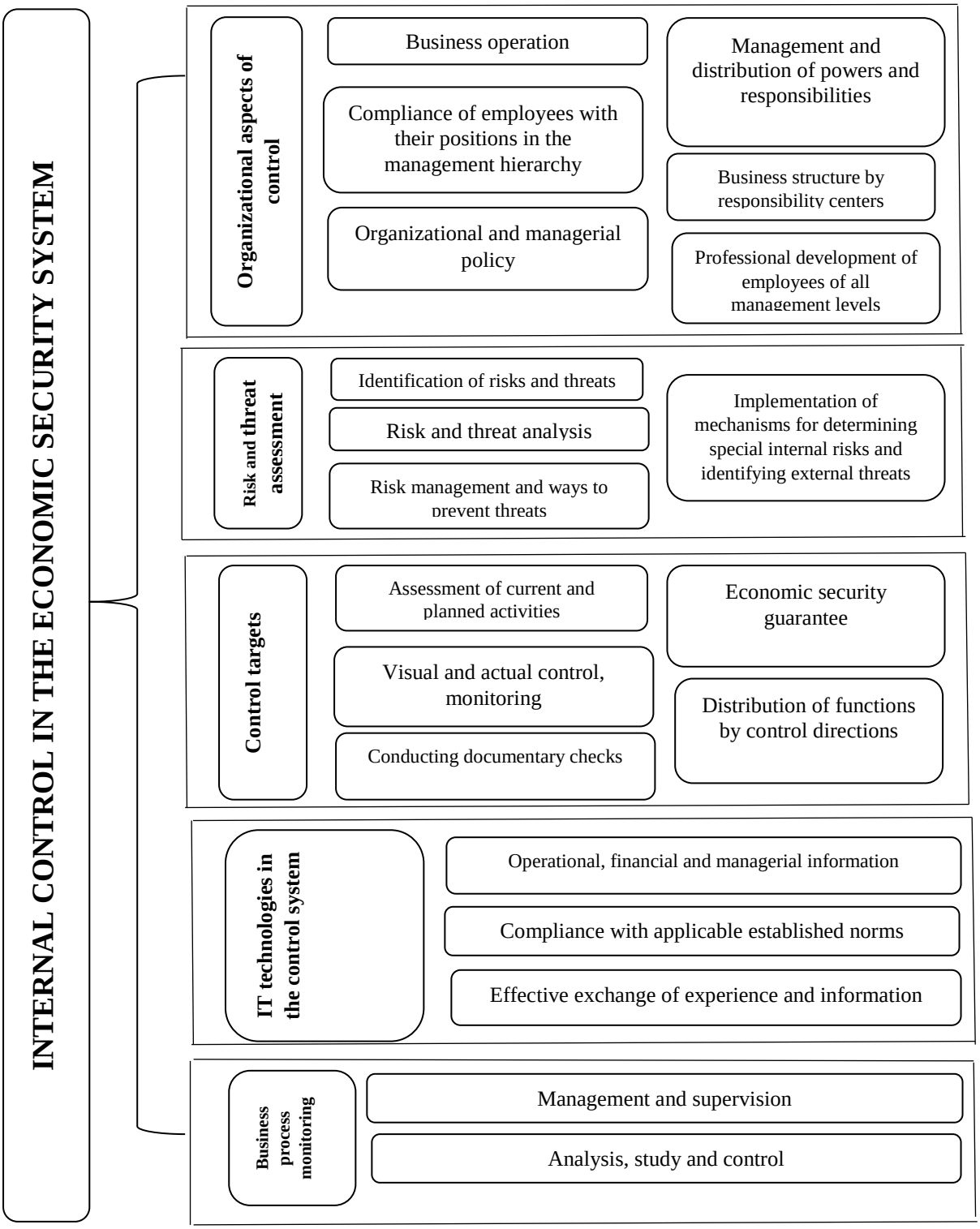

Figure 2. The structure of internal control in the economic security system of the agricultural and processing organizations (author's development).

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Management accounting and economic security in corporate management of agricultural company operation

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ABSTRACT

The article analyzes management accounting and economic security in the corporate governance system of an agricultural organization in an integrated manner, regarding the study of internal and external factors. The objective of the study is to develop an accounting model in business management, taking into account business development and economic security. In accordance with this objective, the main task was determined, to develop a comprehensive mechanism in terms of business development, resource conservation, production, budgeting and economic security. To develop an accounting model in business management, taking into account business development and economic security, the parameterization method was applied by modeling situations under modern conditions. The need to apply a systematic approach is founded, monitoring indicators are proposed to determine the risks and various threats to the operation and development of a business.

KEY WORDS: management; agricultural organization; economic security; integration.

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Contabilidad de gestión y seguridad económica en la gestión corporativa de operación de empresas agropecuarias

RESUMEN

El artículo analiza la contabilidad de gestión y la seguridad económica en el sistema de gobierno corporativo de una organización agropecuaria de forma integrada, en cuanto al estudio de los factores internos y externos. El objetivo del estudio consiste en desarrollar un modelo de contabilidad en la gestión empresarial, teniendo en cuenta el desarrollo empresarial y la seguridad económica. De acuerdo con este objetivo, se determinó la tarea principal, desarrollar un mecanismo integral en términos de desarrollo comercial, conservación de recursos, producción, presupuestación y seguridad económica. Para desarrollar un modelo de contabilidad en la gestión empresarial, teniendo en cuenta el desarrollo empresarial y la seguridad económica, se aplicó el método de parametrización mediante el modelado de situaciones en condiciones modernas. Se fundamenta la necesidad de aplicar un enfoque sistemático, se proponen indicadores de seguimiento para determinar los riesgos y diversas amenazas para el funcionamiento y desarrollo de un negocio.

PALABRAS CLAVE: gestión; organización agraria; seguridad económica; integración.

Introduction

An important aspect of the successful functioning and economic development of agricultural organizations is the internal functional analytical structures of accounting and economic security that register and collect information for further study and corporate business management.

Current competition, generated under modern conditions in Russian market of production and product processing, impacts development and introduction of management accounting into the corporate management system of agricultural companies (Alborov et al., 2017).

Corporate management is a philosophy in modern economic part of all business processes and functioning of a complex for making strategic and important management decisions (Kostyukova and Bobryshev, 2016).

Agricultural company is expected to develop new approaches to improve efficiency of company operation and expand prospects for further development under conditions of some risk in the market (Ivashkevich, 2017).

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Economic safety assurance, achieved by establishing analytical centers and decentralization of management system, is an important aspect of successful functioning and economic development of agricultural company and whole business (Molchan, et al., 2020; Frantsisko, et al., 2020).

Management accounting and economic security in the corporate governance of an agricultural company have an important aspect for the functioning of a business.

The problems of management accounting and economic security of an organization are highlighted in many works of economists. Considerable experience has been accumulated in management accounting and economic security of the organization, however, management accounting from the point of view of economic security and corporate governance has its own characteristics, so this methodology requires development.

The aim of the study is to develop a management accounting model in corporate business management, taking into account business development and economic security.

Management accounting in corporate management of a company includes some functions such as business development management (Kontsevoi, et al., 2020).

Management accounting is a method of study and release of data planned by an owner of a business. Distributed by special means and communication channels, this data is intended for definite target users to present and promote business (an idea, final products or services) (Ostaev, et al., 2020).

Being integral part of economic safety system by its very nature, management accounting is an economic framework which gives precise estimation of different indicators influencing business.

Management accounting system comprises data of financial area, tax and management activity, and target, budget and forecast, and conceptualized conditions of business operation. This data takes into account some factors and internal and external threats (Khosiev, et al., 2019).

It should be noted that production cost accounting and output cost determination, being the integral parts of management accounting, combine data fields of financial and management accounting in agricultural company (Ostaev, et al., 2019). Data provision dispatch in rapidly fluctuating internal and external policy and business environment is a

distinctive and principal tool of management accounting in corporate business management (Popper, 2012).

Economic and Management Office and Accounting Office (financial, production and management) as well is expected to make reliable calculation of production cost for the sake of resource saving and providing production process. Being integral part of the corporate management structure, Accounting Office should be clearly differentiated by functions and operational tasks. The structure of accounting department in case of corporate management of agricultural company operation is presented in Table 1.

Table 1 – The structure of accounting department in corporate management of agricultural company operation

№ п/п	Accounting department	Management of company operation
1	Financial Accounting Department	In case of corporate management of company operation this department executes observing financial discipline and sustainable utilization of resources.
2	Production Accounting Department	In case of corporate management of company operation this department makes cost-information reports on production (works and services) costs, reveals fund-drainers and sources of non-manufacturing costs, prepares loss prevention measures.
3	Management accounting department	In case of corporate management of company operation researches on business development. Information is structured by significance in order to make strategic decisions.

Compiled by authors

Nowadays management accounting should become the integral information part of well-organized corporate management system of agricultural company operation. Efficiency of management of production operation is provided and supported by information about operation of structural departments and administrative and management departments and offices.

Choice and detailing of cost-accounting objects in corporate management of agricultural company operation is determined by specificities of production process and need and demand in accounting data from the side of business management (Kondratiev, et al., 2020).

Suggested model of management accounting in corporate business management regarding business development and economic safety is presented on Fig. 1.

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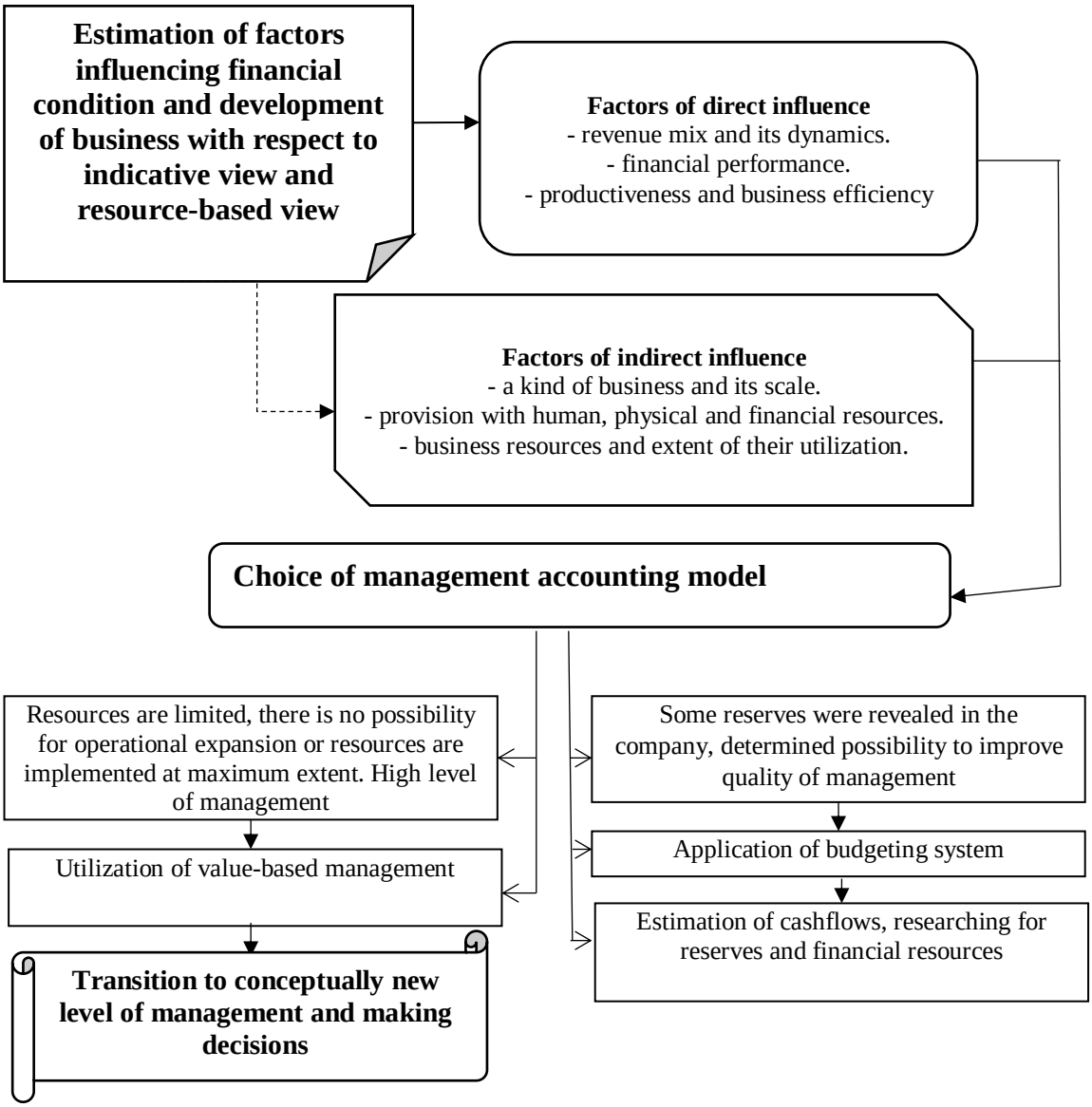

Fig. 1 – Recommended flowchart of determining model of management accounting in corporate business management (developed by the author)

Foremost technical and organizational characteristics of core production influence methodology and arrangement of management accounting in corporate business management. It is caused by the fact that specificity of industry is mostly expressed at the production stage. Hence, arrangement of the efficient information system of corporate business management depends on technical and organizational characteristics of production and processing of raw materials.

The more comprehensive description of busines characteristics and more detailed information, the more efficient decision of management to increase production profitability (Khoruzhy, et al., 2019).

Agricultural and processing companies can achieve targets set earlier in planning of business by means of reliable provision with information, analytical tools and reasonable management decisions. Any taken management decision should be based upon duly analyzed information with respect to economic efficiency, practicability, rate of return and efficiency. In a similar vein, development of a company requires long term outlook estimation of business with respect to management efficiency of company operation.

Considering the role of management accounting in company operation, it should be noted that management accounting is estimated insufficiently in Russia (Mukhina, et al., 2014).

It is caused by the fact that management accounting as a sub-system of bookkeeping accounting appeared quite recently in Russia. However, increasing scale of business, technological improvement and need for improvement of business management under crisis conditions make management accounting more important and cause its extensive use in management system.

1. Methodology

The theoretical and methodological basis of the research is the specific application of the theory of scientific knowledge to the subject of research. The research is based on the dialectical method, which determines the study of economic phenomena and processes in interrelation and continuous development. During the research, both general scientific research methods (dialectics, analysis, synthesis, consistency, complexity, analogy, optimization, etc.) and special techniques and procedures (comparison, grouping, generalization, etc.) were used.

The new provisions are substantiated by the results of research and observations obtained by comparative-historical, dialectical-synthetic and abstract-logical methods. The theoretical basis of the research is the works of domestic and foreign scientists on the problems of theory and methodology of management accounting. The methodological basis of the study was formed by the theory of economic development and related theoretical and practical aspects of the methodology and organization of management accounting.

The significance of the study lies in substantiating the nature of the relationship between the effectiveness of the development of management accounting and economic security in the corporate governance of an agricultural organization.

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2. Results and discussion

Achievement of developmental aims of an object and introduction of these aims into definite business processes are linked with great labor in management accounting and forecasting of condition of a managed object. Reasonable planned model in management accounting is always developed with use of monitoring and forecast data which basically contain analytical results of operation of an economic object over prior periods and other significant internal and external trends. Consequently, the following functions are observed at the initial stage of management process:

– multivariable economic analysis as a set of works in estimation of obtained results (detecting and identification of reserves for further development).

– strategic forecasting as a set of business models of economic actions, which might take place in future.

– adoption of necessary plans and budgets in order to define actions in further economic development of an object.

Management accounting in corporate business management is expected to solve long term outlook problems (Table 2). Development of the model of management accounting in agricultural company assumes that there are some ways of economic future and economic condition is variable one.

Agricultural company should stay capable to keep progressive development and assign its resources to support stable condition under effect of big number of factors of internal and external environment and impact of instability and uncertainty. Hence, management and minimization of risks, appearing during operation activity, should be paid special attention.

In order to define top-priority ways of development, monitoring should be carried out and financial and other indicators of activity should be estimated for budgeting aims as well (Dalkey and Helmer-Hirschberg, 1962).

There are indicators defining quality of budgeting, which characterizes quality of management activity, i.e. statistical and dynamic stability (Rokotyanskaya, et al., 2018).

Statistical stability keeps indicators at the same definite level, and dynamic stability identifies positive changes characterized by development of indicators.

Management decentralization requires arrangement of management accounting by responsibility centers, that helps estimate results and efficiency of activity of each business

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segment and its share in total result of operation activity of a company.

Table 2– Management accounting in corporate business management as a guarantee of solving long term outlook problems

No.	Parameter	Planned level	Forecasted level
1	Time slot	Time period for which a company has or can make detailed plans of development of business	Time period which is out of detailed plans and budgets.
Nota bene: Distance, space between equally spaced positions is time period			
2	Risks	Plans with respect to indicative specificities do not comprise big faults and their forming is not related to unacceptable costs for business	Formation of plans and budgets is related to high extent of unreliability and/or big costs.
Nota bene: Risk analysis considers internal and external threats.			
3	Information	Utmost detailed and reliable information concerns future business process in a company.	Information is generalized and often has high extent of uncertainty.
Nota bene: Detailed elaboration of information is a primary target.			
4	Limits	Opportunity of forming detailed budget is directed from business operation plans.	Indicators of business activity should be modeled in aggregative view or they should have probabilistic nature.
Nota bene: Limits provide answers on questions about given criteria.			

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Arrangement of management accounting by responsibility centers comprises:

– Development of appropriate budgets defining short-term prospects of activity of these centers.

– Arrangement of accounting of costs, incomes and financial results of activity. Responsibility center defines objects of accounting.

– Arrangement of control of planned and descendent facts of business activity of these responsibility centers.

– Formation of internal reporting by responsibility centers in conformance with established system of controlled indicators.

– Analysis of results of activity of responsibility centers and definition of their impact on results of business activity of a company.

Specific conditions of activity of appropriate responsibility centers that is their resource and production capacity, environmental and economic factors of activity, their margin of discretion and responsibility should be considered during development of budgets.

Variation of structure of budget and its expenditure depends on individual, social, economic, environmental, resource and other specificities of a business unit.

Development of budgeting framework defining quality of management of activity is presented on Fig. 2.

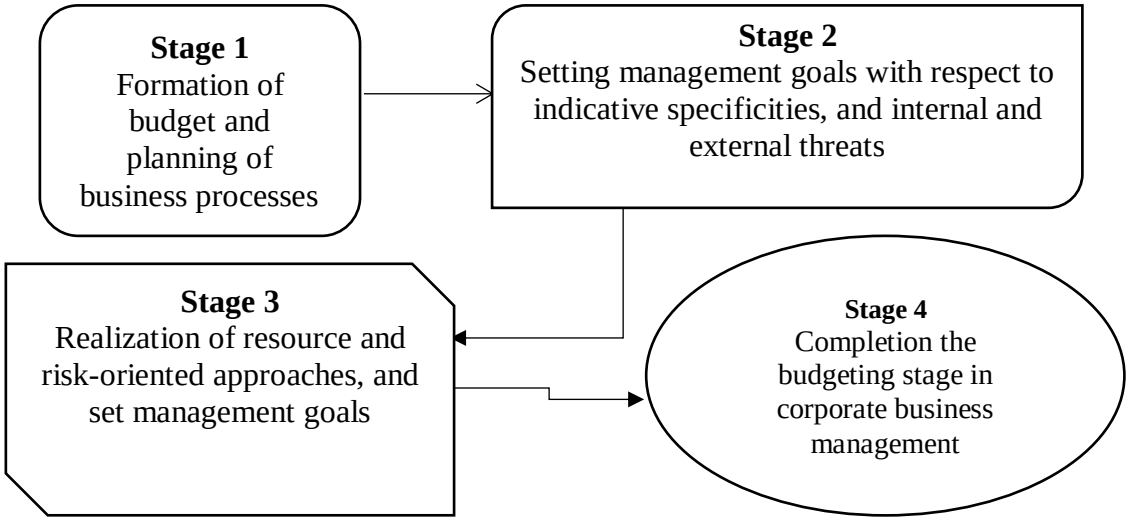

Fig 2 – Flowchart of development of budgeting framework defining quality of management activity (author's development)

Besides, management accounting in corporate business management secures economic safety and it is expressed in protection of interests of agricultural company from appearing threats and providing condition for steady development of a business unit. Reliable and efficient system of economic safety can secure stable social and economic development of a business unit.

Management Accounting Office and Economic Safety Office of a business unit should act as a single entity in the system of monitoring, identification of risks and some threats for operation and development of business.

Being integrated they help define those parameters which should be decided for making reasonable management decisions (Fig.3).

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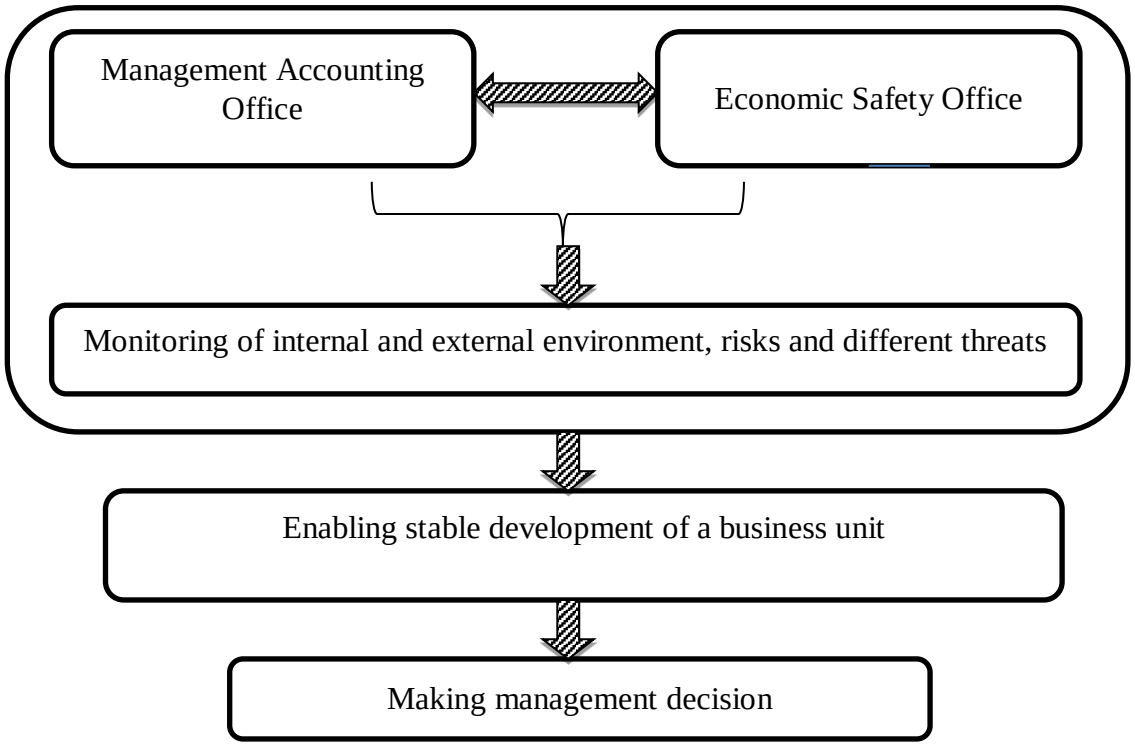

Fig. 3 – Management Accounting Office and Economic Safety Office in the corporate management system of company operation (author's development)

In management accounting some indicators are chosen and subdivided into groups depending on the objects of indicative analysis in order to define criteria of economic safety.

In this research the indicators presented in Table 3 were taken as the universal indicators of economic safety. They define efficiency of agricultural company operation.

A set of indicators used for estimation of economic safety by means of analysis of values of these indicators helps reveal the factors which impact positively and negatively economic safety of a business unit. Consequently, negative impact should be minimized, and positive impact should be strengthened.

The factors of negative impact might cause the following risks for an economic safety system: marketable and material, spatial and time, monetary and cost, intellectual, reference and information, capacity and labor, and special kinds of losses.

The economic safety system in corporate business management is presented on Fig. 4.

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Table 3 – Indicators for economic safety estimation in agricultural company

Indicator	Description	Quality scoring (indicators)			
		4	3	2	1
Indicators of production activity					
Dynamics of revenue	Profitability indicator is the main one for estimation of a company. There is direct dependence of this indicator and internal control system, the more efficient operation of internal control system the more successfully the main goal can be achieved. The main goal of a company is getting profit and increasing prosperity of owners.	> 100	51-99	10 - 50	< 0
Dynamics of sales profit		> 100	51-99	10 - 50	< 0
Indicators of financial condition estimation					
Total Debt to Equity	The indicator identifies degree of financial independence of a company from the point of arrangement of total capital.	> 0,8	0,5 - 0,8	0,1 - 0,5	< 0
Current liquidity ratio	The indicator identifies the most of financial solvency of a company.	> 2	1,7 - 2	1 – 1,7	< 1
Degree of solvency on current liabilities	One of the main indicators used for estimation of financial solvency of a company. It helps define the terms when a company can pay off current liabilities under the condition of saving average monthly revenue at the level of accounting period. Recommended value is Кпто ≤ 3..	≤ 3	1,1 – 2,99	0,1 - 1	< 0
Indicators of efficient utilization of resources, capital and costs					
Return on Sales	The indicator gives a comprehensive view of level of efficiency of utilization of company's resources.	> 3	1 - 3	0,1 - 1	< 0
Return on Assets		> 3	1 - 3	0,1 - 1	< 0
Return on Equity		> 3	1 - 3	0,1 - 1	< 0
Yield of capital investments	The indicator identifies level of efficiency of utilization of basic production assets of a company.	> 5	3 - 5	1 - 3	< 0

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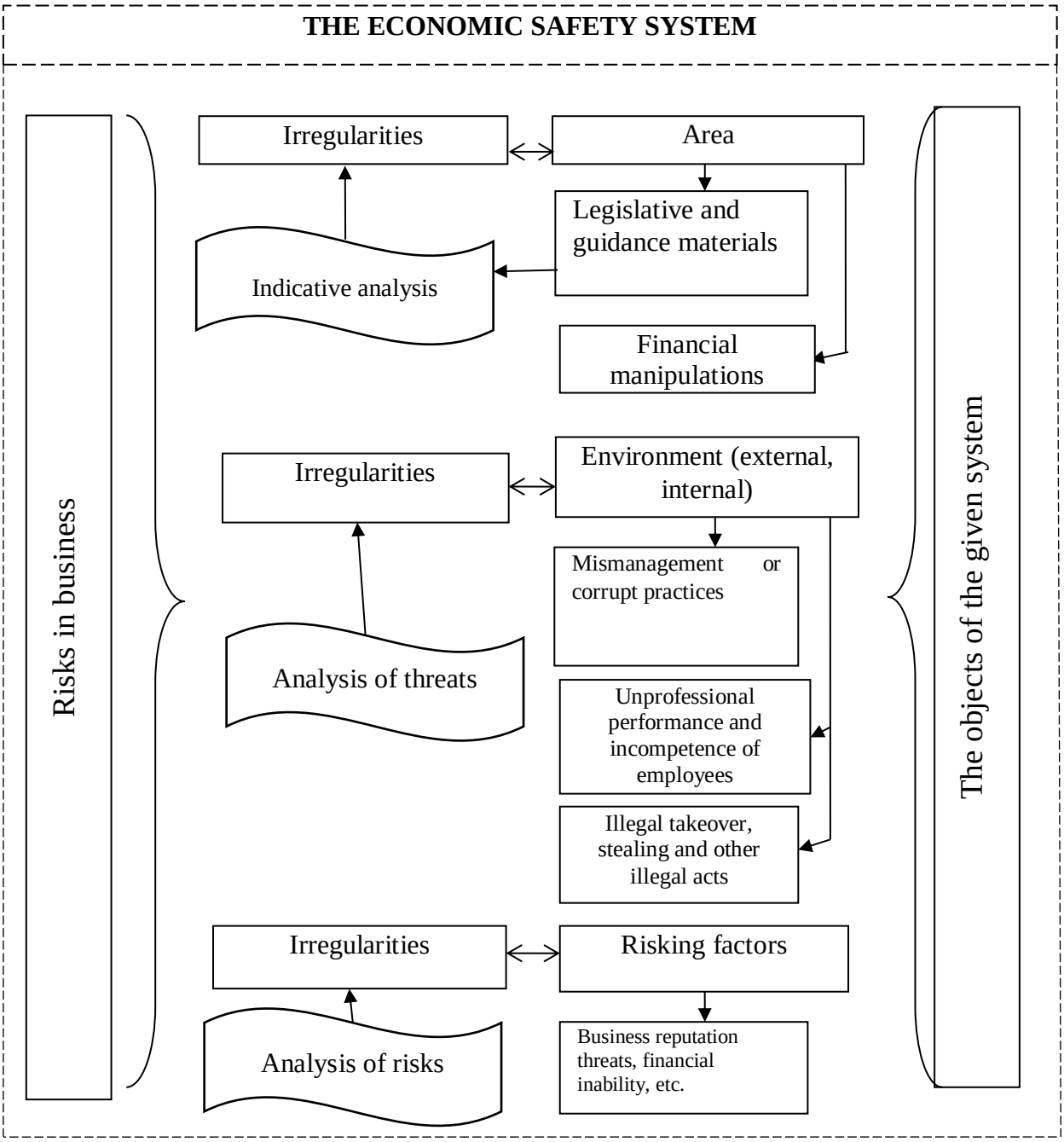

Fig. 4 – The economic safety system in corporate business management (author's development).

Economic safety is provided by Security Office and specialists of Management Accounting Office who perform monitoring of all activity areas of agricultural company.

Management accounting is a such tool of economic safety of business which protects against impact of internal and external derogative factors and provides (reveals) reserves of appropriate resources and management methods.

In order to improve economic safety at business level, management accounting mostly contains aspects of budget formation and distribution of economic resources. Hence, the

matter of costs, control and improvement of fiscal capacity execution should be resolved in management accounting.

Under conditions of digitalization cooperation of management accounting offices in corporate management system of agricultural company is arranged by posting objectives and making tasks within processes and beyond processes with respect to risk management. The task is given to one or more specialists, the terms of performance and the aim of the task is defined, and necessary documents are attached to this task.

The risk management system in agricultural company should be aimed to provide reasonable assurance in performance of the tasks given to a business unit (Table 4).

Table 4 – Targets of risk management in agricultural company

No.	Target of corporate management	Target area
1.	Strategic targets	Providing financial stability and improvement of financial condition of business
2.	Operation targets	Providing efficiency of financial and operational activity, resource saving, and preservation of company's assets.
3	Targets in reporting preparation	Providing completeness and reliability of accounting reports, statistical, management and other accountings.
4	Targets in law observation	Observing of applicable legislation and local regulations

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The objectives of the risk management system are development of risk-based corporate culture, improvement of the process of making decisions and choosing the way of response risk in favor of providing economic efficiency of actions on risk management and economic expediency, reduction of unexpected events and losses in operation activity by extending detection of potential events and taking appropriate actions (response risks), and identification and management total risks in operation activity in favor of more efficient responding different impacts with help of integrative approach.

Conclusion

The results of this research can be used for development theoretical and practical issues of management accounting for the sake of economic safety in any company. So it can

be concluded that companies are expected to collect and process accounting and management information together with accounting and analytical information in order to obtain impartial assessment of internal and external environment in spite of difficulties and specific nature of management accounting for economic safety. Companies should also analyze their operation activity in order to decrease risks. Issues of management accounting and economic safety in corporate management are acute ones and need constant and active research.

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Gestión del Laboratorio Bioambiental de la Universidad Nacional Experimental del Táchira (UNET) como referente de datos físico-químicos de los suelos del estado Táchira-Venezuela

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Cristopher Camargo**
Alexandro Barbosa***
Juan Montilla ****
Erika Trujillo*****
Lency Chacón******

RESUMEN

Los laboratorios de suelos se encargan de ofrecer servicio al público para el análisis de suelos, con un estricto control de calidad que permita la confiabilidad de sus resultados. La correcta interpretación de sus parámetros permite realizar recomendaciones acertadas en beneficio del productor con criterios de sostenibilidad. El objetivo de este artículo es destacar la gestión del Laboratorio Bioambiental de la Universidad Nacional Experimental del Táchira (UNET), como centro de análisis de muestras de suelos y referencia de datos físico-químicos derivados de los mismos para el estado Táchira-Venezuela, mostrando su cobertura geográfica y los promedios generales. Para ello se ubicaron las muestras registradas mediante la utilización de un sistema de información geográfica (SIG), asegurando contener datos de 29 municipios, y se analizaron de forma general para el estado Táchira, entre los años 2015-2019. Los resultados mostraron que la mayoría de los suelos son de textura gruesa y los valores físico-químicos indican que el estado Táchira cuenta con tierras aptas para la actividad agrícola y ganadera.

PALABRAS CLAVE: suelo; Sistema de Información Geográfica; fertilidad del suelo; procesamiento de datos.

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Management of the Bioenvironmental Laboratory of the National Experimental University of Táchira (NEUT) as a reference of physical-chemical data of the soils of Táchira state-Venezuela

ABSTRACT

Soil laboratories are responsible of offering a service to the public for the analysis of soils, with a strict quality control that allows the reliability of their results. The correct interpretation of its parameters allows to make accurate recommendations for the benefit of the producer with sustainability criteria. The objective of this article is to distinguish the management of the Bioenvironmental Laboratory of the National Experimental University of Tachira (NEUT), as a center for the analysis of soil samples and reference of physicochemical data derived from them for the Táchira state -Venezuela, showing its geographic coverage and general averages. For this purpose, the registered samples were located through the use of a geographic information system (GIS), ensuring they contain data from 29 municipalities, and they were analyzed in a general way for the state of Táchira, between the years 2015-2019. The results showed that most of the soils have a coarse texture and the physical-chemical values indicate that the state of Táchira has suitable lands for agricultural and cattle activities.

KEY WORDS: soils; Geographic Information System; Soil fertility; data processing.

Introducción

A nivel mundial los laboratorios de suelos cuentan con una gran responsabilidad al ofrecer servicios de análisis y recomendaciones de fertilización, los cuales serán más exactos, precisos y adecuados en la medida en que el muestreo de suelos haya sido representativo del lote de interés, es decir, recolectando un mayor número de muestras compuestas (Roberts y Henry, 2001; Lizcano *et al*., 2017). El análisis de suelos es una herramienta que reúne una serie de variables analizadas de forma integral por un Ingeniero agrónomo o un asistente técnico experto, el cual permite dar una interpretación para un plan de fertilización de un determinado cultivo; y es por esta razón que es importante realizar de modo correcto el muestreo agrícola para evitar una recomendación equivocada que ocasione una baja productividad al agricultor (Lizcano *et al*., 2017). Además, los laboratorios de análisis de fertilidad de los suelos permiten

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generar mapas digitales y georreferenciados con el fin de planificar un mejor uso del suelo e incrementar el rendimiento de los cultivos (Villareal, 2018), y también sirven como soporte fundamental para el desarrollo de investigaciones relacionadas con el área agrícola gracias a la determinación de los parámetros físico-químicos que ofrecen (Blanco *et al*., 2021).

A pesar de no contar con datos actualizados de los suelos del estado Táchira, se puede mencionar de modo general, con respecto al uso y disponibilidad de tierras, que un 22,4% (198 001 ha) de estas han sido destinadas unicamente a la agricultura (MARNR, 1986; Valero, 2009); De igual modo se conoce que la actividad económica predominante en municipios como: Jáuregui, José María Vargas, Michelena, Lobatera, Andrés Bello, Seboruco y Ayacucho, entre otros, es precisamente la actividad agrícola (Caraballo, 2003; Castillo *et al*., 2014). Por ello, contar con análisis de suelos, constituye la base para obtener el mayor provecho de este recurso en el estado.

El Laboratorio Bioambiental de la Universidad Nacional Experimental del Táchira (UNET), anteriormente conocido como el Laboratorio de Suelos y Agua, desde sus comienzos en marzo de 1983, ha prestado servicio al público, especialmente a los productores agrícolas de la región, ofreciéndoles análisis de rutina de muestras superficiales de suelos, mediante los cuales los productores pueden conocer el recurso que están utilizando, hallar sus limitaciones y potencialidades, así como obtener de personal especializado en el área, las recomendaciones agrícolas óptimas que mejoren la relación costo/beneficio con un enfoque ambientalmente aceptable (Martínez *et al*., 2006). Hoy día el Laboratorio también ofrece servicios de análisis de agua y de alimentos y ha ampliado su gestión en los últimos años a ofrecer servicios y asesorías especializadas en cualquier área del sector agrícola al contar con personal altamente calificado que forma parte de la UNET.

El Laboratorio Bioambiental cuenta con una considerable y variada información sobre características físicas y químicas de los suelos del estado Táchira, la cual permitó a Martínez *et al*. (2006), mostrar a partir del empleo de un Sistema de Información Geográfica (SIG), como la misma se puede organizar, analizar y divulgar. No obstante, en el Laboratorio es común que luego de entregar los resultados de los análisis de rutina al agricultor, los datos queden represados como información interna sin ser procesados con la minuciosidad requerida para

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fines de interés académico, subutilizandose así una información confiable, de calidad y referencial para el estado Táchira.

En vista de esta situación, el objetivo de este trabajo es destacar la gestión del Laboratorio Bioambiental UNET como centro de análisis de muestras de suelo y referente de datos físico-químicos de los suelos del estado Táchira, mostrando la ubicación geográfica a partir de la cual provienen los datos y los valores promedios encontrados en los análisis de rutina.

1. Metodología

1.1. Manejo de las muestras en el Laboratorio

Las muestras de suelo cuentan con un manejo desde la toma de las mismas hasta la entrega de resultados al cliente. Previa consulta, el cliente se asesora de la forma correcta de la toma de muestra y traslado de la misma al Laboratorio (Figura 1). Seguidamente se realizan los análisis de rutina que generalmente son: Textura (Bouyoucus), Materia orgánica (Walkley y Black), Fósforo disponible (Bray I 0,03 M NH4F + 0,025 M HCl), Cationes intercambiables (extracción con acetato de amonio 1 M pH 7,0), pH (pH-metro) y Conductividad eléctrica (conductímetro).

1.2. Metadatos y ubicación de las muestras

Con la finalidad de ubicar puntualmente y de forma fidedigna las muestras recibidas en el Laboratorio Bioambiental UNET, se decidió procesar los datos de los últimos cinco años laborales ininterrumpidos, las cuales corresponden a las muestras de suelos sometidas a análisis durante los años 2015 y 2019 para el estado Táchira (no se incluyeron los años siguientes debido a las diversas interrupciones de actividades del Laboratorio ocasionada por el COVID-19). Los mismos fueron localizados mediante el software de sistema de información geográfica QGis versión 3.16.13, a partir de la información suministrada en la planilla de recepción de análisis (Figura 2), la cual fue precisada con capas vectoriales político-administrativas del SIGOT (Sistema de Información para la Gestión y Ordenación del Territorio) y un mosaico ráster de cartas a escala 1: 100 000 desarrolladas por el IGVSB (Instituto Geográfico Venezolano Simón Bolívar), aunado a aplicaciones web como Google

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Earth (https://earth.google.com/web/), Google Map (https://www.google.com/maps/) y el Directorio de Los Gelvez (https://gelvez.com.ve/), entre otras.

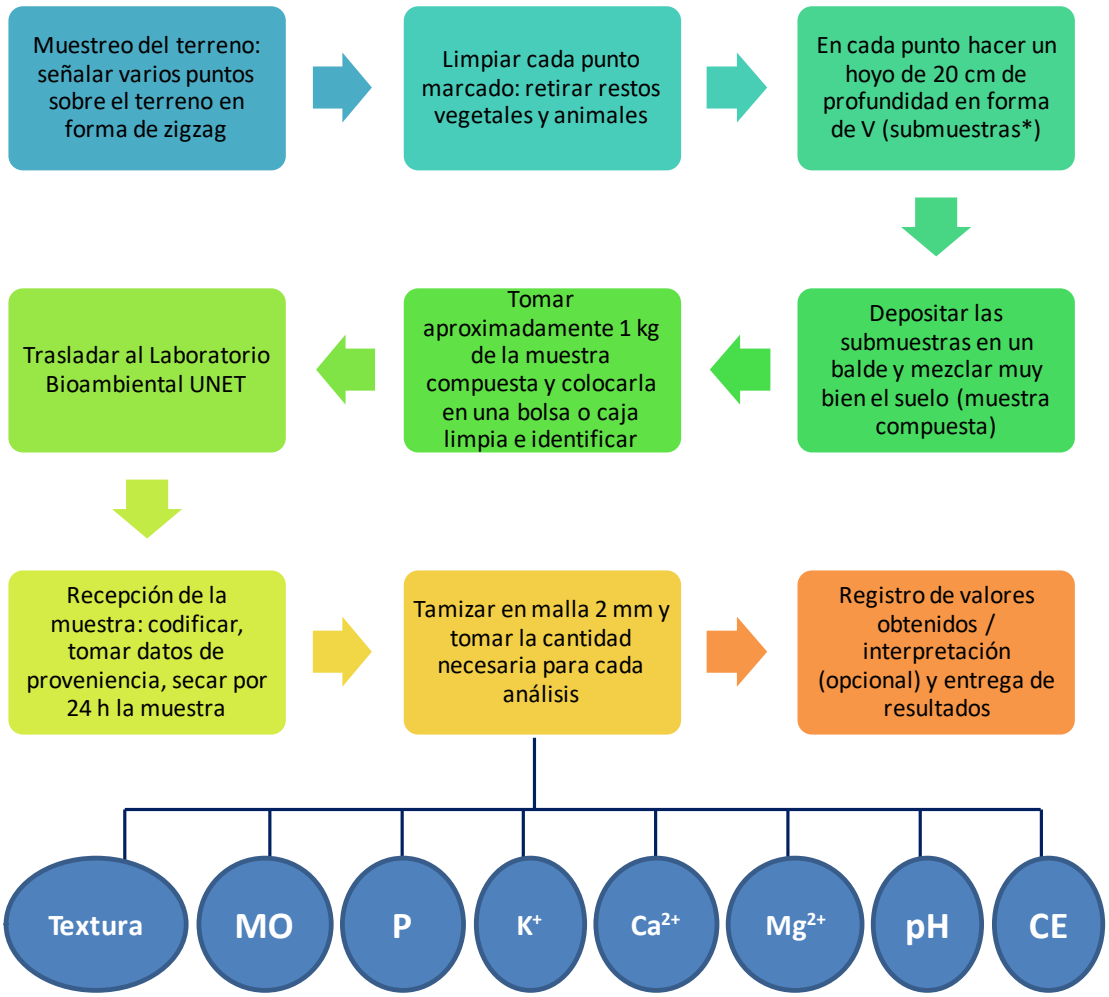

Figura 1. Flujograma del procesamiento de las muestras del suelo en el Laboratorio Bioambiental UNET. MO = materia orgánica; CE = conductividad eléctrica. *El número de submuestras se determina de acuerdo a las características del lote de terreno con previa consulta al Laboratorio.

1.3. Análisis de datos

Los datos de cada una de las propiedades de los suelos se procesaron con Microsoft Office Excel 2007. Asimismo, los resultados de los ánalisis de los suelos se interpretaron bajo los criterios establecidos por PALMAVEN (1992). Los datos de la propiedades de los suelos se analizaron con estadísica descriptiva (media, desviación estandár, valor mínimo y máximo). Además, se realizó el análisis de correlación de Spearman, un método estadístico no

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paramétrico, que pretende examinar la intensidad de asociación entre dos variables cuantitativas (Mondragón, 2014) derivada de un análisis matricial con propiedades del algera lineal (Restrepo et al., 2007), utilizando el software Past3 (definiendo como variables cada una de las propiedades estudiadas). Para ello se estableció una prueba de hipótesis a un intervalo de significancia del 95%, estableciéndose un valor p asociado al estadístico de contraste menor que alfa (0,05) para rechazar como hipótesis nula (H0= 0), que las variables presentan una asociación entre sí (H1≠0).

UNIVERSIDAD NACIONAL EXPERIMENTAL DEL TACHIRA
VICERRECTORADO ACADÉMICO
DECANATO DE EXTENSIÓN
COORDINACION DE EXTENSION AGRARIA
LABORATORIO BIOAMBIENTAL UNET

RECEPCIÓN DE SUELOS PARA ANÁLISIS

FECHA DE RECEPCIÓN: _____ FECHA DE ENTREGA: _____

INFORMACIÓN DEL CLIENTE

Nombre del Cliente: _____ Cédula - Rif_____
Finca o Empresa: _____ Teléfono: _____
Dirección/Localidad: _____ Email: _____
Ciudad: _____ Municipio/Parroquia_____ Estado: _____

INFORMACIÓN DE LA MUESTRA

Fecha de Muestreo	Identificación dada por el cliente	Profundidad Muestreo (cm)	Cultivo a Sembrar	Fertiliza		Cód. Muestra
				SI	NO	

Muestra Tomada por:_____

ANÁLISIS REQUERIDOS.

Análisis Físicos	Análisis Químicos	Macronutrientes	Micronutrientes
___ Granulometría	___ pH	___ Fosforo	___ Cobre
___ Textura	___ C. Eléctrica	___ Potasio	___ Hierro
___ Densidad Aparente	___ Materia Orgánica	___ Calcio	___ Zinc
___ Densidad Real		___ Magnesio	___ Manganeso
___ Porosidad Total		___ Azufre	___ Sodio

Observaciones: _____

Figura 2. Planilla de recepción de datos de las muestras.

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2. Resultados

2.1. Muestras de suelos del estado Táchira

La localización de las muestras de suelos generó una capa vectorial (puntos) que permitió su representación cartográfica y a su vez, una base de datos con 644 registros (100%) que fue exportado en formato dbf (database file) para ser abierto y procesado en excel. De dichos datos, 474 (73,6%) están solo basados en la información existente en las planillas de recepción de análisis (municipio, parroquia y localidad, sin coordenadas geográficas o UTM); 132 (20,5%) fueron corroborados con los usuarios de las fichas vía telefónica o e-mail, quienes suministraron la correcta ubicación de las muestras (envío de capturas de imágenes de Google Earth y Map con sus respectivas coordenadas); 14 (2,17%) registros presentaron las coordenadas en las planillas; 2 (0,31%) solo presentaron direcciones detalladas confiables y finalmente 7 (1,09%) aunque no poseían planillas de recepción, fueron ubicadas a partir de la información digital existente (base de datos del Laboratorio). Para efectos del análisis se incluyeron 15 datos internos del Laboratorio (2,33%), correspondientes a análisis realizados en los años 2006, 2009 y 2012 con el fin de incluir al menos cinco muestras en aquellos municipios que tenían bajo o nulo número de registros (como fue el caso de los municipios Simón Rodríguez, Francisco de Miranda y Sucre), para de esta forma completar la base de datos de los 29 municipios del estado Táchira (Figura 3).

En relación al registro de las muestras de los suelos durante el período 2015-2019 (Figura 4), se registraron 244 muestras (38,79%) para el año 2015, 160 muestras (25,44%) en 2016, 62 muestras (9,86%) en 2017, 107 muestras (17,01%) en 2018 y 56 muestras (8,9%) en 2019, siendo 629 la totalidad de las muestras.

En el mismo orden de ideas, se obtuvo que el municipio con mayor cantidad de muestras de suelos analizadas es Fernández Feo con 115 (17,86%), seguido por García de Hevía con 57 (8,85%), Libertador con 51 (7,92%), Michelena con 49 (7,61%) y Lobatera con 36 (5,59%). Por su parte, los municipios con menor número de muestras fueron San Judas Tadeo y Sucre con 6 muestras cada uno (0,93%), Pedro María Ureña, Seboruco y Simón Rodríguez con 5 muestras cada uno (0,78%) y Francisco de Miranda con 4 muestras (0,62%) (Tabla 1).

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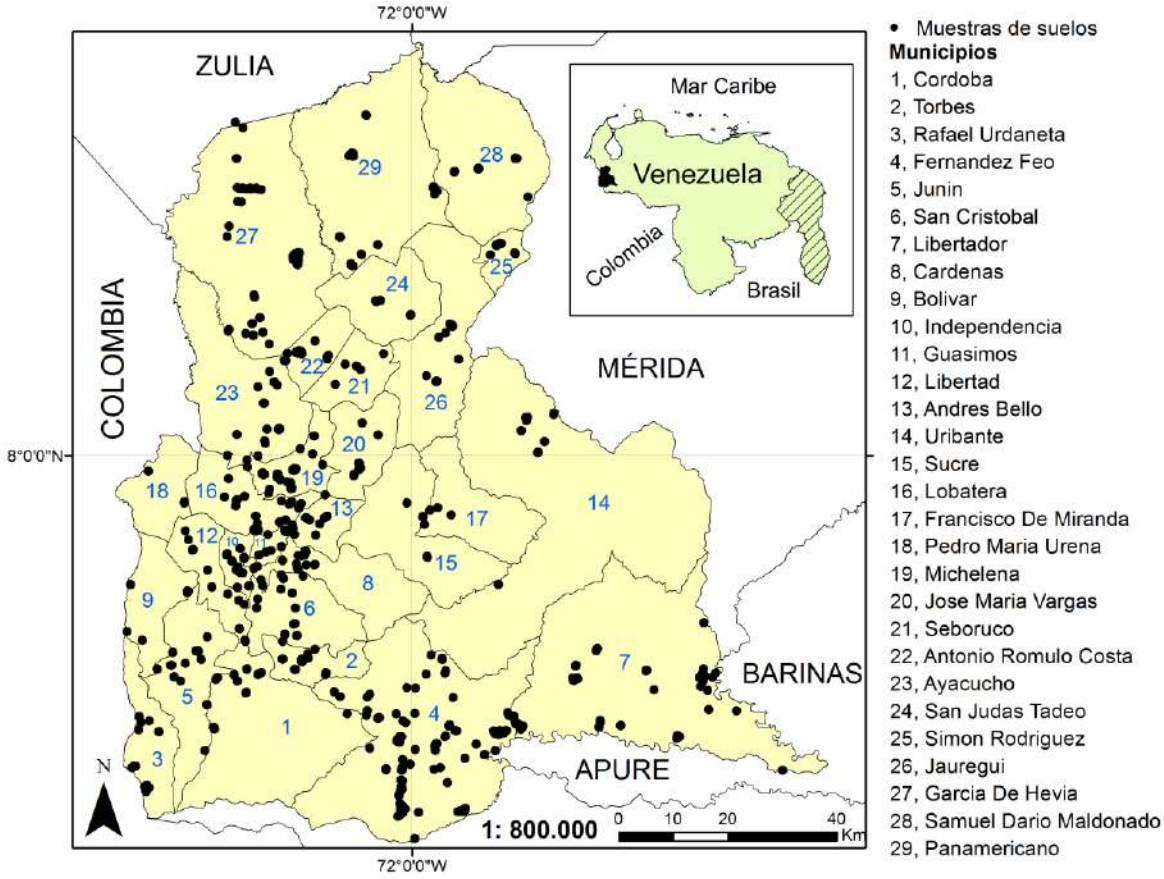

Figura 3. Ubicación de las muestras de suelo del estado Táchira entre los años 2015-2019 del Laboratorio Bioambiental UNET.

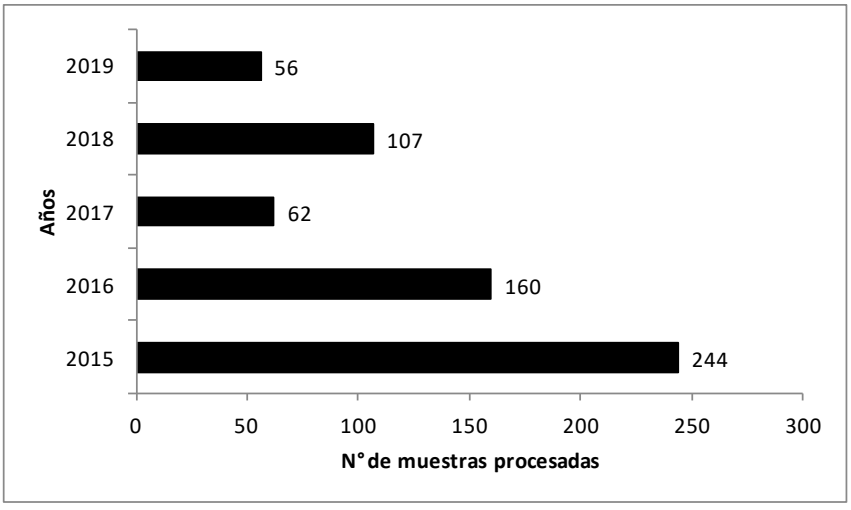

Figura 4. Número de muestras de suelos procesadas en el Laboratorio Bioambiental UNET en los años 2015-2019.

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Tabla 1. Número de muestras analizadas por municipio durante el periódo estudiado (incluyendo las muestras de los años 2006, 2009 y 2012).

Municipio	Nº de Muestras	%
Fernández Feo	115	17,86%
García de Hervia	57	8,85%
Libertador	51	7,92%
Michelena	49	7,61%
Lobatera	36	5,59%
Panamericano	27	4,19%
San Cristobal	24	3,73%
Cordoba	23	3,57%
Independencia	23	3,57%
Antonio Rómulo Costa	21	3,26%
Ayacucho	21	3,26%
Junín	20	3,11%
Tórbes	20	3,11%
Cárdenas	19	2,95%
Rafael Urdaneta	15	2,33%
Uribante	15	2,33%
Andrés Bello	13	2,02%
Libertad	12	1,86%
Jauregui	11	1,71%
José María Vargas	11	1,71%
Samuel Dario Maldonado	11	1,71%
Bolívar	10	1,55%
Guásimos	9	1,40%
San Judas Tadeo	6	0,93%
Sucre	6	0,93%
Pedro María Ureña	5	0,78%
Seboruco	5	0,78%
Simón Rodríguez	5	0,78%
Francisco de Miranda	4	0,62%
Total	644	100,00%

2.2. Propiedades físico-químicas de los suelos del estado Táchira

El análisis de los datos existentes permitió conocer los valores de referencia para los suelos del estado Táchira. En la Figura 5 se observa que más del 70% de los suelos de los

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municipios del estado pertenecen a la clase textural franco arenoso (Fa), un suelo de textura gruesa y el resto de suelos están caracterizados como franco arcillosos (FA), Franco Arcillo arenosos (FAa) y francos (F) que corresponden a suelos de textura media, resultados concordantes con los señalados en PALMAVEN (1992).

En el análisis estadístico descriptivo de los datos (Tabla 2), se observó que la mayor desviación estándar fue presentada en el Ca seguido del Mg, K y P respectivamente. Por otro lado, MO, pH y CE fueron menores a una desviación. A partir de dichos valores, y según los criterios de Palmaven (1992), se consideró los valores de MO y P con una interpretación medio para los suelos del estado Táchira, en cuanto a los valores de K, Ca y Mg, la interpretación es alto. Por otra parte, el pH de los suelos del estado Táchira tienen la tendencia a ser fuertemente ácidos. Finalmente, en lo que respecta a la CE, esta es baja, es lo que indica que no afecta el desarrollo de los cultivos.

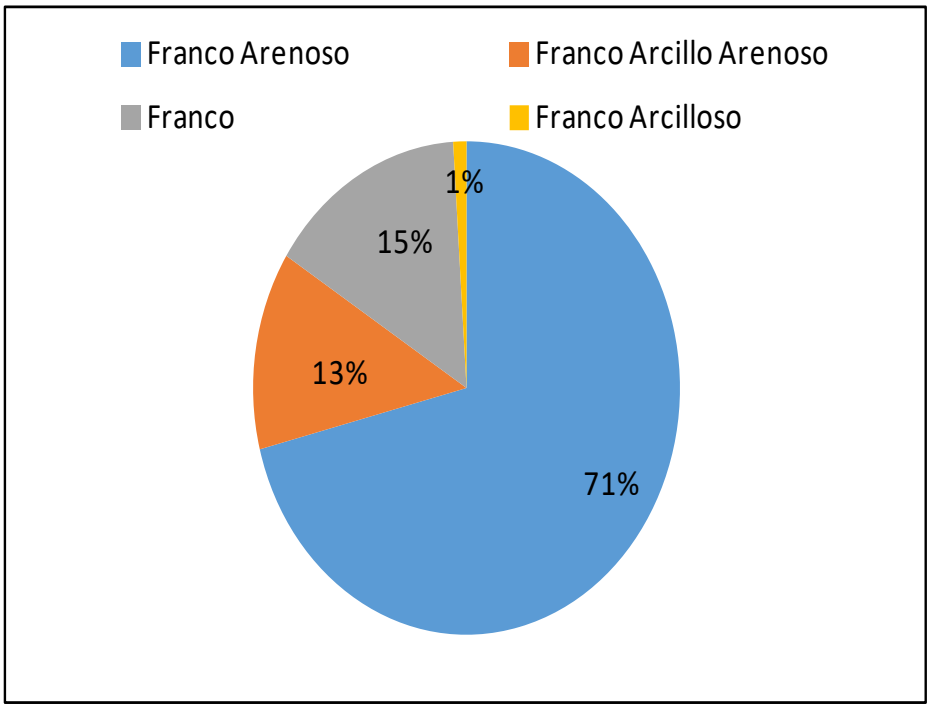

Figura 5. Porcentaje representativo de las clases texturales presentes en los datos analizados de suelos del estado Táchira 2015-2019.

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Tabla 2. Promedio general de los parámetros químicos determinados en los suelos del estado Táchira en el Laboratorio Bioambiental UNET 2015-2019.

Propiedad	Unidades	Media ± DE	Valores mínimos	Valores máximos	Interpretación*
MO[a]	%	1,92±0,99	0,02	7,86	Medio
Pdisp[b]	$mg.kg^{-1}$	25±17	2	242	Medio
K[c]	$mg.kg^{-1}$	155±99	1	4188	Alto
Ca[c]	$mg.kg^{-1}$	894±500	4,33	7435	Alto
Mg[c]	$mg.kg^{-1}$	176±134	0,08	5369	Alto
pH[d] 1:2,5	-	4,95±0,39	3,36	9,26	Fuertemente ácido
CE[e] 1:5	$mS.cm^{-1}$	0,116±0,053	0,01	1,25	Bajo: No afecta ningún cultivo

DE desviación estándar; [a]MO Materia orgánica por Walkley y Black; [b]Fósforo disponible por Bray I (0,03 M NH_4F + 0,025 M HCl); [c]Cationes intercambiables por extracción con acetato de amonio 1 M pH 7,0; [d]pH en agua 1:25 con pH-metro; [e]Conductividad eléctrica 1:5 con conductímetro. *Interpretación de acuerdo con el manual de análisis de suelo de PALMAVEN (1992).

En lo que respecta al análisis de correlación de Spearman entre las variables, se encontró que las mayores asociaciones positivas se dieron entre Pdisp y CE, seguido por Pdisp y K^+, Ca^{2+} y pH principalmente, estas fueron seguidas Mg^{2+} y pH, K^+ y Ca^{2+}, Ca^{2+} y Mg^{2+}, K^+ y Pdisp y finalmente por Pdisp y Ca^{2+}. En cuanto a las restantes positivas aunque fueron mayores al estadistico de contraste, sus asociaciones fueron bajas. En último lugar, se obtuvieron relaciones negativas entre MO y Pdisp y entre Pdisp y pH, siendo las únicas relaciones que se rechazan en la prueba de hipótesis (Tabla 3).

3. Discusión

Es notorio que el número de muestras procesadas por año ha tendido a disminuir debido principalmente a los incesantes paros universitarios en respuesta a la situación de crisis económica del país, que afectan directamente el continuo funcionamiento del Laboratorio Bioambiental de la UNET. Además, las continuas limitaciones de servicios públicos del estado Táchira, como la disponibilidad de combustible, que limita el traslado desde los distintos

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municipios hacia la ciudad San Cristóbal y viceversa, de las muestras tomadas por los agricultores, técnicos y público en general interesado en la realización de análisis de suelos.

Tabla 3. Coeficiente de correlación de Spearman entre las variables determinadas en el Laboratorio Bioambiental UNET.

	MO	Pdisp	K^+	Ca^{2+}	Mg^{2+}	pH	CE
MO	1						
Pdisp	-0,037	1					
K^+	0,228	0,626*	1				
Ca^{2+}	0,091	0,461*	0,580*	1			
Mg^{2+}	0,113	0,204	0,226	0,560*	1		
pH	0,202	-0,026	0,270	0,620*	0,573*	1	
CE	0,184	0,665*	0,514*	0,353	0,154	0,146	1

Los valores marcados con * indican una correlación significativa ($p<0,05$). MO = materia orgánica. Pdisp = fósforo disponible. CE = conductividad eléctrica.

Se corroboró que el Laboratorio Bioambiental UNET maneja registros de los 29 municipios del estado Táchira (Tabla 1). Por esta razón se considera que existe una base de datos representativa de los suelos del estado, que permitió generar un análisis estadístico descriptivo (Tabla 2), que hasta el momento, no se habían determinado para nuestra entidad y que ahora pueden servir como referencia y estar a disposición de investigadores y público en general con interés en el recurso suelo. Sin embargo, en vista de los inconvenientes de la planilla de registro de muestras para ubicar las muestras, se consideró hacer modificaciones de la planilla, como la inclusión de un punto de referencia en la dirección y las coordenadas UTM, con el apoyo de Google Earth, Google map, entre otros, para las siguientes recepciones de muestras; recursos que no estaban disponibles para Martinez *et al.* (2006) al momento de geolocalizar la información de suelos tratada en el Laboratorio.

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Es pertinente acotar que los análisis de suelos presentan un nivel de nutrimentos bajo, medio, alto y muy alto, indicativo de la posibilidad de obtener una respuesta adicional con la aplicación de un fertilizante (mientras más alto el contenido del nutriente en el suelo, menor probabilidad de obtener una respuesta con la aplicación de fertilizantes) (PALMAVEN, 1992). En este sentido, Casanova (2005) ha señalado que la materia orgánica es altamente importante para el crecimiento de las plantas, ya que esta mediante la mineralización libera cantidades apreciables de nitrógeno, azufre y fósforo y algunos micronutrientes esenciales para el crecimiento y producción de las plantas. Asimismo, se considera que hay un contenido de N del 5,8% en la MO y que la MO mejora las características físicas y el almacén de energía para la vida microbiana del suelo (Trinidad-Santos y Velasco-Velasco, 2016). Por lo tanto, si un suelo posee poca materia orgánica es necesario incorporar antes de la siembra mediante la adición de abonos orgánicos y residuos vegetales e industriales apropiados. Para el caso del P disponible, de acuerdo con Bravo (2000) este representa apenas el 1% del P total del suelo; por esta razón es recomendable en la mayoría de casos siempre aplicar fósforo, especialmente al momento de la siembra.

Por otro lado, los valores encontrados en las concentraciones de K, Ca y Mg (Tabla 1) son superiores en el caso del K y similares para el Ca y Mg en comparación con suelos de sabanas del estado Cojedes en Venezuela (Depablos *et al*., 2009); mientras que son superiores a los valores encontrados en suelos del estado Yaracuy (Borges *et al*., 2012). Asimismo, los valores encontrados para estos nutrimentos en el estado Táchira son superiores al nivel crítico tanto para el cultivo de hortalizas (FAO, 2013), como para forrajes (Morillo *et al*., 1989), lo que indica que los suelos del Táchira son aptos para el cultivo de estos rubros y para la actividad ganadera.

Con respecto al pH determinado, este corresponde a lo mencionado por Carrero *et al*. (2015), quienes consideran que en los Andes Venezolanos, la mayoría de los suelos tienden a ser ácidos. En estos suelos ácidos, el método de extracción de P disponible por Bray-Kurtz resulta ser más preciso que el método de Olsen (Carrero *et al*., 2015), tal como se realiza en el Laboratorio Bioambiental UNET. Los resultados de pH ácido y suelos desaturados son consecuentes con lo determinado por Ochoa *et al*. (2010) para suelos de los Andes venezolanos (estados Táchira, Mérida y Trujillo), además, es propio del trópico que los suelos presenten

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estas características debido a las altas precipitaciones y temperaturas (Lizcano *et al*., 2017). Los valores de pH indican que en la mayoría de los casos los productores deben realizar prácticas de corrección de este párametro mediante el encalado para mejorar la productividad de los cultivos (FAO, 2013).

De acuerdo con las correlaciones observadas (Tabla 3), se puede considerar que factores como el pH afectan la disponibilidad del Ca, así como también que la disponibilidad de este elemento está asociada a la disponibilidad de Mg, K y P. Igualmente, la disponibilidad de P y K tiene una relación directamente proporcional entre estos y la disponibilidad de ambos elementos está asociada a una mayor CE. Por el contrario, la MO no estuvo asociada a ninguno de los demás parámetros químicos determinados. En nuestros resultados, la correlación entre pH y Ca coincide con lo encontrado por Borges *et al.* (2012) para suelos del estado Yaracuy.

Conclusiones

De acuerdo a la cantidad de muestras y su ubicación, se considera que el Laboratorio Bioambiental UNET contiene datos representativos de los suelos espacialmente distribuidos del estado Táchira. Una alta proporción de estos tiene la condición textural gruesa, así como los valores promedio de los parámetros físico-químicos muestran que efectivamente los mismos son aptos para la actividad agrícola y ganadera. Lo anterior mencionado denota la posibilidad de obtener respuestas positivas a la aplicación de fertilizantes de acuerdo a la interpretación informada. Los resultados mostrados en este trabajo, son el punto de partida que permitirá posteriormente analizar y discutir por municipio, los parámetros físico-químicos de los suelos analizados, constituyendo así al Laboratorio como la referencia de suelos con potencial agrícola para la entidad.

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Calidad de agua de lluvia en prototipos de captación en las comunidades nativas de Tunants y Yahuahua, Amazonas-Perú

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Edwin Adolfo Díaz Ortiz***

RESUMEN

El objetivo de la investigación consistió en determinar la calidad fisicoquímica y microbiológica del agua de lluvia de los cuatro prototipos de captación, instalados en las comunidades nativas de Tunants y Yahuahua, en el departamento de Amazonas, Perú. Se establecieron puntos de muestreo, dos por cada prototipo (entrada y salida); las evaluaciones se realizaron en los meses de febrero, septiembre y octubre del 2020. Se evaluaron parámetros de pH, Turbidez, Coliformes Totales (CT), Coliformes Termotolerantes (CTr), Aluminio (Al) y Zinc (Zn). Los resultados arrojaron valores de pH 7.16; turbidez 1.58 UNT. Estos fueron inferiores a los establecidos por el D.S. Nº 031- 2010- SA; en cuanto a los análisis microbiológicos de CT y CF, se obtuvo valores de 212.5 y 387.5 UFC/100 ml que superan los límites máximos permisibles. Se concluye que el agua de lluvia examinada requiere para su consumo el hervido o desinfección continua con hipoclorito de sodio u otro desinfectante, a fin de asegurar la salubridad de la población y evitar problemas gastrointestinales.

PALABRAS CLAVE: agua potable; tratamiento del agua; calidad del agua; Perú.

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Rainwater quality in catchment prototypes in the native communities of Tunants and Yahuahua, Amazonas-Peru

ABSTRACT

The objective of the research was to determine the physicochemical and microbiological quality of the rainwater of the four catchment prototypes, installed in the native communities of Tunants and Yahuahua, in the department of Amazonas, Peru. Sampling points were established, two for each prototype (entry and exit); The evaluations were carried out in the months of February, September and October 2020. Parameters of pH, Turbidity, Total Coliforms (TC), Thermotolerant Coliforms (TrC), Aluminum (Al) and Zinc (Zn) were evaluated. The results showed values of pH 7.16; turbidity 1.58 NTU. These were lower than those established by the D.S. No. 031-2010-SA; Regarding the microbiological analyzes of CT and CF, values of 212.5 and 387.5 CFU / 100 ml were obtained that exceed the maximum permissible limits. It is concluded that the rainwater examined requires continuous boiling or disinfection with sodium hypochlorite or another disinfectant for consumption, in order to ensure the health of the population and avoid gastrointestinal problems.

KEY WORDS: Drinking water; Water treatment; Water quality; Peru.

Introducción

La calidad del agua, la salud y el crecimiento económico son fundamentales para el desarrollo del ser humano (Villena,2018). Sin embargo, el agua para consumo humano está cada vez más amenazada por los contaminantes que genera la humanidad y la disminución del recurso hídrico debido al calentamiento global (Ripple et al.,2017). El crecimiento poblacional y las condiciones físicas y químicas de los suelos, producto de las escorrentías superficiales y subterráneas deterioran la calidad del agua (Álvarez et al., 2008). Es por ello que los contaminantes de agua incluyen microorganismos bacterianos, virales, fúngicos y parasitarios; adicionales a sustancias químicas simples o complejas como metales pesados, sustancias radiactivas, insecticidas, fertilizante, entre otras que afectan a la salud (Gómez, 2018).

Según Morell y Hernández (2000), la concentración de contaminantes en el agua limita la viabilidad del líquido y aumenta su grado de toxicidad para el ser humano. De acuerdo con el informe Año Internacional del Saneamiento, publicado en el año 2008, la

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quinta parte de la población a nivel mundial no tiene acceso a agua libre de contaminantes (ONU- Agua, 2008). La calidad del agua se determina comparando las características fisicoquímicas y microbiológicas del agua de acuerdo a protocolos o estándares de calidad (Quiñones, 2016).

Entre los parámetros fisicoquímicos se encuentra el potencial de hidrogeno pH, en química es una escala numérica utilizada para especificar la acidez o alcalinidad de una solución (Vázquez y Rojas, 2016); la turbidez que mide la cantidad de partículas suspendidas en el agua, metales pesados como aluminio y zinc; se considera que el incremento en la concentración de estos metales en las fuentes hídricas procede de las diversas actividades antropogénicas, causando efectos nocivos en los sistemas ecológicos y salud (Pabón et al., 2020).

Dentro de los parámetros microbiológicos tenemos el grupo coliformes que están presentes en el ambiente, plantas, suelos y el tracto digestivo de los animales y humanos ("Bacterias Coliformes en el Agua", 2021). Estos se clasifican en Coliformes Totales y Coliformes Termotolerantes; la mayoría de estas bacterias son inofensivas para el ser humano; los síntomas más comunes son malestar gastrointestinal, síntomas de fiebre, calambres abdominales y diarrea ("Bacterias Coliformes", 2020). Es por ello que es importante y necesario realizar estudios de calidad de agua, con fines de salvaguardar la salud de la población.

Sobre la base de lo mencionado, el objetivo de este estudio fue evaluar la calidad fisicoquímica, microbiológica del agua de lluvia colectada de prototipos de captación, en dos comunidades nativas Tunants y Yahuahua pertenecientes a la región Amazonas- Perú.

1. Materiales y métodos

El estudio se realizó en cuatro viviendas de las comunidades de Tunants y Yahuahua de la selva alta del Perú, departamento Amazonas, provincia Condorcanqui, distrito de Nieva, con localización en las coordenadas geográficas UTM-WGS84 Este 180 917.44 y Norte 9 492 371.00; con una altitud de 230 m.s.n.m (PVPP, 2009); tiene una temperatura media anual entre 22 y 26°C, con precipitaciones anuales entre 2600 mm a 4000 mm (MIDAGRI, s.f.) (Figura 1).

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Para todos los análisis fisicoquímicos, microbiológicos y metales pesados, se siguió la metodología establecida en el American Public Health Association (APHA, AWWA, & WPFC, 2005). Para el análisis del pH se utilizó un multiparámetro según el método 4500-H; la turbidez se analizó mediante un Turbidímetro, según el método USEPA 180.1. Los análisis microbiológicos, grupo coliformes, se determinaron en dos fases: fase presuntiva, "el medio de cultivo que se utilizó es el caldo de Lauril Sulfato, el cual permite que los microorganismos presentes en el agua se desarrollen utilizando la lactosa como fuente de alimento" (Camacho et al., 2009); y la fase confirmativa, que se realizó a partir de los tubos positivos que se comprueban en la fase presuntiva, para ello el medio de cultivo que se utiliza es Brilla para confirmación de Coliformes Totales y Ec para confirmación de Coliformes Termotolerantes (Figura 2).

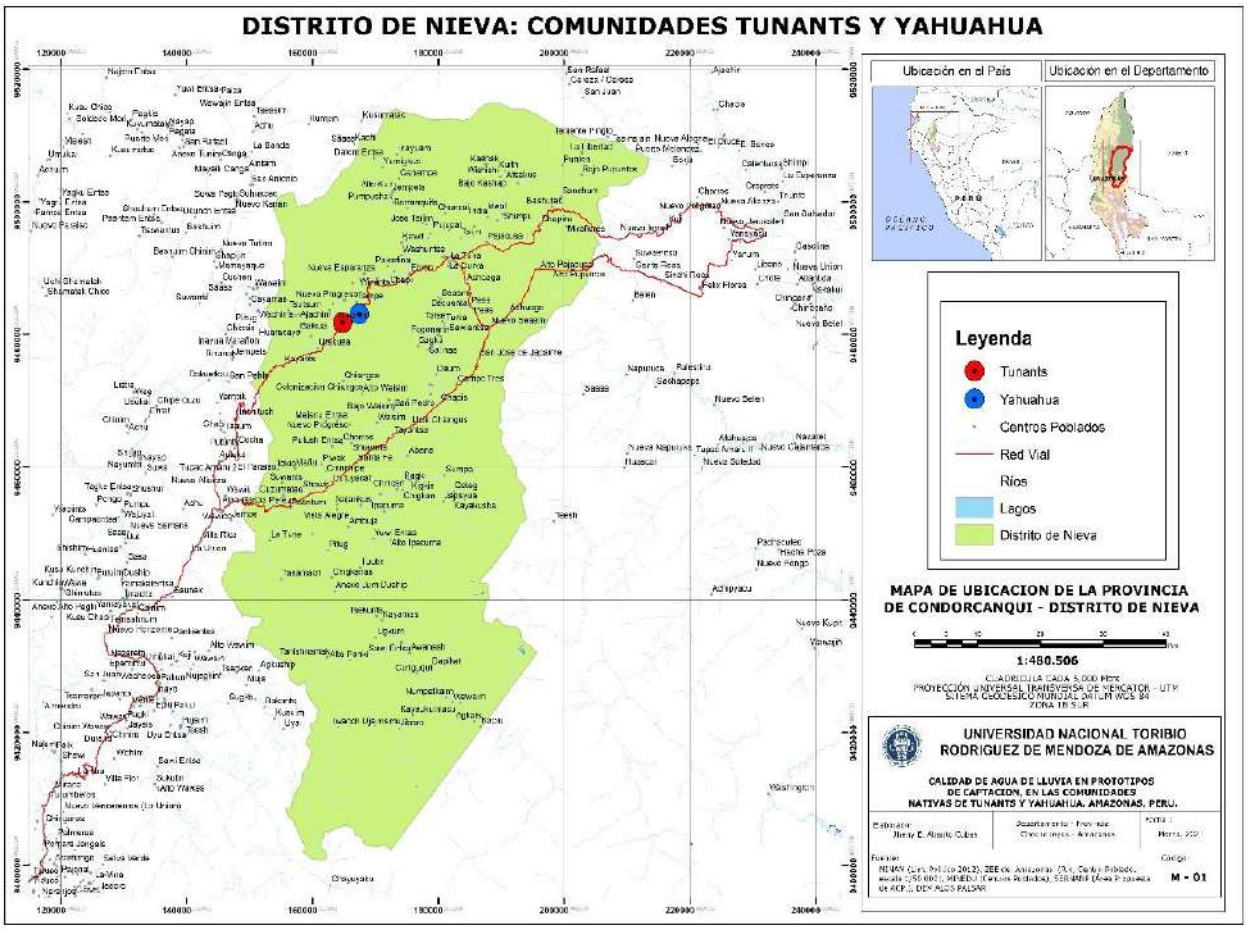

Figura 1. Mapa de ubicación de la provincia de Condorcanqui, distrito Nieva.

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Los parámetros de metales pesados (aluminio, zinc), se determinaron mediante un proceso de filtración y se agregó 0,3 ml de ácido nítrico para su conservación. Las lecturas se efectuaron con un Espectrofotómetro de Barrido marca ERMO SCIENTI. Los análisis se realizaron en el Laboratorio de Aguas y Suelos del Instituto de Investigación para el Desarrollo Sustentable de Ceja de Selva (INDES-CES) de la Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas. Todos los parámetros fueron comparados de acuerdo al Artículo 63, Parámetros de control obligatorio (PCO), del Decreto Supremo Nº 031-2010-S.A.

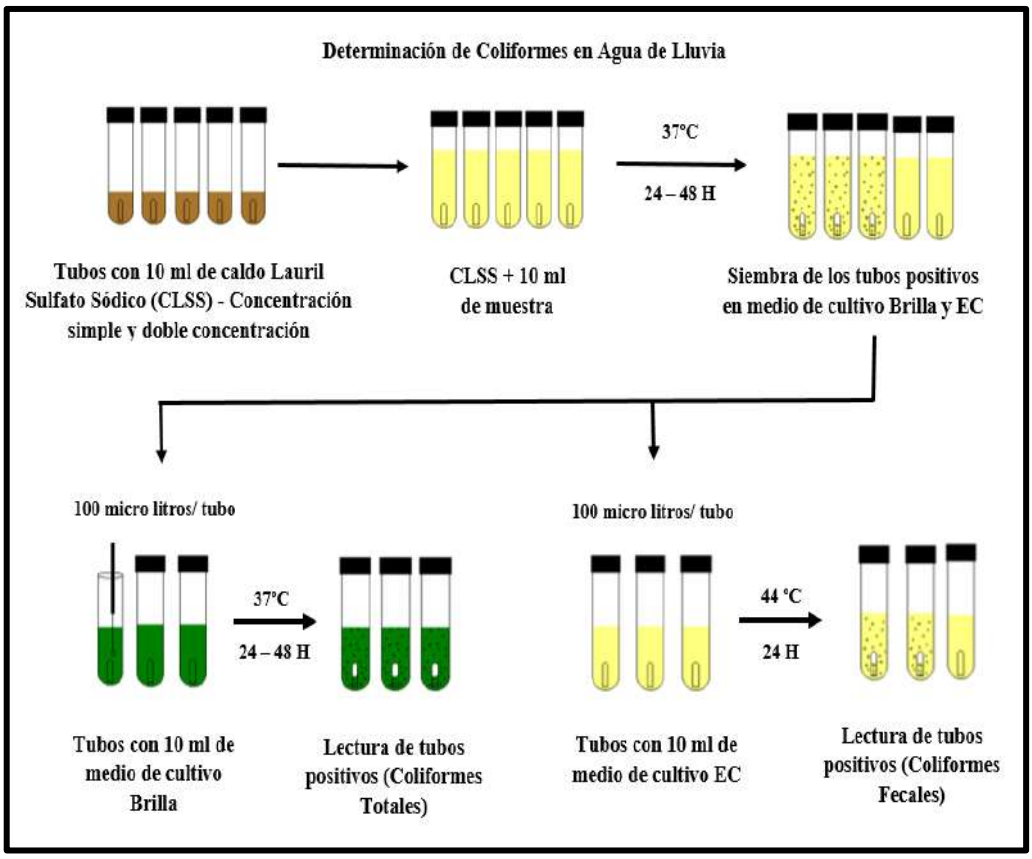

Figura 2: Proceso para determinación de coliformes.

1.1. Análisis de datos

Mediante el test de normalidad de Shapiro-Wilk, se contrastó la normalidad de cada una de las variables en estudio; y mediante T de Student, se determinaron las diferencias significativas de los parámetros evaluados entre la entrada y salida de agua de lluvia, haciendo uso del software Minitab 17.

2. Resultados

Los resultados indican que el pH a la entrada del prototipo obtuvo una mediana de 7,334 a diferencia del valor de salida que obtuvo una mediana de 7,008, valores que se encuentran dentro de los Límites Máximos Permisibles (LMP); la turbidez arrojó una media de 1,616 UNT en entrada y 1.558 UNT en salida. En cuanto a los análisis microbiológicos, los Coliformes Totales entrada obtuvo una mediana de 258 UFC/100 ml, y de salida una mediana de 167 UFC/100 ml; al igual que los Coliformes Termotolerantes, entrada obtuvo una mediana de 637 UFC/100 ml, y de salida una mediana de 138 UFC/100 ml; ambos grupos coliformes obtuvieron valores que superan los Límites Máximos Permisibles (LMP). En los análisis de metales pesados como aluminio entrada se obtuvo una mediana de 0,274 mg Al L^{1} y de salida 0,1458 mg Al L^{-1}; y zinc entrada se obtuvo una mediana de 2,705 mg Zn L^{-1} y de salida 2.369 mg Zn L^{-1} valores inferiores a los límites máximos permisibles. Los datos fueron equivalentes a $p > 0,05$; estos indican que existe una distribución normal y no existe diferencia significativa entre las variables estudiadas. (Tabla 1).

Tabla 1. Resultados de los análisis fisicoquímicos y microbiológicos.

Parámetros	Unidad	Media	Desv.Est.	Valor T	Valor p	LMP
pH (E)		7.334	0.936	1.23	0.246	6.5-8.5
pH (S)		7.008	0.197			
Turb (E)		1.616	0.591	0.32	0.755	5(UNT)
Turb (S)	UNT	1.558	0.429			
CT (E)	NMP/100	258*	494	0.61	0.555	‹1.8 (NMP)
CT (S)	mL	167*	462			
CTr (E)	NMP/100	637*	728	2.55	0.027	‹1.8 (NMP)
CTr (S)	mL	138*	460			
Aluminio (E)	mg Al L-1	0.2748	0.3236	1.27	0.231	0.2(mg Al L-1)
Aluminio (S)		0.1685	0.1458			
Zinc (E)	mg Zn L-1	2.705	1.944	0.94	0.366	3 (mg Zn L-1)
Zinc (S)		2.369	2.087			

LMP: Límites Máximos Permisibles; * Valores que no cumplen con la normativa reportado en el Articulo 63. Parámetros de control obligatorio (PCO). Decreto Supremo Nº 031-2010-S.A.

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En la Figura 1 se observa el comportamiento de los parámetros en entrada y salida del prototipo de captación, siendo los Coliformes Termotolerantes y Coliformes Totales con mayor concentración en la entrada y concentración baja en la salida, debido a que se aplicó hipoclorito de sodio al 5 %, con una concentración de 1 gota por litro, para su desinfección y consumo.

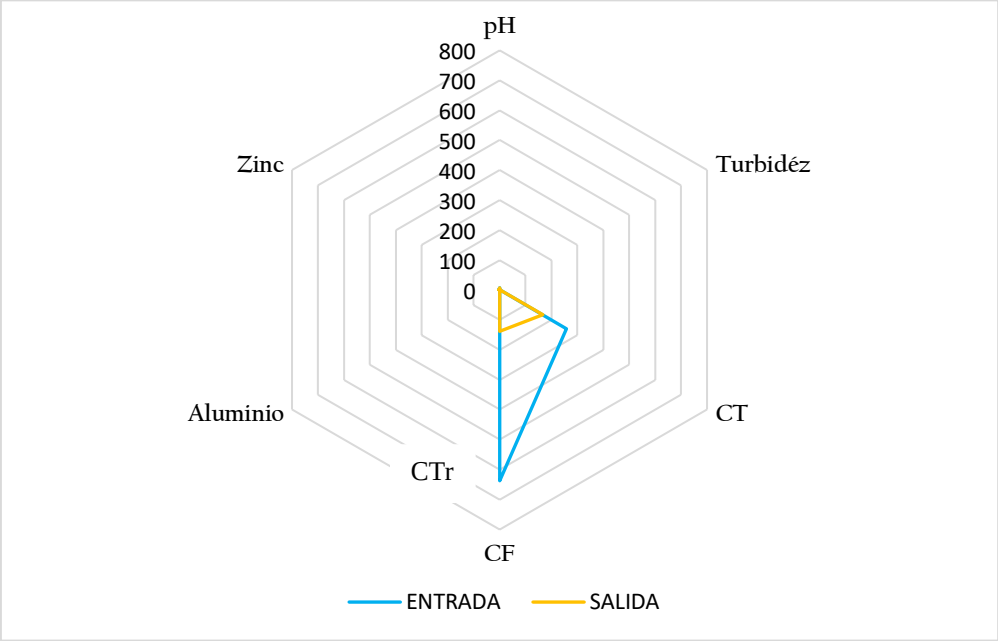

Figura 1. Comportamiento de los parámetros en entrada y salida del prototipo de captación; CTr= Coliformes Termotolerantes; CT= Coliformes Totales

3. Discusión

El pH en los prototipos evaluados tuvo un valor promedio de media de 7,16 valor que se encuentra dentro del Límite Máximo Permitido según el D.S. Nº 031-2010-S. A, que coincide con las investigaciones de Sazakli et al. (2007), quienes evalúan la calidad de agua subterránea o mezclada con agua de lluvia y calidad de agua de lluvia en la isla de Cefalonia, Grecia; donde los valores de pH oscilaron entre 7,63 y 8,80 con una media de 8, 35, siendo el valor del pH mayor en el agua de lluvia, encontrándose dentro de los límites establecidos por la directiva 98/93/UE.

En relación a la turbidez, se obtuvo un valor promedio de media de 1,58 UNT, encontrándose dentro del límite máximo permisible; lo que concuerda con las investigaciones de Minju et al. (2017), quienes evaluaron la calidad del agua de lluvia sin tratar y agua de lluvia

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con tratamiento para consumo en Vietnam, donde los valores de turbidez oscilaron entre 1 UNT y 0,3 UNT, siendo el valor de la turbidez bajo en el agua de lluvia tratada, encontrándose dentro de los estándares de agua potable de Vietnam.

En el caso de la calidad microbiana del agua de lluvia, los Coliformes Totales y Coliformes Termorolerantes obtuvieron valores promedio de media de 212,5 UFC/100 ml y 387,5 UFC/ 100 ml superando ambos valores los límites máximos permisibles. Estos resultados guardan relación con lo que sostienen Minju et al. (2017), quienes obtuvieron un valor de 270 UFC/100 ml en coliformes y 8 UFC/100 ml de Escherichia Coli en todas las muestras de agua de lluvia sin tratar, "siendo los principales causantes de enfermedades gastrointestinales que influyen en la desnutrición infantil" (Medina et al.,2019).

En lo que respecta a los metales pesados, el aluminio obtuvo un valor promedio de media de 0,22 mg Al L-1, lo que es preocupante ya que su ingesta podría causar anemia y desnutrición crónica infantil (Cárdenas y Merma, 2018). Finalmente, el valor promedio de media de zinc fue de 2,54 mg Zn L-1, valor que se encuentra dentro de los límites máximos permisibles, algo que no coincide con las investigaciones de Mao et al. (2020), quienes evaluaron el efecto de los materiales del techo y los patrones climáticos en la calidad del agua de lluvia en Shanghái, obteniendo valores de Zn en el techo de material galvanizado, valores que oscilan entre 397 mg Zn L-1 y 1 970 mg Zn L-1. Sin embargo, comparado con otros tipos de material para techos, el techo de metal galvanizado produce fácilmente la contaminación con metales pesados durante el uso a largo plazo (Zhang et al.,2014), ya que consta de una capa galvanizada en la superficie y una capa de hierro en el interior.

Conclusiones

Los parámetros fisicoquímicos evaluados como: pH, turbidez, aluminio y zinc obtuvieron valores 7,16; 1,58 (UTN); 0,22 mg Al L-1 y 2,54 mg Zn L-1, valores que están dentro de los Límites Máximos Permisibles, asegurando la calidad del agua de lluvia.

Los valores de Coliformes Totales y Coliformes Termotolerantes presentan valores de 212,5 UFC /100 ml y 387,5 UFC /100 ml, valores que no cumplen con los Límites Máximos Permisibles, como lo establece la normativa en el Articulo 63, Parámetros de control obligatorio (PCO), Decreto Supremo Nº 031-2010-S.A., siendo necesario para su consumo el

hervido o desinfección continua con hipoclorito de sodio u otro desinfectante, que aseguren la salubridad de la población y poder así evitar problemas gastrointestinales.

Agradecimientos

Al Proyecto de Investigación "Prototipos de sistema de potabilización del agua de lluvia en comunidades nativas del departamento de Amazonas. Perú 2019-2020" (PROLLUVIA), al Instituto de Investigación para el Desarrollo Sustentable de Ceja de Selva (INDES-CES) de la Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas, por el apoyo logístico para realizar la presente investigación, así como al FONDECYT por el financiamiento del proyecto de investigación mediante contrato de subvención Nº 185-2018-FONDECYT-BM-IADT-SE.

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Anexos

Anexo 1: Sistema de prototipo de captación y muestreo de agua de lluvia.

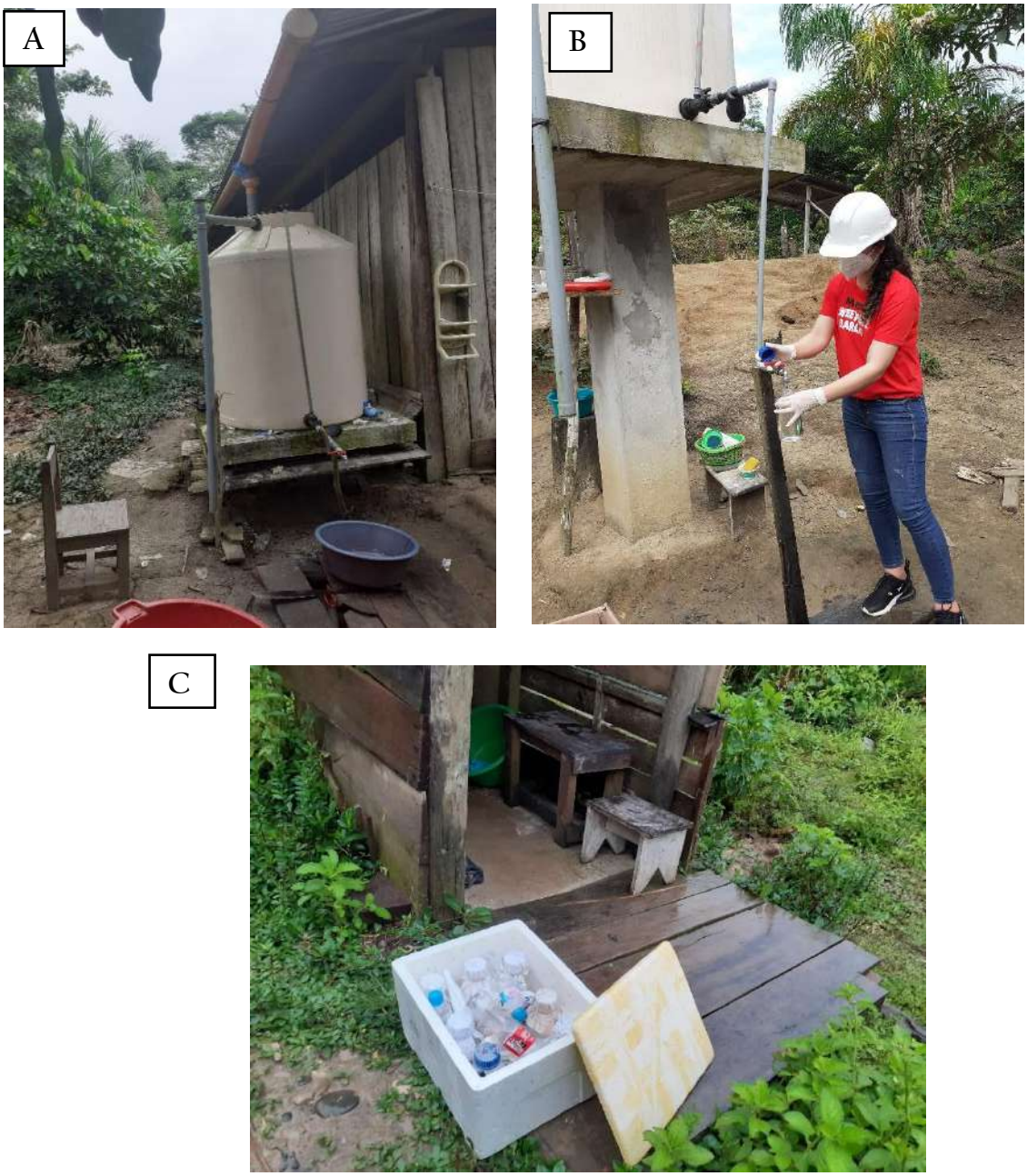

Figura A=Prototipo de captación y reutilización de agua de lluvia; Figura B=Recolección de muestras de agua; Figura C=Caja de tecnopor acondicionada con hielo seco para el traslado de muestras.

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Análisis numérico comparativo para la determinación del peso de naves industriales

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RESUMEN

Por medio de este artículo, se realiza una investigación sobre la aplicación del análisis numérico a cálculos estructurales tomando como base una muestra, en la que están determinadas algunas métricas que describen su comportamiento, como por ejemplo su peso; con estos valores se obtiene un polinomio que describe el modelo representado en una curva, que puede lograrse a través de una interpolación o regresión. Para la obtención del polinomio por interpolación se aplicaron los métodos numéricos de: diferencias divididas de Newton, Lagrange y trazadores o splines; se los graficó en forma independiente, luego se agrupó para analizar su comportamiento. Con la regresión se aplicó el método de mínimos cuadrados para obtener el polinomio y representar su curva. Con todos los polinomios obtenidos se trazaron todas sus curvas, consolidándolas en un solo gráfico, en el que se analiza la categoría y método más recomendado del análisis numérico, tomando en cuenta los errores encontrados.

PALABRAS CLAVE: Análisis numérico; cálculo; industria; regresión.

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Comparative numerical analysis to determine the weight of industrial warehouses

ABSTRACT

Through this article, an investigation about the application of numerical analysis to structural calculations is carried out based on a sample, in which some metrics that describe its behavior are determined, such as its weight, with these values a polynomial is obtained that describes the represented model on a curve, which can be obtained through interpolation or regression. To obtain the polynomial by interpolation, the numerical methods of: Newton's divided differences, Lagrange and tracers or splines were applied, they were graphed independently, then they were grouped to analyze their behavior. With the regression, the least-squares method was applied to obtain the polynomial and represent its curve. With all the polynomials obtained, all their curves were drawn, consolidating them in a single graph, in which the most recommended category and method of numerical analysis is detailed, taking into account the mistakes found.

KEYWORDS: Numerical analysis; calculus; Industry; regression.

Introducción

Actualmente, el análisis numérico constituye una parte esencial dentro de la educación matemática para ingenieros, pues está ligado a distintos campos del conocimiento (Faure et al., 2018). Los problemas en Ingeniería se les puede resolver mediante la aplicación de diversas metodologías, donde destacan los métodos numéricos, que proporcionan una serie de puntos a favor en la comprensión de los fenómenos, con un buen equilibrio entre tiempo, costo y calidad (Araujo, 2017; Muñoz, 2020).

Con los métodos numéricos, que no son más que aplicaciones de algoritmos, se formulan y solucionan problemas matemáticos de tal forma que sean resueltos con operaciones aritméticas elementales, las cuales producen soluciones aproximadas de mucha relevancia, puesto que la precisión que se requiere determina la cercanía a una solución exacta de un problema (Roa, 2018; Ávila, 2016).

Dentro de la Ingeniería civil, y principalmente en el campo de la construcción, se deben elaborar presupuestos que tengan una buena estructuración para conseguir una correcta

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ejecución de un determinado proyecto. Por lo tanto, se debe realizar un análisis y diseño sismorresistente de la estructura (Guerrero, 2019), como en el caso específico de las naves industriales, en las cuales se deben obtener las cantidades de los materiales, como por ejemplo el peso del acero.

En consecuencia, en la presente investigación se planteó utilizar los resultados del índice peso sobre área obtenidos de un análisis y diseño estructural de un grupo de naves industriales (Loachamin et al., 2021), que tienen características particulares en cuanto a longitud, altura y separación entre pórticos, para posteriormente aplicar varios métodos numéricos que permitieron observar entre estos, cuál es el más cercano al determinado por el análisis estructural previo.

1. Materiales y Métodos

1.1. Análisis numérico del peso de naves industriales

El objetivo fundamental de esta investigación fue realizar un análisis numérico (Cortés et al., 2019) de las métricas obtenidas en el artículo Loachamin et al., (2021); se realizó un ajuste de las curvas de cada una de las variantes de la nave industrial, tales como: altura de columna, longitud y separación de pórticos, como se indica en la figura 1. La altura de las naves industriales varió desde 6 a 9 m, mientras que la luz libre de pórticos fue de 15 a 35 m, y por último se indica que la separación entre pórticos que se utilizó en la presente investigación fue de 6 m.

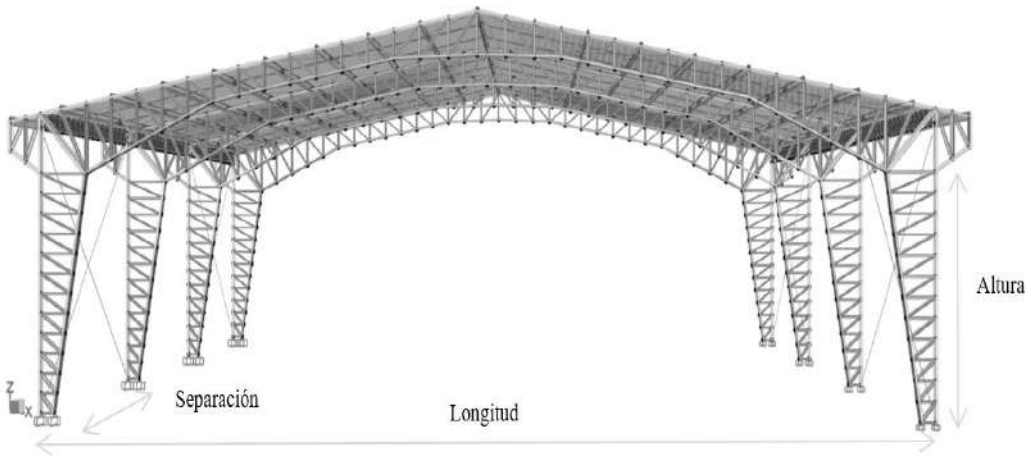

Figura 1. Características geométricas de nave industrial.

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Una de las consideraciones que se tomaron en esta investigación fue el peso obtenido en cada una de las variantes, que constituyó una base de datos para el análisis numérico.

1.2. Ajuste de curvas

Es común que los datos se den como valores discretos a lo largo de un continuo. Sin embargo, quizás se requiera la estimación de un punto entre valores discretos (Chapra & Canale, 2015)

Existen dos métodos generales para el ajuste de curvas que se distinguen entre sí al considerar la cantidad de error asociado con los datos. Primero, si los datos exhiben un grado significativo de error o "ruido", la estrategia será obtener una sola curva que represente la tendencia general de los datos.

Como cualquier dato individual puede ser incorrecto, no se busca intersecar todos los puntos. En lugar de esto, se construye una curva que siga la tendencia de los puntos tomados como un grupo. En la figura 2 se indica un procedimiento de este tipo que se denomina regresión por mínimos cuadrados (Chapra & Canale, 2015).

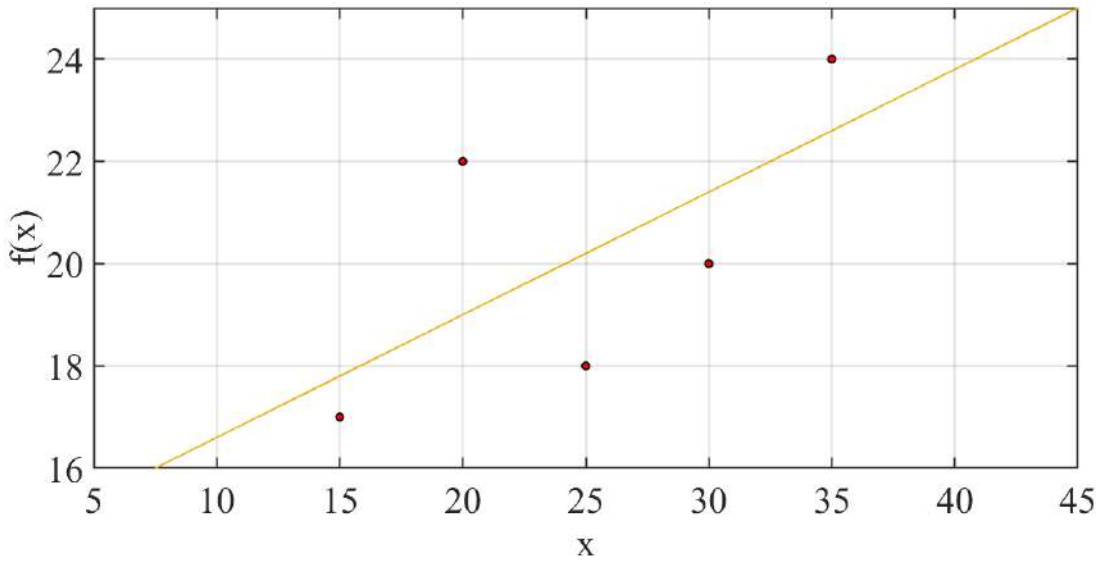

Figura 2. Intento de ajustar una curva por mínimos cuadrados.

Segundo, si se sabe que los datos son muy precisos, el procedimiento básico será colocar una curva o una serie de curvas que pasen por cada uno de los puntos en forma directa. La

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estimación de valores entre puntos discretos bien conocidos se llama interpolación, como se muestra en la figura 3. La unión de los puntos se la puede realizar por rectas o por curvas.

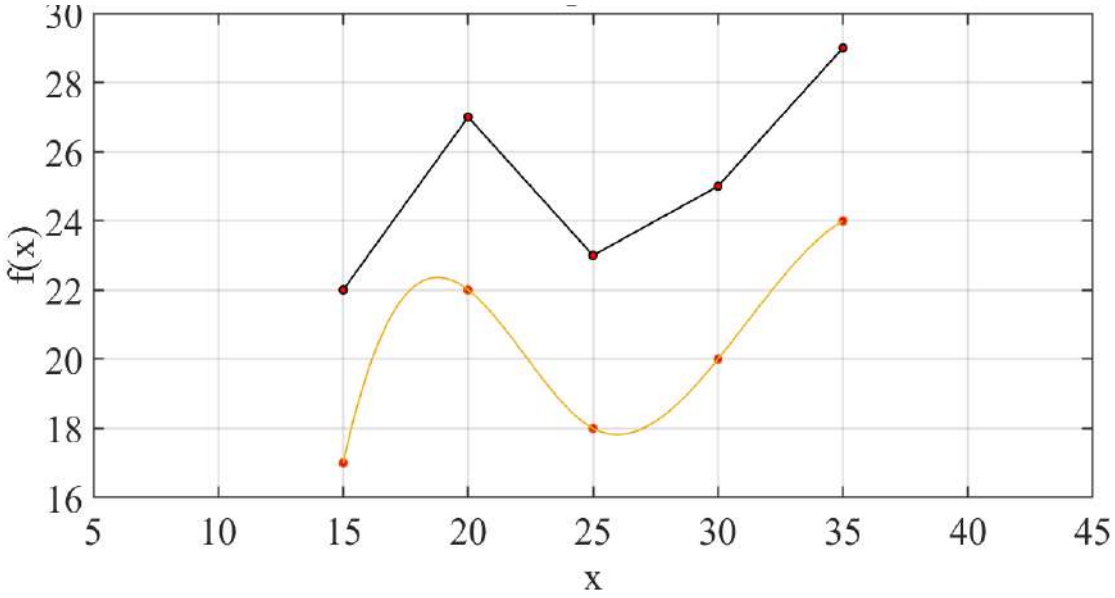

Figura 3. Intentos de ajustar una curva por interpolación lineal y curvilínea.

En la investigación se ajustó las curvas de los pesos de las naves industriales por interpolación y por regresión.

1.3. Ajuste por interpolación

La interpolación polinomial consiste en determinar el polinomio único de n-ésimo grado que se ajuste a n+1 puntos asociados con datos. Este polinomio, entonces, proporciona una fórmula para calcular valores intermedios. Aunque hay uno y sólo un polinomio de n-ésimo grado que se ajusta a n+1 puntos, existe una gran variedad de formas matemáticas en las cuales puede expresarse este polinomio (Chapra & Canale, 2015). En esta investigación se realizaron tres métodos, donde cada una de ellas tiene su información, dependiendo del tipo de proceso que se vaya a analizar. Los métodos numéricos para la interpolación fueron: Newton, Lagrange y Splines.

1.4. Interpolación polinomial de Newton en diferencias divididas

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Sea f_n una variable discreta de n elementos y sea x_n otra variable discreta de n elementos los cuales corresponden, por parejas, a la imagen u ordenada y abscisa de los datos que se quieran interpolar (Chapra & Canale, 2015), como se pueden observar en las ecuaciones 1 a 4:

$$f(x_k) = f_k, \quad k = 1, \dots, n \tag{1}$$

El polinomio de grado n-1 resultante tendrá la forma:

$$\sum_{j=0}^{n-1} a_j \, g_j(x) \tag{2}$$

Definiendo g_j (x) como:

$$g_j(x) = \prod_{i=0}^{j-1} (x - x_i) \tag{3}$$

y definiendo a_j como:

$$a_0 = f[x_0], a_1 = f[x_0, x_1], \dots, a_j = f\left[x_0, x_1, \dots, x_{j-1}, x_j\right] \tag{4}$$

Los coeficientes a_j son las llamadas diferencias divididas.

Aplicando este método a los pesos obtenidos en Loachamin et al., (2021) a las naves industriales de 6 m, 7 m, 8 m y 9 m de altura de las columnas, con separación de 6 m en cada una de ellas, y realizando scripts en (Matlab, 2020), se obtuvieron los polinomios tal como se observa en tabla 1.

Utilizando la variable independiente, en este caso la luz libre (m), se tuvo como resultado los pesos de las naves industriales que se indica en la Tabla 2 y representados en graficas como se muestra en la figura 4.

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Tabla 1. Polinomios obtenidos por el método de diferencias divididas de Newton.

Altura de columnas (m)	Polinomio para modulación de 6,00 m
6	$-0{,}00005202X^4 + 0{,}00502247X^3 - 0{,}169699X^2 + 2{,}5608983X + 4{,}0668$
7	$-0{,}00005772X^4 + 0{,}00580293X^3 - 0{,}204101X^2 + 3{,}161547X + 2{,}2153$
8	$-0{,}00004244X^4 + 0{,}0040833X^3 - 0{,}134701X^2 + 1{,}96191X + 10{,}8714$
9	$-0{,}00003574X^4 + 0{,}0037254X^3 - 0{,}1344605X^2 + 2{,}142535X + 10{,}5911$

Tabla 2. Pesos de las estructuras obtenidos por el método de diferencias divididas de Newton.

Luz libre (m)	Altura columna 6 m Peso (kg/m^2)	Altura columna 7 m Peso (kg/m^2)	Altura columna 8 m Peso (kg/m^2)	Altura columna 9 m Peso (kg/m^2)
15	18,6153233	20,3785938	21,6249375	23,2394015
20	19,261726	20,99408	22,1052	23,742402
25	20,1831638	21,8147563	22,9544625	24,3651025
30	21,635139	23,29672	24,3705	25,489103
35	23,0928543	25,0302688	25,9144875	26,9599035

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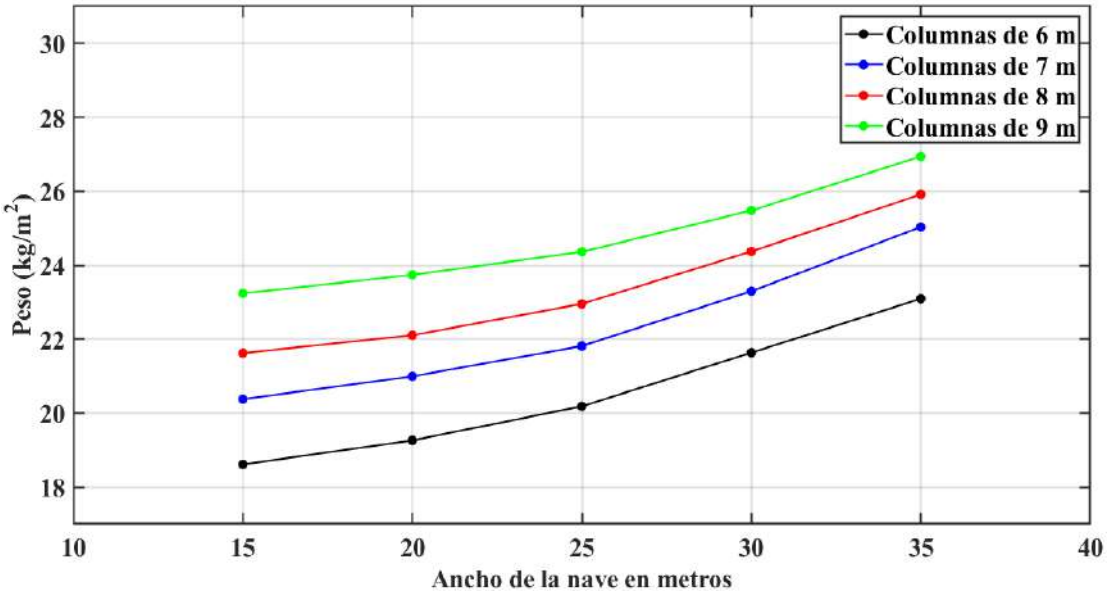

Figura 4. Curvas de interpolación obtenidas por el método de diferencias divididas de Newton.

1.5. Interpolación polinomial de Lagrange

Con la base de datos provistos en Loachamin et al., (2021) se obtuvieron los polinomios de Lagrange (Cortés et al., 2019) y el índice de peso sobre área de cada nave industrial, como se puede observar en las tablas 3 y 4, respectivamente; adicionalmente con la utilización de lo descrito anteriormente se procedió con la representación de estos índices, como se aprecia en figura 5.

1.6. Interpolación polinomial con trazadores o splines de grado 3

En los tópicos descritos anteriormente se usaron polinomios de n-ésimo grado para interpolar entre n+1 puntos asociados con datos. Por ejemplo, para cinco puntos se puede obtener un perfecto polinomio de cuarto grado. Esta curva podría agrupar todas las curvas (al menos hasta, e incluso, la cuarta derivada) sugeridas por los puntos de esta investigación. No obstante, hay casos donde estas funciones llevarían a resultados erróneos a causa de los desaciertos de redondeo y los puntos lejanos. Un procedimiento alternativo consiste en colocar polinomios de grado inferior en subconjuntos de los puntos asociados con datos. Tales

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polinomios conectores se denominan trazadores o splines (Chapra & Canale, 2015; González, 2017).

Tabla 3. Polinomios obtenidos por el método de Lagrange, (Loachamin et al., 2021)

Altura de columnas (m)	Polinomio para modulación de 6,00 m
6	$-0{,}000051995774X^4 + 0{,}005020070126X^3 - 0{,}16961307485X^2 + 2{,}5595574928334X + 4{,}0742935699997$
7	$-0{,}0000577088473X^4 + 0{,}0058016731133X^3 - 0{,}2040495284167X^2 + 3{,}160650052166X + 2{,}2209046100005$
8	$-0{,}00004244142X^4 + 0{,}0040834585333X^3 - 0{,}1347050531X^2 + 1{,}9619656976667X + 10{,}8710326799998$
9	$-0{,}0000357244873X^4 + 0{,}0037238146867X^3 - 0{,}1344014422167X^2 + 2{,}1415842808333X + 10{,}59668517$

Tabla 4. Pesos de las estructuras obtenidos por el método Lagrange, (Loachamin et al., 2021).

Luz libre (m)	Altura columna 6 m Peso (kg/m²)	Altura columna 7 m Peso (kg/m²)	Altura columna 8 m Peso (kg/m²)	Altura columna 9 m Peso (kg/m²)
15	18,6151647	20,3786479	21,6249569	23,2394472
20	19,2614507	20,9940636	22,1053665	23,7423934
25	20,1828056	21,8148246	22,9548768	24,3651174
30	21,6345675	23,2968383	24,371286	25,4890774
35	23,0921374	25,0303799	25,9157708	26,9598642

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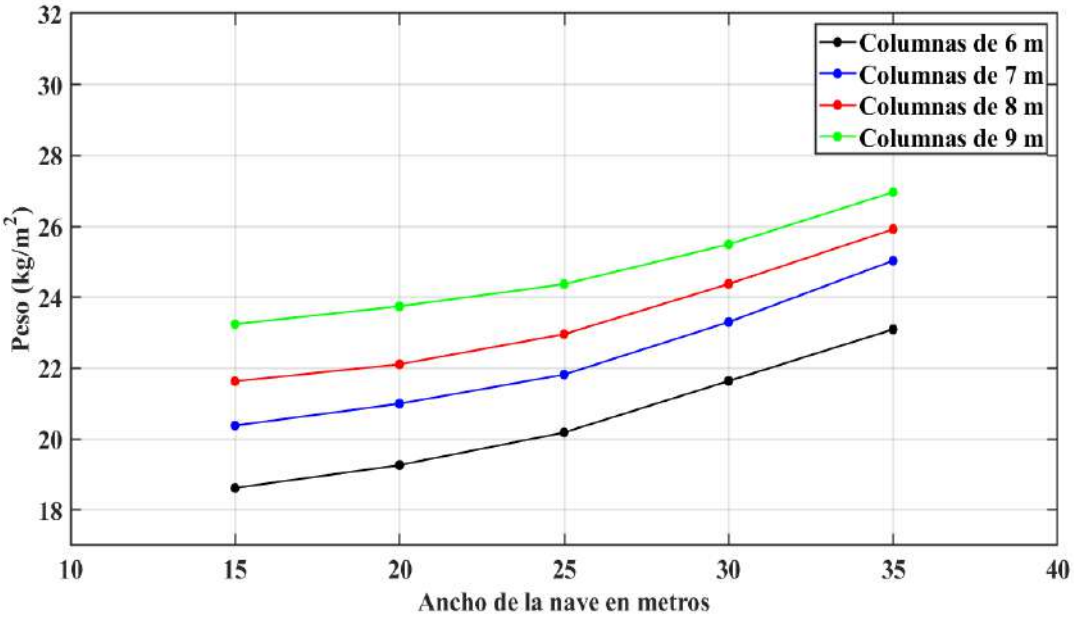

Figura 5. Curvas de interpolación por el método de Lagrange (Loachamin et al., 2021).

El objetivo en los trazadores cúbicos es obtener un polinomio de tercer grado para cada intervalo entre los nodos, como se detalla en ecuación 5.

$$f_i(x) = a_i x^3 + b_i x^2 + c_i x + d \qquad (5)$$

Así, para n+1 puntos asociados con datos (i = 0, 1, 2, ..., n) existen n intervalos y, en consecuencia, (4.n) incógnitas a evaluar.

Se requieren (4.n) condiciones para evaluar las incógnitas. Éstas son:

1. Los valores de la función deben ser iguales en los nodos interiores (2n−2 condiciones).
2. La primera y última función deben pasar a través de los puntos extremos (2 condiciones).
3. Las primeras derivadas en los nodos interiores deben ser iguales (n−1 condiciones).
4. Las segundas derivadas en los nodos interiores deben ser iguales (n−1 condiciones).
5. Las segundas derivadas en los nodos extremos son cero (2 condiciones).

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La interpretación visual de la condición 5 es que la función se vuelve una línea recta en los nodos extremos. La especificación de una condición tal en los extremos nos lleva a lo que se denomina trazador "natural" (Chapra & Canale, 2015); que requiere que dos secciones de curvas adyacentes tengan tanto la primera como la segunda derivada igual en su frontera común; es decir, debe haber continuidad (González, 2000).

Matlab, (2020) tiene varias funciones preconstruidas que abarcan el tema de interpolación con trazadores o splines cúbicos (Palm III, 2019; Kiusalaas, 2009), tal como se indica en la tabla 5.

Tabla 5. Funciones de Matlab, (2020) para trazadores o splines cúbicos.

Función	Descripción
polyfit	Devuelve los coeficientes para un polinomio p(x) de grado n.
polyval	Evalúa el polinomio p(x) en cada punto de x.
interp1	Interpolación 1-D (tabla 1-D).
spline	Interpolación de datos con trazador o spline cúbico.

Tomando los datos de los pesos de las naves industriales calculadas por el método de DFCR (Loachamin et al., 2021), se realizó scripts en Matlab, (2020); y como consecuencia de su aplicación se obtuvieron los nuevos índices de peso sobre área de las naves industriales y su representación gráfica, tal como se puede observar en la tabla 6 y la figura 6, respectivamente.

Tabla 6. Pesos de las estructuras obtenidos con trazadores o splines de grado 3.

Luz libre (m)	Altura columna 6 m Peso (kg/m^2)	Altura columna 7 m Peso (kg/m^2)	Altura columna 8 m Peso (kg/m^2)	Altura columna 9 m Peso (kg/m^2)
15	18,6152	20,3786	21,625	23,2394
20	19,2615	20,9941	22,1054	23,7424
25	20,1828	21,8148	22,9549	24,3651
30	21,6346	23,2968	24,3713	25,4891
35	23,0921	25,0304	25,9158	26,9599

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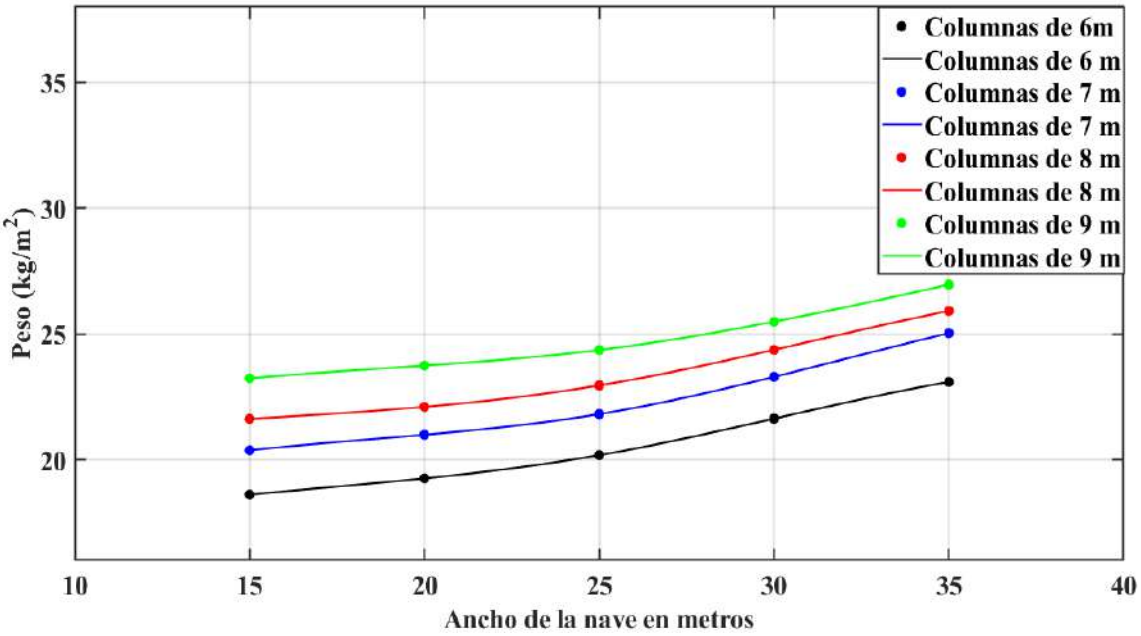

Figura 6. Curvas de interpolación obtenidas con trazadores o splines de grado 3.

2. Resultados

2.1. Resumen del ajuste de curvas por Interpolación

Se procedió a realizar un resumen del ajuste de curvas utilizando los distintos métodos de interpolación, como se describe en la tabla 7 y figura 7.

2.2. Ajuste por regresión

Cuando los datos tienen errores sustanciales, la interpolación polinomial es inapropiada y puede dar resultados poco satisfactorios cuando se utiliza para predecir valores intermedios. Con frecuencia los datos experimentales son de este tipo. Una estrategia apropiada en tales casos consiste en obtener una función de aproximación que se ajuste a la forma o a la tendencia general de los datos, sin coincidir necesariamente en todos los puntos (Chapra & Canale, 2015; Mathews & Fink, 2003). En la presente investigación se analizaron las coordenadas de los puntos que representan los pesos y se optó por realizar una regresión polinomial, cuyo objetivo consiste en encontrar una función que mejor se ajuste a los datos dados; es decir, una función cuya representación gráfica sea una curva.

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Tabla 7. Resumen de los pesos de las estructuras obtenidos por interpolación.

Luz libre (m)	Diferencias divididas (Newton)				Lagrange				Trazador o spline cúbico			
	Altura columna 6 m Peso (kg/m²)	Altura columna 7 m Peso (kg/m²)	Altura columna 8 m Peso (kg/m²)	Altura columna 9 m Peso (kg/m²)	Altura columna 6 m Peso (kg/m²)	Altura columna 7 m Peso (kg/m²)	Altura columna 8 m Peso (kg/m²)	Altura columna 9 m Peso (kg/m²)	Altura columna 6 m Peso (kg/m²)	Altura columna 7 m Peso (kg/m²)	Altura columna 8 m Peso (kg/m²)	Altura columna 9 m Peso (kg/m²)
15	18,615323	20,378594	21,624938	23,239402	18,615165	20,378648	21,624957	23,239447	18,6152	20,3786	21,625	23,2394
20	19,261726	20,99408	22,1052	23,742402	19,261451	20,994064	22,105366	23,742393	19,2615	20,9941	22,1054	23,7424
25	20,183164	21,814756	22,954463	24,365103	20,182806	21,814825	22,954877	24,365117	20,1828	21,8148	22,9549	24,3651
30	21,635139	23,29672	24,3705	25,489103	21,634567	23,296838	24,371286	25,489077	21,6346	23,2968	24,3713	25,4891
35	23,092854	25,030269	25,914488	26,959904	23,092137	25,03038	25,915771	26,959864	23,0921	25,0304	25,9158	26,960

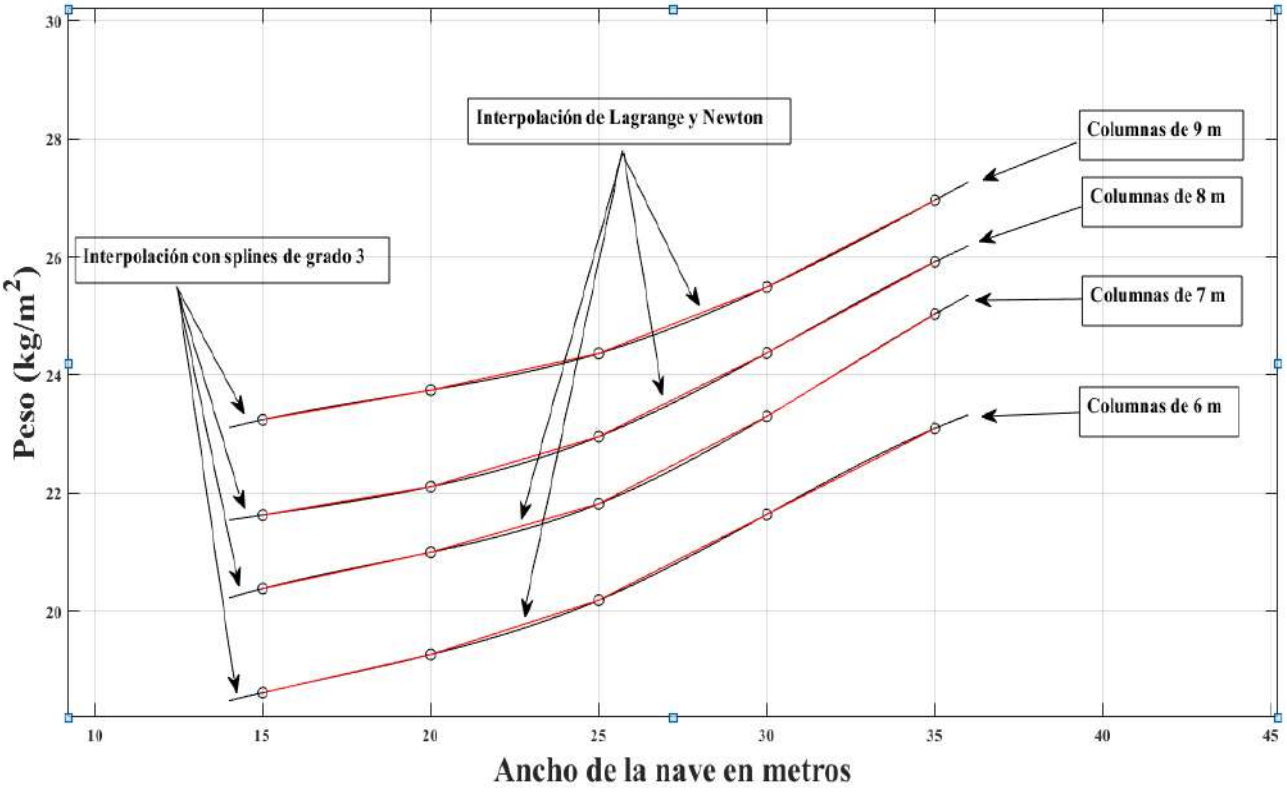

Figura 7. Curvas de los pesos de las estructuras obtenidos por interpolación.

El problema general de aproximar un conjunto de datos {(xi, yi) | i = 1, 2, ..., m}, con un polinomio algebraico (Burden et al., 2017), tal como se indica en las ecuaciones 6 a 12.

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$$P_n(X) = a_n X + a_{n-1} X_{n-1} + \cdots + a_1 X + a_0 \quad (6)$$

de grado n<m-1, por medio del procedimiento de mínimos cuadrados. Seleccionamos las constantes $a_0, a_1, \ldots, a_n$ para minimizar el error de mínimos cuadrados $E = E2\ (a_0, a_1, \ldots, a_n)$, donde:

$$E = \sum_{j=1}^{m} (Y_i - P_n(X_i))^2 \quad (7)$$

$$E = \sum_{i=1}^{m} {Y_i}^2 - 2\sum_{i-1}^{m} P_n(X_i) Y_i + \sum_{i=1}^{m} (P_n(X_i))^2 \quad (8)$$

$$E = \sum_{i=1}^{m} {Y_i}^2 - 2\sum_{j=0}^{m} a_j \left(\sum_{i=1}^{m} Y_i {X_i}^j\right) + \sum_{j=0}^{n}\sum_{k=0}^{n} a_j a_k \left(\sum_{i=1}^{n} {X_i}^{j+k}\right) \quad (9)$$

Para minimizar E es necesario que ∂E/∂aj = 0, para cada j = 0, 1, ..., n. Por lo tanto, para cada j, debemos tener:

$$0 = \frac{\partial E}{\partial aj} = -2\sum_{i=1}^{m} Y_i {X_i}^j + 2\sum_{k=0}^{n} a_k \sum_{i=1}^{m} {X_i}^{j+k} \quad (10)$$

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Esto nos da n +1 ecuaciones normales en las n + 1 incógnitas a_j. Éstas son:

$$\sum_{k=0}^{n} a_k \sum_{i=1}^{m} {X_i}^{j+k} \tag{11}$$

$$= \sum_{j=1}^{m} Y_i \, {X_i}^{j} \, , para \; cada \; j$$

$$= 0,1,\ldots,n$$

Es útil escribir las ecuaciones de acuerdo con lo siguiente:

$$a_0 \sum_{i=1}^{m} {X_i}^{0} + a_1 \sum_{i=1}^{m} {X_i}^{1} + a_2 \sum_{i=1}^{m} {X_i}^{2} + \ldots + a_n \sum_{i=1}^{m} {X_i}^{n} = \sum_{i=1}^{m} Y_i \; {X_i}^{0} \tag{12}$$

$$a_0 \sum_{i=1}^{m} {X_i}^{1} + a_1 \sum_{i=1}^{m} {X_i}^{2} + a_2 \sum_{i=1}^{m} {X_i}^{3} + \ldots + a_n \sum_{i=1}^{m} {X_i}^{n+1} = \sum_{i=1}^{m} Y_i \; {X_i}^{1}$$

$$a_0 \sum_{i=1}^{m} {X_i}^{n} + a_1 \sum_{i=1}^{m} {X_i}^{n+1} + a_2 \sum_{i=1}^{m} {X_i}^{n+2} + \ldots + a_n \sum_{i=1}^{m} {X_i}^{2n} = \sum_{i=1}^{m} Y_i \; {X_i}^{n}$$

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Estas ecuaciones normales tienen una única solución siempre y cuando las X_i sean distintas. Para el presente trabajo se tomaron las métricas de los pesos de las naves industriales (coordenadas), que se obtuvieron con el método DFCR de Loachamin et al., (2021) y realizando scripts en Matlab, (2020), se obtuvo lo indicado en las tablas 8, 9 y la figura 8.

Tabla 8. Polinomios obtenidos por el método de Regresión curvilínea de grado 3

Altura de columnas (m)	Polinomio para modulación de 6,00 m
6	$-0{,}000179533333333X^3 + 0{,}019616142857144X^2 - 0{,}402383809523832X + 20{,}854397142857330$
7	$0{,}000030933333333X^3 + 0{,}005958571428572X^2 - 0{,}126431904761924X + 20{,}842368571428711$
8	$-0{,}0001606666667X^3 + 0{,}019750285714287X^2 - 0{,}455657619047656X + 24{,}567394285714585$
9	$0{,}0001514X^3 - 0{,}004392428571428X^2 + 0{,}106631428571419X + 22{,}124908571428634$

Tabla 9. Pesos de las estructuras obtenidos por el método de Regresión curvilínea de grado 3.

Luz libre (m)	Altura columna 6m Peso (kg/m²)	Altura columna 7m Peso (kg/m²)	Altura columna 8m Peso (kg/m²)	Altura columna 9m Peso (kg/m²)
15	18,6263471	20,3909686	21,6340898	23,2470586
20	19,2169114	20,9446257	22,0690169	23,7117657
25	20,2496829	21,8890114	23,0094582	24,4110514
30	21,5900114	23,2473257	24,3349139	25,4584657
35	23,1032471	25,0427686	25,9248838	26,9675586

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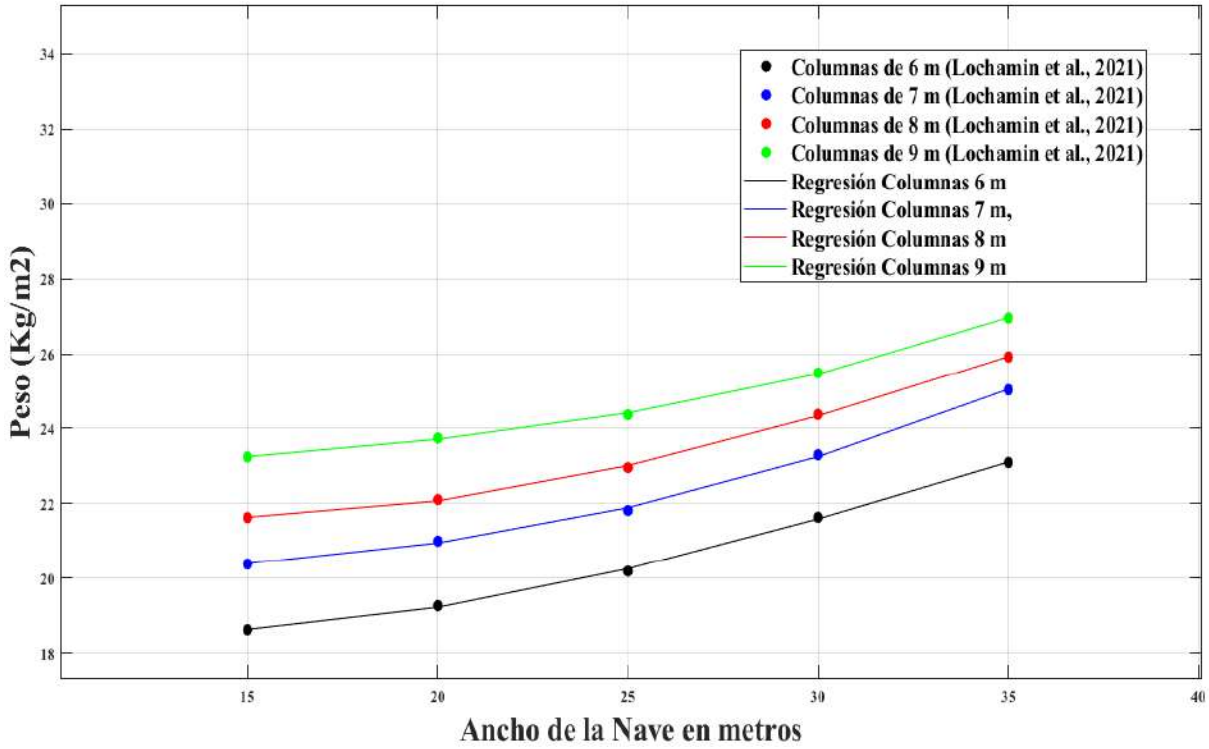

Figura 8. Curvas de los pesos de las estructuras obtenidos por regresión grado 3.

2.3. Análisis de resultados del ajuste de las curvas de los pesos de las naves industriales por interpolación y regresión

Con base en los resultados que se obtuvieron en los tópicos anteriores, se procedió a realizar un análisis de resultados de cada uno de los métodos de interpolación y regresión, como se puede observar en las tablas 10 a 13 y su representación gráfica en la figura 9.

2.4. Comprobación de resultados

Para efectos de comprobación de los métodos de interpolación y regresión, en el presente manuscrito se procedió a verificar los respectivos valores de índice de peso sobre área de naves industriales y error relativo, utilizando luces que variaron entre 21,83 a 33,42 m para distintas alturas de columnas de los pórticos, como se puede apreciar en la tabla 14.

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Tabla 10. Pesos de las estructuras para columnas de 6 m por interpolación y regresión

Luz libre (m)	Método DFCR (Loachamin et al., 2021)	Columnas de 6,00 m de altura							
		Interpolación						Regresión	
		Lagrange		Diferencias divididas		Splines cúbicos		Mínimos cuadrados	
	Peso (kg/m²)	Peso (kg/m²)	Error relativo (%)	Peso (kg/m²)	Error relativo (%)	Peso (kg/m²)	Error relativo (%)	Peso (kg/m²)	Error relativo (%)
15	18,6152	18,61516474	0,000189427	18,61532325	0,000662093	18,6152	0	18,62634714	0,05988194
20	19,2615	19,26145065	0,000256186	19,261726	0,001173325	19,2615	0	19,21691143	0,231490649
25	20,1828	20,18280561	2,77939E-05	20,18316375	0,001802277	20,1828	0	20,24968286	0,331385423
30	21,6346	21,63456745	0,000150444	21,635139	0,00249138	21,6346	0	21,59001143	0,206098432
35	23,0921	23,09213742	0,000162053	23,09285425	0,003266269	23,0921	0	23,10324714	0,048272539

Tabla 11. Pesos de las estructuras para columnas de 7 m por interpolación y regresión

Luz libre (m)	Método DFCR (Loachamin et al., 2021)	Columnas de 7,00 m de altura							
		Interpolación						Regresión	
		Lagrange		Diferencias divididas		Splines cúbicos		Mínimos cuadrados	
	Peso (kg/m²)	Peso (kg/m²)	Error relativo (%)	Peso (kg/m²)	Error relativo (%)	Peso (kg/m²)	Error relativo (%)	Peso (kg/m²)	Error relativo (%)
15	20,3786	20,37864786	0,000234862	20,37859375	3,06694E-05	20,3786	0	20,39096857	0,060693921
20	20,9941	20,99406363	0,000173263	20,99408	9,52649E-05	20,9941	0	20,94462571	0,235658045
25	21,8148	21,81482457	0,000112641	21,81475625	0,000200552	21,8148	0	21,88901143	0,340188443
30	23,2968	23,29683835	0,000164598	23,29672	0,000343395	23,2968	0	23,24732571	0,212365156
35	25,0304	25,03037988	8,03881E-05	25,03026875	0,000524362	25,0304	0	25,04276857	0,049414198

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Tabla 12. Pesos de las estructuras para columnas de 8 m por interpolación y regresión

Luz libre (m)	Método DFCR (Loachamin et al., 2021)	Columnas de 8,00 m de altura							
		Interpolación						Regresión	
		Lagrange		Diferencias divididas		Splines cúbicos		Mínimos cuadrados	
	Peso (kg/m²)	Peso (kg/m²)	Error relativo (%)	Peso (kg/m²)	Error relativo (%)	Peso (kg/m²)	Error relativo (%)	Peso (kg/m²)	Error relativo (%)
15	21,625	21,62495686	0,000199492	21,6249375	0,000289017	21,625	0	21,63408979	0,042033691
20	22,1054	22,10536646	0,000151729	22,1052	0,000904756	22,1054	0	22,06901686	0,16458939
25	22,9549	22,95487683	0,000100939	22,9544625	0,001905911	22,9549	0	23,00945821	0,237675676
30	24,3713	24,37128602	5,73662E-05	24,3705	0,00328255	24,3713	0	24,33491386	0,14929915
35	25,9158	25,91577078	0,000112755	25,9144875	0,005064478	25,9158	0	25,92488378	0,035051144

Tabla 13. Pesos de las estructuras para columnas de 9 m por interpolación y regresión

Luz libre (m)	Método DFCR (Loachamin et al., 2021)	Columnas de 9,00 m de altura							
		Interpolación						Regresión	
		Lagrange		Diferencias divididas		Splines cúbicos		Mínimos cuadrados	
	Peso (kg/m²)	Peso (kg/m²)	Error relativo (%)	Peso (kg/m²)	Error relativo (%)	Peso (kg/m²)	Error relativo (%)	Peso (kg/m²)	Error relativo (%)
15	23,2394	23,23944723	0,00020324	23,2394015	6,45456E-06	23,2394	0	23,24705857	0,032955117
20	23,7424	23,74239338	2,79012E-05	23,742402	8,42375E-06	23,7424	0	23,71176571	0,129027755
25	24,3651	24,36511738	7,1346E-05	24,3651025	1,02606E-05	24,3651	0	24,41105143	0,18859528
30	25,4891	25,48907738	8,87522E-05	25,489103	1,17697E-05	25,4891	0	25,45846571	0,120185827
35	26,9599	26,95986417	0,000132896	26,9599035	1,29822E-05	26,9599	0	26,96755857	0,028407269

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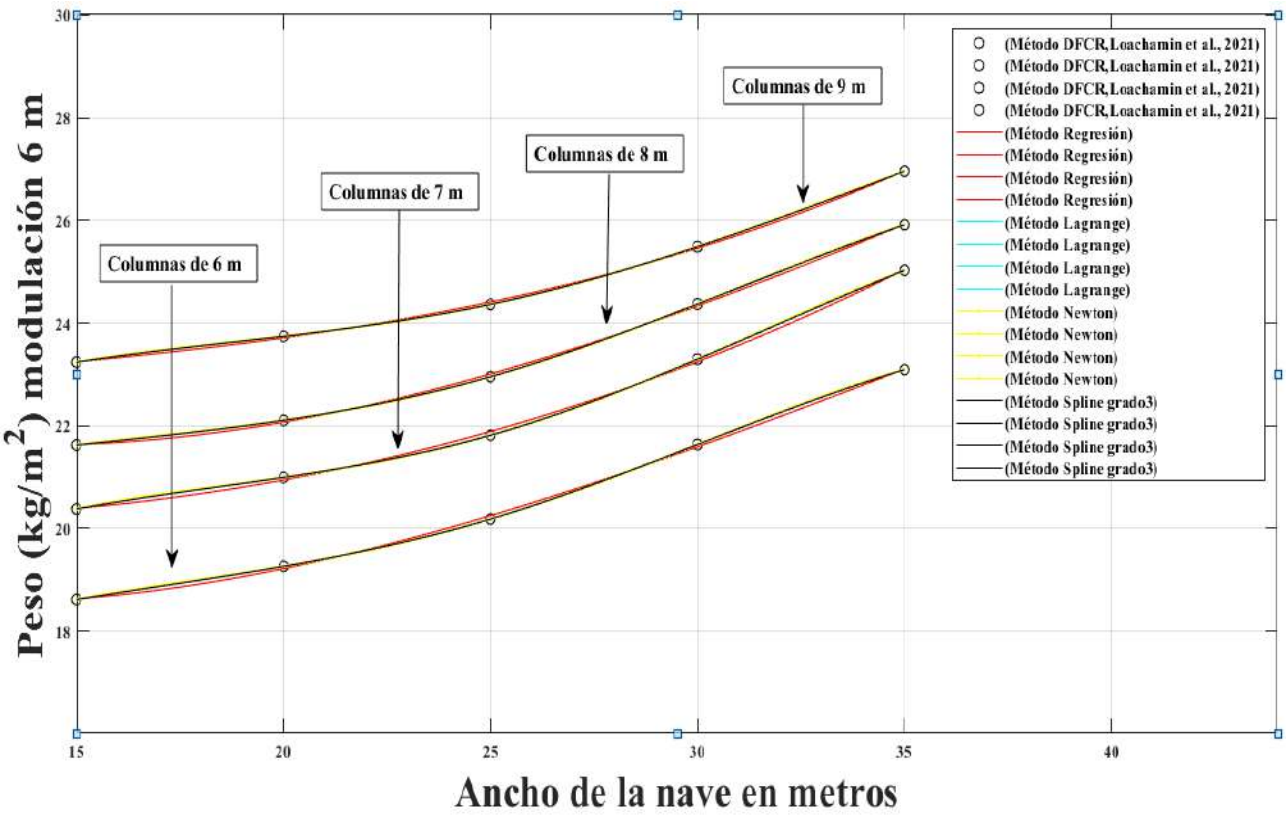

Figura 9. Curvas de los pesos de las estructuras obtenidos por interpolación y regresión

Tabla 14. Comprobación de resultados

Luz libre (m)	Altura columnas (m)	Método DFCR (Loachamin et al., 2021)	Análisis numérico							
			Lagrange		Interpolación Diferencias divididas Newton		Splines cúbicos		Regresión Mínimos cuadrados	
		Peso (kg/m²)	Peso (kg/m²)	Error relativo (%)	Peso (kg/m²)	Error relativo (%)	Peso (kg/m²)	Error relativo (%)	Peso (kg/m²)	Error relativo (%)
33,42	6	22,71	22,6944901	0,06829567	22,6951952	0,06519073	22,6746	0,15587847	22,6145467	0,42031396
26,16	7	22,08	22,1007341	0,09390447	22,1006476	0,09351249	22,1033	0,10552536	22,16641549	0,39137451
21,83	8	22,33	22,3492754	0,08632072	22,3490316	0,08522887	22,3546	0,1101657	22,36093347	0,13852876
31,76	9	25,98	25,9913706	0,0595576	25,9914126	0,0597192	25,9821	0,02386828	25,93117668	0,17217235
			Media	0,07701961	Media	0,07591282	Media	0,09885945	Media	0,28059739
			Desviación	0,01583917	Desviación	0,01605962	Desviación	0,05491542	Desviación	0,14575296

Conclusiones

Cuando se realiza el análisis numérico aplicado al ajuste de curvas, se debe trabajar en sus dos categorías: interpolación y regresión. En esta investigación, en lo que respecta a la

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interpolación, se encontraron que, al comparar los valores obtenidos de los pesos de las naves industriales, por el método DFCR hallados en Loachamin et al., (2021), con los datos de las interpolaciones de: Newton y Splines de grado 3, se obtuvo un error medio bastante bajo; y las curvas de Lagrange y de Newton eran similares, difiriendo en un error menor con la de Spline de grado 3. En cuanto a la regresión se obtuvo un error medio más alto que las curvas de interpolación; por lo que se concluye que para esta investigación se puede utilizar cualquiera de los métodos numéricos de la interpolación, esto es debido a la tendencia global de los datos: donde sus cálculos van a hacer más precisos que al utilizar una regresión, y su desviación estándar va a ser menor. Además, se concluye que para obtener pesos intermedios de naves industriales utilizando el método DFCR (que es una de las métricas del cálculo estructural), se puede aplicar el análisis numérico a través de la obtención de un polinomio, y su precisión dependerá de la tendencia de la muestra.

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Analysis of the structural behavior of flat and circular self-supporting roof using finite elements

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ABSTRACT

The development and innovation of Science, specifically in the branch of construction in Civil engineering, has led the implementation of new alternatives in analysis, design and construction of industrial buildings. For this reason, in this research it was proposed to carry out a study of structural behavior of two types of self-supporting roofs: flat and circular, which were analyzed using computational tools for simulation through finite elements, in which initially the structure made up of columns, beams and steel sheets was completely modeled with an equivalent cross section, which made up the self-supporting roofs; then only the steel sheets with real cross section were discretized, and it was noted that in the extremes were the greatest stresses generated by the application of horizontal and vertical loads; and the maximum displacement of the circular roof was 14.32 % of the flat one.

KEYWORDS: Construction engineering; structural design; self-supporting roof; weight.

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Análisis del comportamiento estructural de cubierta autoportante plana y circular utilizando elementos finitos

RESUMEN

El desarrollo e innovación de la Ciencia y específicamente dentro la rama de la construcción en Ingeniería civil ha provocado que se implementen nuevas alternativas en análisis, diseño y construcción de naves industriales. Por tal motivo, en la presente investigación se planteó realizar un estudio del comportamiento estructural de dos tipos de cubiertas autoportantes: plana y circular, las mismas que fueron analizadas utilizando herramientas computacionales para simulación a través de elementos finitos, en las que inicialmente se modeló de forma completa a la estructura constituida de columnas, vigas y láminas de acero con una sección transversal equivalente, que conformaron las cubiertas autoportantes; posterior a ello se discretizó únicamente las láminas de acero con sección transversal real, y se observó que en los extremos fueron los mayores esfuerzos generados por la aplicación de solicitaciones horizontales y verticales; y el desplazamiento máximo de la cubierta circular fue 14.32 % de la plana.

PALABRAS CLAVE: Ingeniería de la construcción; diseño estructural; cubierta autoportante; peso.

Introduction

Innovation and competitiveness in the world of construction causes the manufacture of roofs for industrial buildings to change both in their materials and their geometry. The most used materials for the construction of sheds are wood, aluminum, and steel, which easily adapt to various environments or climates without losing their functionality (Soria, 2020).

Industrial buildings made of structural steel provide qualities such as versatility, implementation of new facilities, extensions, and improvements in general. Besides, this type of structure can be designed in a plastic range in order to reduce manufacturing costs (Arnedo, 2016).

Currently, industrial buildings use self-supporting roofs which are an enclosure or membrane-type roof that uniformly distributes the stresses received, either thermal or climatic of any order, and distributes them on the walls in a uniform way, contributing to the distribution of loads and their linear and uniform transmission to the foundations. As there is no supporting structure, the roofs rest on the load-bearing beams or perimeter beams, which constitutes their

main differential element: the total absence of purlins, trusses, beams, or any other intermediate resistant element. These are works in which the calculation of the geometry of the structure must be carried out with accuracy since it is not a system based on standard pieces but it is manufactured and custom-made for each building, allowing to incorporate elements such as isolations, translucent, which can be curved or flat (Durma, 2016).

In Ecuador, the analysis and design of industrial buildings have been pivotal for the implementation of several projects on a national scale (Cuichán, 2016), which promote and make the country's productive system grow; for this reason, there is a need to know the structural behavior between a flat and circular self-supporting roof (Pilamunga, 2021; Páez, 2020); hence, the aim of this research is to establish a comparative analysis between these types of industrial buildings.

The application of the finite element method allows finding approximations in the solution, since it divides the continuous medium of a domain into elements with finite dimensions, which supports the analysis of the structural response of a system (Nápoles et al., 2015). Regarding the application of this method, it is very useful to predict the performance and possible failures of a specific design; consequently, it will serve to obtain structures with greater benefits in safety, stability, and economy (Vásquez & López, 2001).

1. Materials and Methods

The main objective of this research was to carry out a comparative analysis of the structural behavior between two flat and circular self-supporting roofs, using finite elements with the help of computer packages to determine the roof with the best structural performance when faced with the application of vertical and horizontal stresses.

1.1. Description of self-supporting roofs

In this research, two industrial buildings were considered that are made up of columns, truss-type perimeter beams and steel sheets as covering of the buildings, as can be seen in figure 1; it is worth mentioning that these structures lack of main beams and purlins. The free span that was used was 20 m, and the separation between frames depended on the useful width of which each steel sheet is formed to create the self-supporting roof. Regarding the height of the columns

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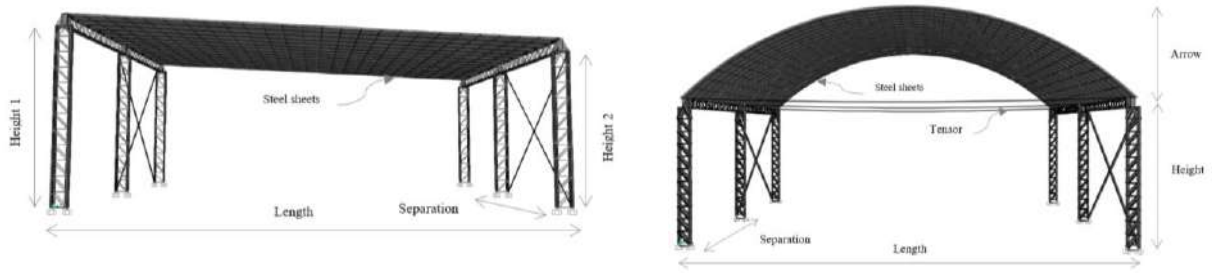
of the sheds, they obeyed the type of shape that the roof received, i.e., both columns were raised in the circular shed to be equal in height, i.e., 6.00 m; while on the flat roof, a minimum slope of 5 % was applied (Fernández, 1998)height of its columns had to be different, i.e., height 1 was 6.00 m and height 2 was 6.70 m.



(a) (b)

Figure 1. Self-supporting roofs geometry: a) flat, b) circular.

1.2. Characteristics of the material used in beams, columns, and steel sheet for self-supporting roofs

For the configuration of the truss-type columns and perimeter beams, hot-rolled profiles were used, which had equal side angles (AISC, 2016), and cold-formed profiles type "C" or channels (AISI, 2016); thus, in this research ASTM A36 steel was used.

For the coverage of the sheds in this research, the Imap-800 sheet (Açoport, 2021), CS 1000-610 (Sanxing, 2021) was used for flat and circular roof respectively. Each of these has a different useful width, height and thickness recommended for the 20 m span, as shown in table 1 and figure 2.

Table 1. General characteristics of self-supporting roofs: flat and circular.

Roof type	Designation	Width (mm)	Height (mm)	Recommended thickness (mm)
Flat	Imap-800	800	260	1.55
Circular	CS 1000-610	610	252	0.61

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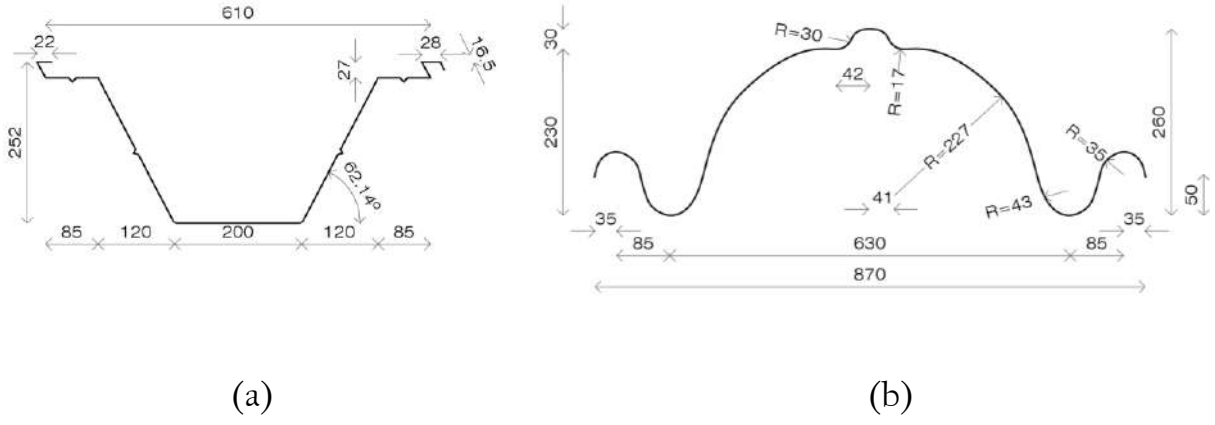

(a) (b)

Figure 2. Steel sheets for self-supporting roofs: a) circular, b) flat.

The material used for the conformation of the self-supporting roofs comes from galvanized steel coils that lack of paint as indicated in the regulations (ASTM A653, 2020). Table 2 shows the technical sheet of the constituent material of the industrial buildings that were analyzed in this research.

Table 2. Technical data sheet of the material used in self-supporting roofs: flat and circular.

Description	Flat and circular roof
Coating designation	Z275-G90
Coating weight on both sides (g/m²)	275
Base metal density (kg/m³)	7850
Young's modulus (kg/m³)	200000
Poisson's ratio	0.3
Bulk modulus (MPa)	167000
Shear modulus (MPa)	76900
Yield stress (MPa)	380
Tensile strength (MPa)	480

Additionally, it can be indicated as part of the specific geometry of the circular self-supporting roof that the arrow used was 4.00 m, which was determined through equations 1 (Ruiz, 2003) to 2 (Páez, 2020).

$$R = \frac{L^2}{8 * f} + \frac{f}{2} \quad (1)$$

$$f = c * L \quad (2)$$

Where "R" is the radius of the circumference of the self-supporting roof; "L" is the distance of the roof; "F" is the arrow on the cover, and "c" is a percentage that depends on the aesthetic or architectural environment; this value fluctuates between 0 to 50 % (Proingcol, 2021). For this research, a percentage of 20 % was used to generate a more economical roof, since the greater the deflection, the greater the length of the steel sheet, consequently, the greater weight of the steel.

In the flat self-supporting roof, a minimum slope indicated in the previous topics of this manuscript was used, as a consequence, the maximum height applied was 6.70 m.

1.3. Loads and load combinations applied to self-supporting roofs: flat and circular

In this research, the loads applied to the self-supporting roofs were dead, live, hailstone, wind, and earthquake, i.e., vertical and horizontal loads.

The dead load corresponds to the own weight of the structural elements such as truss-type perimeter columns and beams and the so-called self-supporting steel sheets. Regarding the live load, it had a value of 70 kg/m² considered as an overload to carry out maintenance of the roof. The hailstone load on the circular self-supporting roof considered as a reference the slopes generated by the roof itself, less than 15 % and less than 5 %, with the application of loads directed in the sense of gravity, which were 50 kg/m² and 100 kg/m² respectively; while in the flat self-supporting roof a value of 50 kg/m² was applied, being a representative value of a uniform accumulation of 5 cm of hailstone (NEC Cargas no sísmicas, 2014). The latter points out that the hailstone load application values are different due to the shape of the roofs and the possible accumulation of hailstone.

For the application of wind load in the analyzed structures, it is evident that it is due to the configuration presented in figure 1, i.e., a flat roof on one side and a circular roof on the other. It can be seen in figure 3 how the application diagrams are different.

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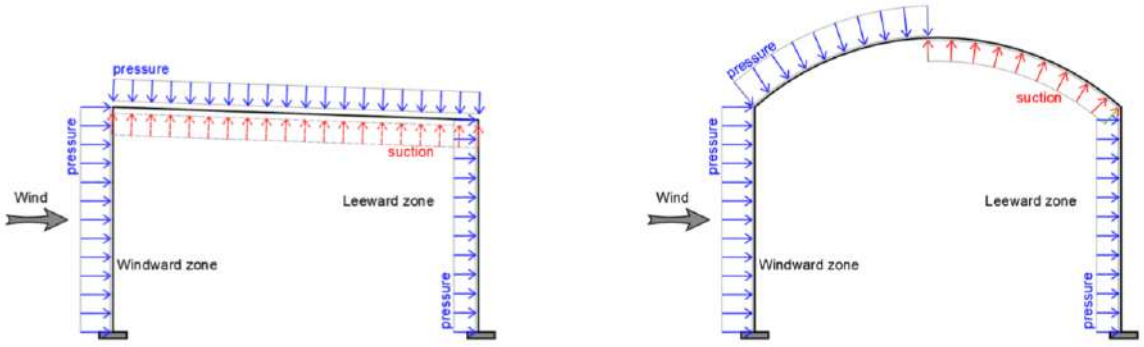

Figure 3. Wind load application diagrams on self-supporting roofs: a) flat, b) circular.

Because of the latter, tables 3 and 4 indicate the parameters used for the application of the wind load and table 5 shows the horizontal force due to the earthquake in industrial buildings.

Table 3. Parameters for wind load application on flat self-supporting roof.

Length (m)	Cover height (m)	C_1	C_2	V_b (km/h)	W.P. (kg/m²)	L.P. (kg/m²)
20	7.66	0.880	1.63	66.53	10.64	21.28

C_1: height correction coefficient, C_2: height environment coefficient, V_b: corrected wind speed, W.P.: windward pressure, L.P.: leeward pressure.

Table 4. Parameters for wind load application on circular self-supporting roof.

Length (m)	Cover height (m)	C_1	C_2	V_b (km/h)	W.P. (kg/m²)	L.P. (kg/m²)
20	10.30	0.902	1.91	68.20	30.50	26.15

C_1: height correction coefficient, C_2: height environment coefficient, V_b: corrected wind speed, W.P.: windward pressure, L.P.: leeward pressure.

In this paper, analysis and design of the self-supporting roofs were carried out using the method by load and resistance factor design with its acronym LRFD, in which the resistance or failure condition is considered and where the applied service loads of the structure is factored

and also the resistance of the material is reduced. This factored load must be less than or equal to the reduced resistance (Loachamin et al., 2021); for this purpose, a computational package that works with finite elements was used (SAP 2000, 2021).

Table 5. Parameters to define the basal shear used in self-supporting roofs: flat and circular.

Description	Parameter	Value
Importance factor	I	1.00
Seismic force reduction factor	R	3.00
Seismic zone	-	V
Zone acceleration factor	Z	0.40
Spectral amplification ratio	η	2.48
Soil type	-	C
F_a site fact	F_a	1.20
F_d site fact	F_d	1.11
F_s inelastic behavior factor of the soil	F_s	1.11
Project geographic location factor	r	1.00
Limit period in T=T_o	T_o (s)	0.103
Limit period in T=T_c	T_c (s)	0.565
Limit period in T=T_l	T_l (s)	2.664
Plant irregularity factor	ϕ_P	1.00
Elevation irregularity factor	ϕ_E	1.00
Basal shear with respect to reactive load	V	0.3968

The load combinations used in this research are those detailed in equations 3 to 10 (NEC Cargas no sísmicas, 2014).

Where "D" is the dead load; "L" corresponds to live load; "Lr" is the live roof load, "S" represents the hail load; "W" corresponds to the wind load; "E" represents the load due to earthquake.

After the analysis and design (SAP 2000, 2021), the structure was discretized and only the steel sheets with the cross-section indicated in figure 2 were taken into consideration for self-supporting roofs: flat and circular, in which the computational tool for analysis and simulation by finite elements (ANSYS, 2021) was used, in which the self-supporting roofs were modeled.

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The modeling of 9 steel sheets was proposed for the circular self-supporting roof, while 15 steel sheets were used in the roof in the flat for modeling, as indicated in figures 4 and 5.

$$U_1 = 1.4D \tag{3}$$

$$U_2 = 1.2D + 1.6L + 0.5max(Lr, S) \tag{4}$$

$$U_3 = 1.2D + 1.6max(Lr, S) + max(L, 0.5W(+,-)) \tag{5}$$

$$U_4 = 1.2D + W(+,-) + L + 0.5max(Lr, S) \tag{6}$$

$$U_5 = 1.2D + E\big(x(+,-), y(+,-)\big) + L + 0.2S \tag{7}$$

$$U_6 = 0.9D + W(+,-) \tag{8}$$

$$U_7 = 0.9D + E\big(x(+,-), y(+,-)\big) \tag{9}$$

$$U_8 = D + L \tag{10}$$

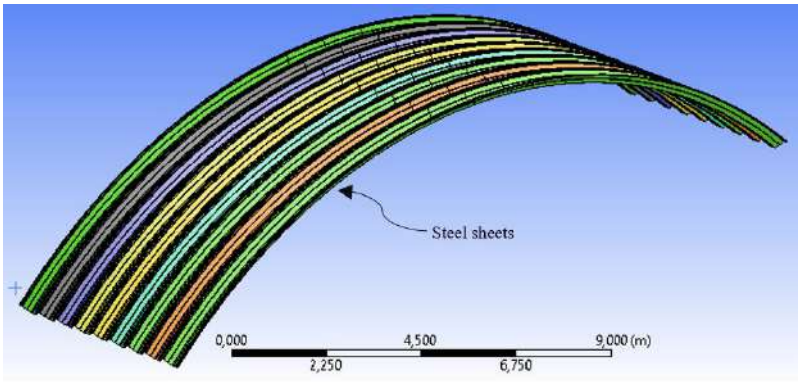

Figure 4. Steel sheets for circular self-supporting roof.

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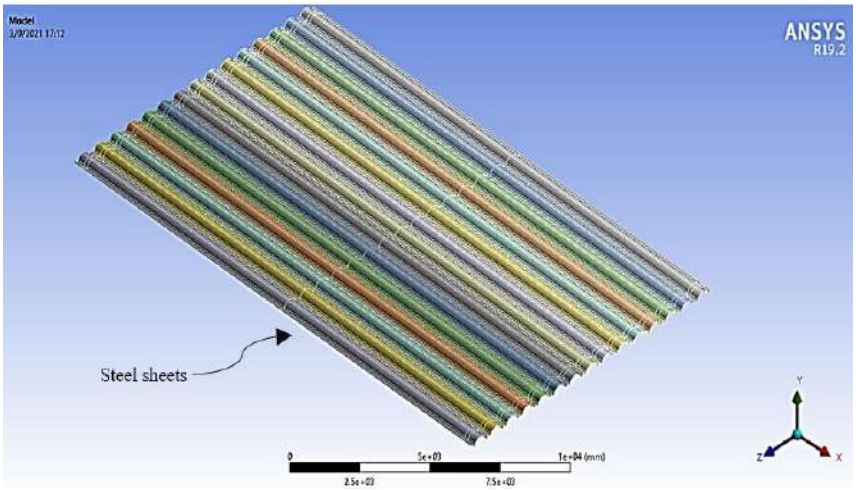

Figure 5. Steel sheets for flat self-supporting roof.

Regarding the analysis of the simulation by finite elements (ANSYS, 2021), in the self-supporting roofs: flat and circular for the discretization of the steel sheets, surface bodies were used due to the small thicknesses indicated in table 1, i.e., these elements have their nodes located at their vertices. This alternative was chosen due to the less computational time generated in it; these surface bodies that were used were triangular and quadrilateral elements (Lee, 2019), as seen in figures 6 and 7.

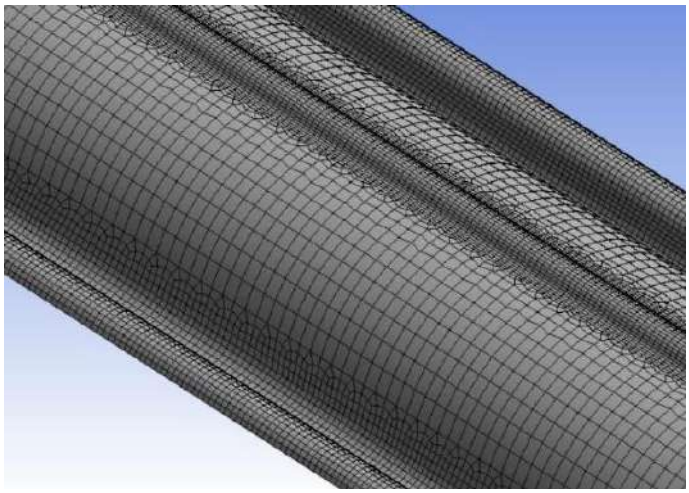

Figure 6. Discretization of flat self-supporting roof.

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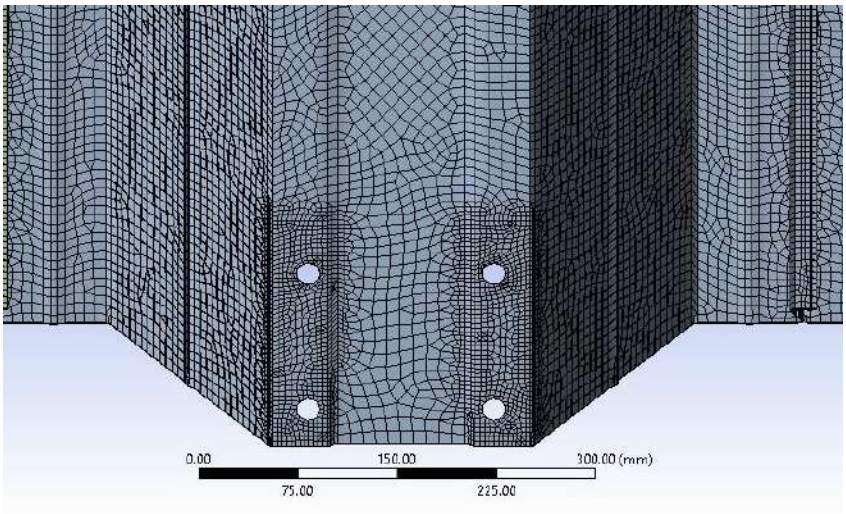
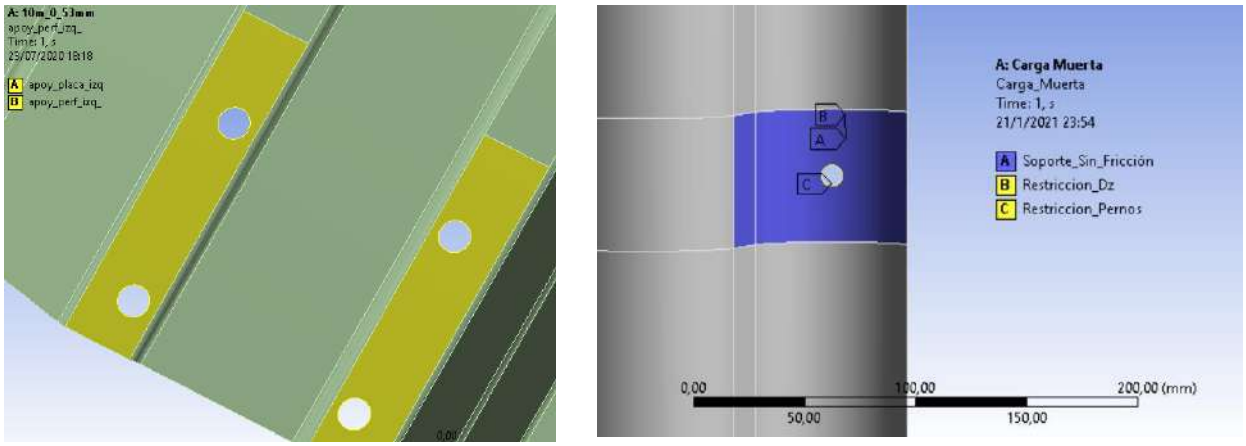


Figure 7. Discretization of circular self-supporting roof.

The supports that were applied in the circular self-supporting roof were an edge condition without displacements as can be seen in figure 8 but allowing rotations; in addition, the interaction that existed between the steel sheets with the clamping plates were taken into account. This is a vertical displacement restriction on the surfaces that are in direct contact with the support plate, and the same edge condition was applied in the flat self-supporting roof (Páez, 2020; Pilamunga, 2021).



(a) (b)

Figure 8. Edge condition in self-supporting roofs: a) circular, b) flat.

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2. Results and Discussions

Due to the complexity of the cross-sections of the steel sheets used for flat and circular self-supporting roofs, an equivalent thickness was used as shown in table 6; these were modeled in a computer package (SAP 2000, 2021), which served as starting point to analyze the complete structure, consisting of structural elements such as columns, beams, and steel sheets.

Table 6. Equivalent thickness of self-supporting roofs.

Roof type	Equivalent thickness (mm)
Flat	60.91
Circular	50.70

Analysis and design of the elements that make up the industrial buildings were carried out using steel sheets for flat and circular roofs; tables 7 to 10 show axial loads and displacements for certain load combinations indicated in the equations described in the previous section of this manuscript. The reactions were taken from the zone with the largest tributary area; additionally, the displacements were extracted in the upper part of the left and right column, both for the flat and circular self-supporting roof. Table 11 shows the behavior of the structures concerning vibration modes and periods (SAP 2000, 2021), for both self-supporting roofs.

Table 7. Flat self-supporting roof reactions.

	Reactions (kgf)			
Load pattern	D	L	D+L	1.2D+1.6L
Left column	1646.70	262.91	1909.61	2396.70
Right column	1656.86	269.29	1926.14	2419.08

In the tables presented above, it is evident that concerning the reactions for a combination of dead load plus live load, the circular self-supporting roof transmitted greater load, and this corresponds to 2.24 times the value of the load transmitted by the self-supporting

roof in the flat; consequently, structural elements such as columns of the circular self-supporting roof were found with higher axial loads.

Table 8. Displacements of flat self-supporting roof.

Load pattern	Displacements (mm)					
	Left column		Right column		Center of span	
	Seismic X	Seismic Y	Seismic X	Seismic Y	D	D+L
Direction X	11.81837	0.02099	11.81232	0.02174	-3.24299	-3.88444
Direction Y	0.01579	4.81941	0.02903	3.1696	-0.00217	-0.00229
Direction Z	0.03891	0.13525	0.0831	0.08181	-54.0214	-64.61017

Table 9. Circular self-supporting roof reactions.

	Reactions (kgf)			
Load pattern	D	L	D+L	1.2D+1.6L
Left column	845.97	3466.26	4312.25	6561.20
Right column	846.00	3466.64	4312.64	6561.82

Table 10. Displacements of circular self-supporting roof.

Load pattern	Displacements (mm)					
	Left column		Right column		Center of span	
	Seismic X	Seismic Y	Seismic X	Seismic Y	D	D+L
Direction X	10.14669	0.62355	10.14891	-0.56252	-0.00169	-0.01378
Direction Y	0.01279	1.10895	0.01278	1.10295	0.0007009	0.00348
Direction Z	-0.06678	0.06323	0.6676	-0.06251	-6.4048	-34.6591

Table 11. Vibration modes and periods in self-supporting roofs: flat and circular.

	Flat cover	Circular cover
Mode	Period (s)	Period (s)
1	0.419204	0.322233
2	0.34656	0.314963
3	0.218914	0.243651

On the other hand, about the displacements under the same combination described in the previous paragraph, it was found that the displacement in the direction of gravity for the circular self-supporting roof corresponds to 53.64 % of the value found for the flat self-supporting roof; consequently, the circular roof has a lower deflection located in the center of the span.

Regarding the seismic behavior of industrial buildings, it was observed that the vibration modes and periods of each of the analyzed structures comply with the provisions of the Ecuadorian Construction Standard in the chapter corresponding to seismic danger, which indicates that the fundamental period of vibration corresponds to an estimate of the value of the period of the structure, which allows finding the horizontal forces due to earthquakes applied to the structure (NEC Peligro sísmico, 2014), applying equation 11.

$$T = C_t * h_n^{\alpha} \quad (11)$$

Where "T" is the period of vibration of the structure, "C_t" is the coefficient that depends on the type of structure. For this investigation a value of 0.073 was taken, which represents a steel structure with bracing. Additionally, as a consequence of this value, the coefficient "α" was considered with a value of 0.75 and in turn this depends on the type of structure, "h_n" is the maximum height of the structure measured from the base in meters. If the value obtained from the period found with equation 11 is increased by 30 %, this value constitutes the period of vibration calculated analytically according to (NEC Peligro sísmico, 2014); therefore, the period of vibration found with a modal analysis (SAP 2000, 2021) should not exceed the calculated analytically, as can be seen in table 12.

Table 12. Calculated vibration period of self-supporting roofs: flat and circular.

Roof type	T_{ma} (s)	T_a (s)
Flat	0.4192	0.4368
Circular	0.3222	0.5456

T_{ma}: vibration period of modal analysis, T_a: vibration period analytically calculated.

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Analyzing tables 11 and 12 it is observed that the period found by the modal analysis corresponds to a lower value than that calculated analytically, consequently, both self-supporting roofs comply with what is indicated in the Ecuadorian Construction Standard,seismic danger chapter.

Table 13 shows the inelastic drifts in the X and Y directions. It can be seen that the drifts obtained from the structural analysis did not exceed the value of the maximum inelastic drift corresponding to 0.02 (NEC Peligro sísmico, 2014), calculated as indicated in equation 12.

$$\Delta_i = 0.75 * R * \Delta_e \quad (12)$$

Where "Δ_i" is the maximum inelastic drift, "R" corresponds to the response reduction factor and "Δ_e" corresponds to the relation between displacement and height.

Table 13. Inelastic drifts of self-supporting roofs.

Roof type	Δ_x	Δ_y	Δ_i
Flat	0.004109	0.001559	0.02
Circular	0.002907	0.000883	0.02

Δ_x: inelastic drift in direction "x", Δ_y: inelastic drift in direction "y", Δ_i: maximum inelastic drift.

Another very important piece of data within the field of design and construction which directly affects the cost of steel corresponds to the weight index of the structure over the area of the industrial buildings, as can be seen in table 14. The index of the circular self-supporting roof is less than the flat roof, i.e., the total weight in the circular self-supporting roof corresponds to 56 % of the corresponding value in the flat self-supporting roof.

Table 14. Weight index on self-supporting roof area: flat and circular.

Roof type	Steel sheet weight (kg/m²)	Beams and columns weight (kg/m²)	Total weight (kg/m²)
Flat	21.85	8.76	30.61
Circular	11.00	6.16	17.16

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Regarding the modeling used (ANSYS, 2021), and considering figures 6 and 7, in table 15 it is possible to observe the number of elements and nodes in which the self-supporting roofs were discretized, in which it could be seen that the number of nodes and elements of the flat self-supporting roof corresponds to a value of 50 % of that obtained for a circular self-supporting roof.

Table 15. Number of nodes and elements in self-supporting roofs: flat and circular.

Roof type	Steel sheet quantity	Node quantity	Elements quantity
Flat	15	869164	853834
Circular	9	1706600	1985400

In the finite element simulation process, in order to comply with what is related to the stresses and displacements obtained in the industrial buildings, the thickness of the steel sheets that made up the self-supporting roofs was increased, as indicated in table 16, being the allowable limit value in creep 342 MPa and the allowable limit displacement of 100 mm. It was observed that stresses and displacements on both roofs are fully met with these parameters; additionally, it was observed that the greatest stresses were presented at the supports of each roof as shown in figure 9, i.e., at the ends; while the maximum displacements were presented in the center of the span of each roof as shown in figure 10.

Table 16. Maximum stresses and displacements in self-supporting roofs.

Roof type	Initial thickness (mm)	Final thickness (mm)	Maximum stress (MPa)	Maximum displacement (mm)
Flat	1.55	1.95	330.19	89.273
Circular	0.61	0.76	272.42	12.785

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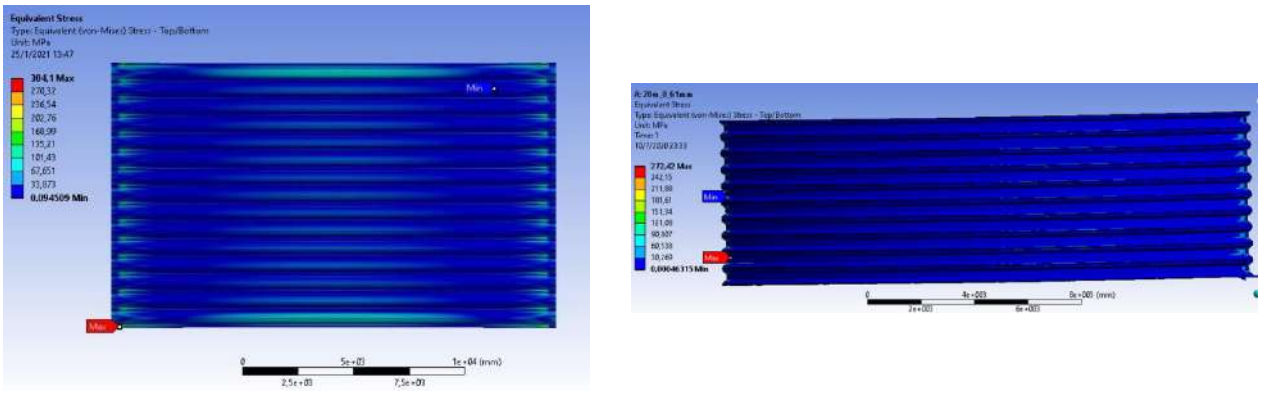
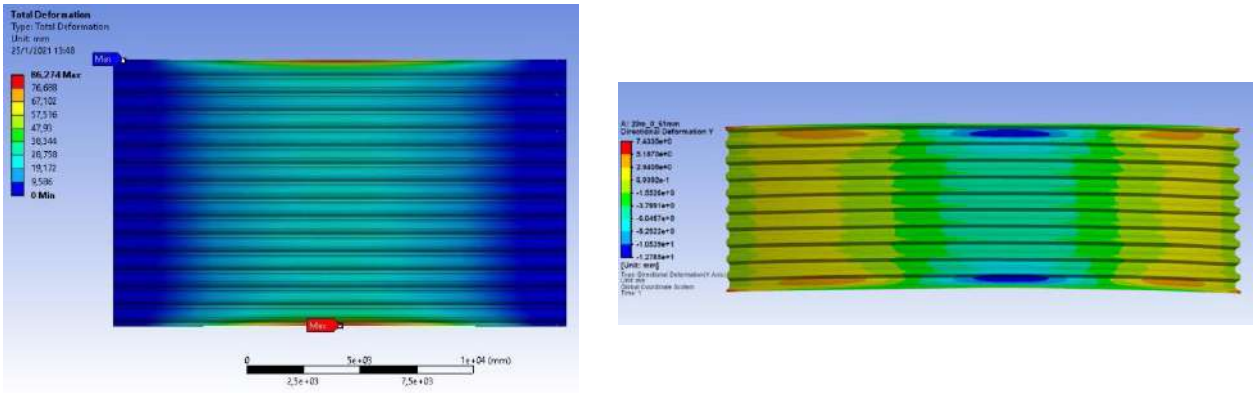


(a) (b)

Figure 9. Maximum stresses in self-supporting roofs: a) flat, b) circular.



(a) (b)

Figure 10. Maximum displacements in self-supporting roofs: a) flat, b) circular.

Conclusions

In this research, when analyzing the structures corresponding to self-supporting roofs: flat and circular with the characteristics described in this manuscript it can be concluded that the circular self-supporting roof provides better benefits in terms of structural behavior, i.e., both the efforts and displacements generated by the application of horizontal and vertical

stresses easily comply with the parameters established within the Ecuadorian Construction Standard.

After the analysis and structural design, it is very important to mention that the weight of the steel sheets that make up the circular self-supporting roof was less in the construction area than the sheets that make up the flat self-supporting roof; consequently, this factor will greatly influence in deciding to choose any of the alternatives (flat and circular) for the application in a certain project.

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Robots in aerospace industry

Leonid B. Sobolev *

ABSTRACT

Robotization is a logical continuation of computerization and automatization of industrial and service processes on previous stage of world-wide economy's evolution development. Before, automatic machines with computer numerical control and automatic lines have replaced workers with completing many typical production operations by doing it with more speed and accuracy. In development of automatization, industrial and service robots have additional sensors (analogues for human senses' organs), and they can choose the program of built-in computer, depending on operators' commands in regime of remote control or sensors' signals in autonomous regime. Robotization with computerization and automatization is a necessary part of fourth industrial revolution, in which world-wide economy is. Robots are already working everywhere: in industrial workshops, on farmlands, in hospitals and in replacing "labor" resource with "capital" resource, because such replacement has economic value. The goal of this article is analysis the use of robots in world-wide aerospace industry and robotization impact on the labor market.

KEY WORDS: robotics; industrial robots; service industries; aerospace industry; vehicles.

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Robots en la industria aeroespacial

RESUMEN

La robotización es una continuación lógica de la informatización y automatización de los procesos industriales y de servicios en la etapa anterior del desarrollo de la evolución de la economía mundial. Antes, las máquinas automáticas con control numérico por computadora y líneas automáticas han reemplazado a los trabajadores para completar muchas operaciones de producción típicas al hacerlo con más velocidad y precisión. En el desarrollo de la automatización, los robots industriales y de servicios tienen sensores adicionales (análogos para los órganos de los sentidos humanos), y ellos pueden elegir el programa de computadora incorporada, dependiendo de los comandos de los operadores en régimen de control remoto o señales de sensores en régimen autónomo. La robotización con informatización y automatización es la parte necesaria de la cuarta revolución industrial, en la que se encuentra la economía mundial. Los robots ya están funcionando en todas partes: en talleres industriales, en tierras de cultivo, en hospitales y en la sustitución de recursos "laborales" por recursos "de capital", porque dicha sustitución tiene valor económico. El objetivo de este artículo es analizar el uso de robots en la industria aeroespacial mundial y el impacto de la robotización en el mercado laboral.

PALABRAS CLAVE: robótica; robots industriales; industrias de servicio; industria aeroespacial; vehiculos.

Introduction

We should distinguish automatization and robotization. Robot, according to International Federation of Robotics (IFR) must be able to make three types of operations: Sense, Think and Act, i.e. has a sensitive element (or some sensitive elements), built-in computer with software and making mechanism, which comes as technical or intellectual device. Automatization answers only one or two of the mentioned conditions. Robots can have different sizes (from micro-devices for bio-medical research to giant robotic industrial systems), different view (from human-like to absolutely not-normal) and different skills depending on sensors' type and computers' software (Yang et al., 2018).

More and more countries (developed or developing) understand the meaning of robotization for developing their economies and use robots in different industrial spheres and service industry. Robotics became independent industry, including hundreds of big, middle and small enterprises. There appeared national robotic associations, which are coordinated by IFR, made in 1987 as non-commercial organization. IFT collects statistical

data about industrial markets and service robots in the world, accompanies completing international conferences and robotic symposiums.

IFR divides robots into industrial and service ones in connection with separating economy in two sectors: industry and service. Therefore, service robots are also divided in two segments. The first segment includes professional robots, taking part in labor activity (medicine, trade, logistics, guard, etc.) The second segment is everyday robots, which help completing home works and leisure (vacuum cleaners, lawn mowers, game robots, "smart home", etc.) One of the directions of professional service robots is projecting and production of military robots (scouts, sappers, orderlies), which are made for completing defined by armed forces functions.

For comparative analysis of robotic industry condition in countries and separate companies there are usually four quantitative indicators: revenue, number of established robots (in the country, industry or separate Company), robotic density (number of robots for 10 000 workers) and relative growth of this or that indicator during a defined time section. Modern robotics can surely be determined as one of the high-tech spheres of industry. It is clear that with appearing new sensor elements, development of computer technics, appearing new materials and technologies, one robots get “old” and they are being replaced by new generation of robots (Küpper et al., 2019).

Until the end of XX century robots were rather expensive and labor in many developing countries was cheap. That is why robots had restricted usage even in developed countries, because it was possible to transfer harmful and non-requiring high qualification manufacturing in countries with cheap work force. However, in the world there are constant differently developed trends on decreasing robots’ prices and increasing the cost of work force in developing countries. Industrial robots find more and more wide usage in different spheres of many countries (Tilley, 2017).

IFR data shows that world-wide sales of industrial robots in 2018 have made $16.5 billion, taking into consideration peripheral equipment, software and costs for setting: about $44.6 billion. In quantitative expression there has been sold 422 000 robots. Density of robotization on average has reached 99 units on 10 000 workers. Main consumers of industrial robots in 2018 were: automotive industry (more than 120 000 units, 30% of the market), electronic and electrotechnical industries (105 000 units, 25% of the market) and

metalworking and engineering industries (43 000 units, 10% of the market). Despite the whole number of established robots in the world is already higher than 2 million units, their amount in different spheres continues to grow fast (Shaw, 2019).

World Economy Forum (WEF) in its annual report "The Future of the Jobs-2018" estimated the share of world-wide production as 29%, which has been partly robotic (World Economic Forum, 2018). As it was mentioned before, the growth of demand on robots is accompanied by lowering their cost and expanding usage spheres. China more than other countries buys industrial robots and, according to the data of Company IFI Claims, leads in the amount of received patents and given applications for robotics (35% of the whole amount), what is two times more than holding the second place Japan (Keisner et al., 2016).

In 2019 the growth of sales of industrial robots was slowed down because of structural re-building of world-wide automotive industry (main consumer of industrial robots) and certain saturation of the consumer electronics market. In 2020 there was a pandemic of COVID-19, which has caused the crisis of touristic industry, and, as a result the demand falls for civil aircrafts. Further development of aerospace industry in the nearest perspective, including industry's robotization will depend on rapidness of solving mentioned problems (Yahoo finance, 2020). However, already in 2021, the recovery growth of the entire global economy and industries affected by COVID-19 began. The purpose of this article is to analyze the use of robots in the global aerospace industry, which is characterized by low production volumes and the widespread use of manual labor of highly skilled workers.

1. Methodology

The article uses Qualitative Case Study Methodology, which is widely used in studies related to the complexity or uncertainty of predicting the outcome. Aerospace sphere has started robotization with delay, caused by rather small amounts of airplanes supplies, space devices and surface equipment for this sphere. According to Flight Global, in 2019, there were 67 aerospace companies in the world with revenues in excess of $1 billion and another 25 companies with revenues from $0.5 billion to $1 billion, in which the use of robots can increase the company's efficiency. Manufacturing components and assembly and control processes are connected with big amount of hand operations, which are difficult for robotization. Nevertheless, aerospace corporations more and more invest in robotization for

increasing the production flexibility and increasing labor productivity. Robots are widely used in space exploration.

There are about 400 companies working on the world-wide market, producing industrial robotics. Many small companies make robots' accessories or software. Companies-integrators collect form the ready accessories robots by consumer's demands. Such individual robots are more expensive for the consumer than ready robots. In robotic industry there are many startups, created with the government support, which have made prototype and look for the investor or a big Company for organizing mass production. The article shows examples (cases) of successful cooperation between the aerospace and robotics industries, providing an increase in labor productivity, safety and quality of production, assembly and research work.

2. Results

2.1 Industrial robots in aerospace corporations

In aerospace industry the first to use robots in production processes were leaders of aircraft industry: Boeing, Airbus, Lockheed Martin and Bombarlber, who have reached rather high volumes of production. All these companies have created robotic departments, which closely interact with leading Japanese and European manufacturers of industrial robots and with small companies, available to complete specialized order. Nowadays, the leading places in production of industrial robots for different spheres of industry are taken by big Japanese companies (FANUC, Yaskawa, Kawasaki, Nachi, Denso, Mitsubishi, Epson) and some European companies (ABB, KUKA, Staubli, Universal Robots). Therefore, four companies (FANUC, ABB, KUKA и Yaskawa) hold more than 50% of the market. With them mostly interact leaders of the aircraft industry interact (Technavio Blog, 2019).

Thus, Boeing has implemented on its plants some robots of big industrial robots' manufacturers: Fanuc and Kuka. Boeing is used Fanuc robots for drilling, riveting, coating, painting, welding of aluminum structures and polishing. Robots of Kuka are established on the fuselage assembly lines B777 in the city Everett, where sections of fuselage are collected using rivets (about 60 000 units). Two manipulators of Kuka funcion synchronically: one establishes and rivets fasteners and another inside the fuselage performs the function of an anvil. Drilling holes in the fuselage is made by robot of another famous Company Electroimpact Inc, which drills holes and installs fasteners. Clients of Electroimpact Inc,

except Boeing, are Northrop Grumman, Bombardier and Embraer. Four-year experience of using robots for assembling fuselages B777 has shown that on this stage of robotization the Company cannot fully decline the usage of experienced mechanics (Johnsson & Shukovsky, 2019). The automatic Kuka platform omniMove also works on the Boeing enterprise for transferring large details. The Company has created its robotic research department (Boeing Research & Technology - BR&T), which has even patented fully robotic fuselage assembly line. It is known that Lockheed Martin also uses robots for fuselage assembly F-35 and painting with using Fanuc, Kuka and Comau robots.

Airbus also partners with Kuka: in 2016 the Company has given Airbus platforms omniMove for transferring parts of fuselage, which because of the weight and sizes are hard for transferring by cranes. Platforms can gather in "contents", that is why they are easy to adapt for details of different length. Since 2015 Airbus implements collaborative robots (cobots), which are workers' helpers. Mainly they are small robots on the wheels, which can move inside the fuselage of the being-built airplane safely for people working there. As the experience of airplanes' assembly robotization shows, small robots can become more profitable for aviation than big manipulators with lower cost and bigger universality. In this theme on the enterprise Airbus in Hamburg two robots on moving chassis Luise and Renate successfully work on the assembly line of A320, their function is drilling holes in the fuselage compartments for its further assembly. Before drilling, holes parts of fuselage are combined and perfectly flattened by laser. Spanish concern MTorres (Airbus division) has developed its small robot FDH (Flexible Drilling Head), which is moving in the fuselage and makes drilling and riveting. Since 2016 Airbus partners with a small Japanese Company Joint Robotics Laboratory for developing anthropomorphic robots (Norrris, 2013)

Except from drilling and riveting robots are widely used for welding, shape milling, painting, coating and non-destructive testing. Welding in the whole hardness of creation aviation technics is 40-50%. Wings of modern airplanes have a complex construction, including fuel tanks, hydraulics, flaps, ailerons, etc. For completing works inside the wing there are developed robots, which have a snake-like shape. In 2014-2018 years, Euponean Union (EU) has financed 17 robotic projects with a common name Horizon 2020, where each one is made for developing industrial and service robotics. Three of them are connected to aircraft industry (AEROARMS, AEROWORKS, COMANOID).

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2.2. Service Robots and Unmanned Aerial Vehicles (UAV)

All types of robots, which do not participate in manufacturing SA are service robots. The main demand in this segment have logistic robots, military robots, medical robots, robots for guard and control. In 2018, according to IFR report, sales' volume of professional service robots (without taking into consideration UAV) was $9.2 billion. Sales' volume of home service robots, such as vacuum cleaners, lawn mowers and play robots is $3.7 billion (the growth is 15%). The main developers of service robots are American companies: iRobot, Intuitive Surgical (manufacturer of medicated robots da Vinci), Chinese Company DJI (amateur quadcopters) and Japanese Company Nachi-Fujikoshi. Production of separate types of robots is also made by manufacturers of industrial robots mentioned before: Kuka, Omron и Yaskawa.

In air transportation industry in the near future we can expect appearance of service robots for helping service personnel in the airplane and in airports:

- robots-stewards;
- robotic check-in desks and boarding passes;
- robot police, equipped with television cameras, scanning the faces of people at the airport to find wanted criminals;
- robotic logistics systems for receiving and transporting baggage;
- robots informants;
- robots for cleaning airport premises.

Separate class of service robots are suggested by UAV or drones, which market is separated in two segments: military and civil UAV. According to the prediction of International Data Corporation, the world-wide market of UAV in the near future will grow at a steady pace. In 2018 the UAV market's volume made up $12.3 billions, in which $7.2 billion were used for military UAV and other $5.1 billion were used for civil one. Further annual growth is expected to be about 20%, just because of civil segment. The biggest developers in military segment are American, British and Israel companies: Boeing, BAE Systems, General Atomics, Israel Aerospace Industries and Elbit Systems (Gertler, 2012).

Market of civil UAV has separated in two parts: commercial (professional) drones and home (consumers) drones. In commercial segment of UAV developers DJI Company dominates which was the first to successfully lower costs and suggest apparats by the price

lower than $1 000 for individual usage. Commercial drones are used in police, cinematographic, agriculture and cartography. With multi-copters of Chinese manufacturers there are successfully compete drones of American Company iRobot and drones of French Company Parrot, which suggests consumers models (Canis, 2015).

There are a lot of ideas of using drones for different services, however, it is far away from industrial production. Low-cost commercial drones' payload, range and reliability still leave a lot to be desired. There are examples of successful decisions. Thus, drones-savers of American Company Zipline deliver blood and medicine to Ruande, but they do not raise more than 2 kilograms, Amazon Company demands using UAV for logistic goals.

2.3 Service Robots for Space

Separate consideration demand service robots, used in space. There are some competitive space markets, which satisfy common demands of defense and civilian character, scientific needs for knowledge of near-earth space and the Universe, and individual leisure needs for space communications, television, precise location determination, weather predictions and even exotic space tourism. Production sector includes developing and manufacturing launch vehicles, spacecraft (SC) of various sizes and purposes and ground infrastructure (cosmodromes, tracking and communication points with space objects, etc.). Service sector includes launch services, telecommunications services, data on the state of the earth's surface, etc. About usage of industrial robots in space manufacturing there is little information, but in some spheres of space activity service robots received wide usage.

World-wide space market in 2018 by data of American analytic Company Bryce Space and Technology made up $360 billion. The main income (more than 80% from world-wide economic activity in space) was received from sales of commercial products and services. These space products and services include launch services, telecommunications, broadcasting, navigation and the Earth observation. Other 20% were for counties' government programs, taking part in space activity. The main share of costs (about $50 billion) had the USA.

Space industry is one of the most high-tech and high-cost industries of monetary and intellectual character. The main players on this market are the USA, EU, China, Russia, Japan, Canada, Israel and India, which have SC of their own production and means of launching into near-earth orbits and interplanetary trajectories (launch vehicles). Because of

the necessity in big investments, which are not always occupied, there is widely known international partnership in holding scientific researches and building big space objects. Nowadays there is one such piloted SC of module type on near-earth orbit, whose name is International Space Station (ISS).

In recent years there are significant changes on space markets. Due to the appearance of new players in the industry (firstly Company SpaceX) and tightening of competition there decreases the cost of space launches. Production of SC is moved to the side of increasing the amount of small satellites for receiving more data about the state of the Earth's surface and the purposes of telecommunications. Space industry is becoming more available and attractive for other industries, public organizations and ordinary citizens. Space products and services in connection with traditional systems of telecommunications and monitoring the Earth's surface provide increasing services' quality and these services' availability.

All piloted space activity in service sphere is connected to cosmonauts' life risks, which start with rocket's launching and finish only after successful landing. That is why robots' usage in space industry is not only useful from the point of decreasing costs, but also are necessary from the point of dangers of being in outer space without a special protective spacesuit due to hard cosmic radiation. The main tools of space products are focused on big studying of the Moon, the Mars and other planets of Solar Systems, and also the possibility of making works in outer space.

For solving these tasks there are many different robotic systems, which can be separated in three types:

1. Orbital robots-manipulators for carrying out various work in orbit, which in turn are divided into three types; large manipulators for assembling complex structures in orbit or planets: small multifunctional manipulators and flying manipulators (Free-Flyers);
2. Collaborative robots-helpers in piloted SC;
3. Non-planetary stationary and mobile robots (rovers) equipped with manipulators.

According to distance to the Earth (and related signal's delay, while exchanging information between robot and operator) and also from the character of made work, robots can have three level of autonomy (control mode):

1. Tele management regime (operator always can control robot's work);

2. Semi-automatic (supervision) regime, when operator makes commands for changing works' program only when robot asks for it;
3. Automatic regime, when operator does not have the possibility to control the robot and only receives information from him (usually while working in the far outer space).

Space robots are important due to their ability to complete works in space, which are hard for cosmonaut or connected with life risk. In fact, every flight to space from the Earth's orbit ends with robots' death, because returning on the Earth is more expensive than creating new robot. Robots' delivery in space is an expensive "pleasure" (delivery to low orbit "costs" about 10 thousand dollars per kilogram), however, cheaper than a person, what makes it attractive for many space programs. Let us consider some examples of successfully realized and only projected space robots, which will be related or to manipulators, or to rovers that have manipulators (Wilcox et al., 2006).

2.3.1 Manipulators

In the end of 80s the USSR was the only country, which was able to create piloted module station "Mir" in near-earth orbit, which existed in orbit for 14 years. The USA was the first to understand technology of creating multi-usage space ships (Shuttle), which were used for researching outer space and for flying to the Moon. After the USSR's collapse, Russia, in cooperation with the USA and other countries, became a participant in the construction of ISS, built on a modular basis using Russian docking devices. However, while assembling ISS there were used American remotely controlled manipulators SRMS (Shuttle Remote Manipulator System), which were delivered in Shuttle cargo compartments. Then on ISS there was mounted remotely controlled manipulator (Space Station Remote Manipulator - SSRMS «Canadarm 2»), later to it there was added flexible manipulator «Dextre» (Special Purpose Dexterous Manipulator - SPDM), which has rather enlarged functional abilities of SSRMS. Both manipulators were developed and produced by Canadian Company MDA (MacDonald, Dettwiler and Associates).

Manipulator Restore-L, made by NASA order by Company Space Systems/Loral (SSL), is an example of "flying" manipulator for development of technologies for servicing satellites in near-earth orbit. The first stage of project is launching a robotized SC for refueling an active satellite Landsat 7. After Restore-L will make rendezvous, capture,

refueling and correction of the satellite's orbit, NASA will begin to test a number of other key technologies that are needed to explore the Mars. Technologies of Restore-L include a system of autonomous navigation with supporting onboard radio electronics and small programmed robotic manipulators launched from SC to refuel the satellite or modernization.

Harder program of satellites' management DARPA in geostationary orbit (RSGS) is built on the same principal and allows making the following works with the usage of multi-functional manipulations:

- checking and reduction from mechanical malfunctions such as failures in deploying solar panels and antennas;
- help in completing orbital maneuvers;
- setting of dockable modules, allowing to upgrade SC.

Though both programs are focused on SC management technologies demonstration in orbital flight, between them there is a difference in management. Rover Restore-L is oriented on tele management from the Earth, while RSGS will complete tasks in autonomous regime because of the connection delay due to the large distance to the flight control center.

Nowadays the exit to the orbit of large-scale constructions is not possible due to not enough carrying capacity of existing launch vehicles and large sizes of the required head fairings. To one of the projects of building large-scales constructions in near-earth orbits we can add the project «SpiderFab» of the Company Tethers Unlimited Inc.

2.3.2 Cosmonaut's Robots-Helpers

According to the place of holding additional works, collaborative robots usually function or in the ISS habitable compartment and are safe, while interacting with cosmonaut, or are situated and make works outside the ISS. In 2011 to the ISS there was delivered anthropomorphic robot Robonaut-2 (R2), developed by NASA and General Motors. Robot R2 is made mainly for making reconstructive works in depressurized compartments and outside the ISS and is capable of performing simple operations with a set of instruments. In 2014 there was made an attempt to make modernization in the ISS board by providing it with two additional grips ("legs"). The attempt was not successful due to wiring problems and the robot was returned on the Earth. Nowadays all problems on R2 are solved and there is a plan to return R2 in the ISS for holding further tests.

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In 2019 in the ISS there was delivered Russian anthropomorphic robot FEDOR for holding tests in work sphere. Tests have shown that robot can complete a few simple operations and needs revision. After series of tests the robot was returned on the Earth.

In the Institute of Robotics and Mechatronics of the German Center for Aviation and Astronautics, the anthropomorphic robot Justin has been designed to work in space, the main advantage of which is the ability to perform complex operations using 2 interacting grips ("hands").

2.3.3 Rovers

Up to nowadays with the usage of rovers deep researches of the closest planets started: the Moon and the Mars. Rovers-moonwalkers can be controlled from the Earth in tele management regime. On the Moon up to now there worked three managed rovers: Soviet "Lunokhod-1" (1970-1971), "Lunokhod-2" (1973) and Chinese moonwalker "Yuytu" (2013-2014). In 2020-2021 private companies Ispace (Japan) and SpaceX (USA) are planning to send two rovers-moonwalkers to the Moon.

Rovers Mars walkers are usually controlled in semi-automatic regime. The first to try to do it was the USSR, but all three attempts (Mars-2, Mars-3 and Mars-6) ended unsuccessfully. In 2016, ESA, together with Roscosmos, sent the Schiaparelly lander to Mars, but this attempt ended in failure. From the end of 1990s there were 4 American rovers successfully worked: Sojourner, Spirit, Opportunity and Curiosity, on which there were set manipulators for samples of soil, devices for studying the surface and climatic conditions and devices for transmitting the information received to the Earth. The fifth rover InSight has strated on May 5, 2018 and will start examining inner planet's composition: its crust, mantle and core for information on the history of the formation of the planet. Rover is equipped with manipulator InSight IDA (Instrument Deployment Arm), which is able to drill a well of 5 meters deep and measure heat fluxes and physical properties of the Marsian soil. Nowadays there are rover Curiosity and stationary geological manipulator InSight on the planet.

Japanese rover Hayabusa-1 in 2005 made a successful landing and sampling of soil samples from the near-earth asteroid Itokawa, which were delivered on the Earth in 2010. In 2018 another Japanese lander Hayabusa-2 made landing on the asteroid's Rugu surface and using three movable mini-rovers, which have different tools made series of researches,

including surveying the surface, measuring the temperature and mineral composition of the surrounding rocks. All information was transferred on the Earth.

3. Discussion

In the biggest aircraft building companies of the world (Boeing, Airbus, Lockheed Martin, Dassault Aviation), which have military and civil segments, growth of the labor productivity is a result of as growth of aviation production sales, as complex of activities for increasing production effectiveness (including automatization and robotization) (Sobolev, 2020). However, robotization creates fears, in aviation industry too, that robots will leave people without work. How much are justified these fears? Is there growing unemployment in the countries, which are leaders in implementation of industrial robots?

For answering these questions let us take such parameter as robotization density (number of robots on 10 000 workers). According to statistical IFR data for 2018 the world-wide leaders are Singapore, South Korea, Germany and Japan. In these countries the robotization density makes more than 300 units and robots halp to develop electrical industry, automotive industry and aerospace industry. Other countries with developed aerospace industry come into the top 20 of countries by robotization density: USA, Canada, Italy, France, China (135-247) with the middle number of 99 robots around the world. The exception makes Brazil, Russia and India, where robotization density is very low (less than 10 robots), there are weakly developed automotive and electrical industries. China is an absolute leader by the number of bought robots, trying to keep the "world workshop" position. The researches have shown that unemployment on this stage of robotization does not increase in the countries with high level of robotization and work places, which are replaced by robots are compensated with the appearance of new work places on growing robotic industry (Rodgers III & Freeman, 2019).

The following positive effect from robotization received the name "reshoring", which means return productions to developed countries with good investment climate that were transferred before to developing countries. Reshoring has become in the USA, which was caused by low costs on energy resources and economical effectiveness from robots' usage. The main reasons of reshoring are: growth of salary in developing countries and lowering robots' prices. The advantage of reshoring also consists in the fact that return of production allows companies create new work places in domestic country, easer logistics and lower

logical costs. By doing this, manufacturers can reduce the time for performing the task and quickly adapt production for local consumers (Reshoring Initiative, 2017).

There can be mentioned other positive effects from robotization. For example, replacing the human by robots on dangerous for life and health work places, such as painting automobiles and airplanes, underground works, outer space, serving patients in a pandemic. Robots are already successfully used in Japan for working in elderly houses, solving the world-wide problem of the nation getting old.

Then who is losing from robotization? There lose countries with low labor productivity and unqualified workers in all countries, which can be easily replaced by robots with higher productivity. Cheap work force was an advantage during the times, when robots cost rather high and could not compete in price with cheap work force in the third world countries. However, scientifically technical progress has changed the existing way of things. Robots has become cheaper and work force, in contrast, has become more expensive. Taking in addition transport costs for transferring raw materials and ready production, robotic production in developed countries is becoming competitive to the cheapest labor, not demanding knowledge and professional skills.

Conclusion

The analysis made in the article is built on the world-wide aerospace industry condition in 2018 and optimistic forecasts for the future. Economic crisis, connected with COVID-19 can even "whip up" development and production of separate types of service robots. There is the necessity in medical robots of different type, observation and control robots, aeroport service robots. Undoubtedly, there will continue development of UAV.

Analysis of aerospace robotics has shown that it is developing in three directions: complex manipulations (including "flying") for completing different works in open space, robots-helpers to cosmonauts in piloted flights and rovers for boarding on near-by planets of Solar systems for their detailed examination. More success in creation space robots the USA, Japan, EU and Canada have.

Robotics already has impact on labor market and this impact will only continue to grow. Robots are getting cheaper and their usage becomes more economically useful than hiring unqualified workers. From robotization there win more developed countries and

China, which have high density of robotization, what allows them decrease costs and hold the production in their countries' boarders.

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Strategic analysis of the demand for satellite communication services in the telecommunications market and construction of marketing strategy

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ABSTRACT

The article focuses on the strategic analysis of the demand for satellite communications services in the telecommunications market, degree of development of the problem, object, topic, initial assumption and goal of the research. A study of the telecommunications market by its key segments was carried out. The classification of key segments was chosen based on the criterion of the list's minimalism and not allowing double accounting of revenue, which is possible with B2B and then B2C chains. The most rapidly developing segment of the market, which is mobile communications, has been identified. The problems and prospects of the development of such market segments as mobile communications, fixed voice telephony, broadband Internet access and television are studied. The revenue's distribution of the global telecommunications market by regions is considered. The change in the cost of mobile Internet in the countries of the world and the correlation of mobile communication's price with the cost of signal delivery lines to base stations are determined. The introduction coefficient of broadband Internet access provided by such wired lines as an optical fiber communication line, twisted pair and power supply lines of the network is considered.

KEY WORDS: consumers; marketing; mobile communication; satellites; telecommunications networks.

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Análisis estratégico de la demanda de servicios de comunicaciones por satélite en el mercado de telecomunicaciones y construcción de estrategia de marketing

RESUMEN

El artículo se enfoca en el análisis estratégico de la demanda de servicios de comunicaciones por satélite en el mercado de las telecomunicaciones, grado de desarrollo del problema, objeto, tema, supuesto inicial y meta de la investigación. Se realizó un estudio del mercado de las telecomunicaciones por sus segmentos clave. La clasificación de los segmentos clave se eligió con base en el criterio del minimalismo de la lista y no permitiendo la doble contabilización de los ingresos, lo que es posible con las cadenas B2B y luego B2C. Se ha identificado el segmento del mercado de más rápido desarrollo, que son las comunicaciones móviles. Se estudian los problemas y perspectivas de desarrollo de segmentos de mercado como las comunicaciones móviles, la telefonía vocal fija, el acceso a Internet de banda ancha y la televisión. Se considera la distribución de ingresos del mercado global de telecomunicaciones por regiones. Se determina el cambio en el costo de Internet móvil en los países del mundo y la correlación del precio de la comunicación móvil con el costo de las líneas de entrega de señal a las estaciones base. Se considera el coeficiente de introducción del acceso a Internet de banda ancha proporcionado por líneas cableadas como una línea de comunicación de fibra óptica, par trenzado y líneas de suministro de energía de la red.

PALABRAS CLAVE: consumidores; marketing; comunicaciones móviles; satélites; redes de telecomunicaciones.

Introduction

Relevance of the research topic and problem statement: the study is devoted to the selection of activities of the Russian company: Russian Satellite Communications Company, which owns an orbital group in GSO in the world satellite communications market.

Competition within the satellite communications market is very fierce. The number of satellite operators with their space fleets has recently increased, as some states have entered this market by creating their own operators in order to protect their national interests. The active implementation of projects began in other types of orbits, in particular in low-orbit (at an altitude of 160 km - 2000 km): OneWab (Great Britain) and Starlink (USA).

The largest players in the global satellite communications market are three leaders: SES (Luxembourg, founded in 1958; 47 spacecrafts in GSO) (SES.com, 2021), Intelsat

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(Luxembourg, founded in 1964; 49 spacecrafts in GSO) (Intelsat.com, 2021) and Eutelsat (Paris, France, founded in 1977; 34 spacecrafts in GSO) (Eutelsat.com, 2021).

If we talk about Russian satellite communications market, there are two satellite communications operators with their own space fleet: Russian Satellite Communications Company (12 spacecrafts) and Gazprom Space Systems (4 spacecrafts). Thus, the issues of strategic planning and the study of the demand for satellite communications services for Russian operator are currently very relevant.

As a scientific hypothesis of the study, the authors accepted and proved that marketing planning based on identifying the demand for certain satellite communication services will allow Russian Satellite Communications Company to reduce its costs and increase work efficiency and will definitely strengthen its competitiveness in the global market.

The degree of elaboration of the problem: the main problems of development and increasing the competitiveness of satellite communications were considered by a large number of researchers and presented in the previous works of the authors.

In the article "On the prospects for the development of the satellite orbital constellation of Russian Satellite Communications Company" there are the main directions of development of satellite communications (Euroconsult-ec.com, 2019). In his opinion, these are tele- and radio broadcasting and satellite broadband access in Ka-band. He is also a supporter of a restrained company development policy and for the use of proven technologies and methods, in connection with which it is impossible to imagine the company as a pioneer in the global market.

1. Theoretical Basis

The research used the theory of strategic competitive analysis (Ageeva et al., 2012; Novikov, 2018). According to this theory, in order to study the demand for satellite communication services, it is necessary to identify all possible competitors, determine the key factors of the company's success, segment the market, identify links between individual market segments and assess the key values for consumers of the space segment in GSO (Novikov, 2018).

Further, the work used the classical theory of marketing and strategic marketing (Mikhailova, 2020).

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In accordance with the theory set forth in earlier works (Komarova & Slav, 2021), a strategy for increasing the competitiveness of satellite communications in the telecommunications market was developed and in works (Komarova et al., 2019; Novikov et al., 2019a; Novikov et al., 2019b; Novikov et al., 2020) a strategy for personnel management, within which it is possible to use network working groups.

2. Methodology of Research

The methodological basis of the study was formed by the concepts and views of Russian and foreign experts in the field of communications and scientific workers.

Virtually all alternative types of communication are competitors of the company under consideration, therefore, we will consider all sectors of the telecommunications market. In addition, due to the high cost of equipment for organizing a satellite communication line, the main consumers of the space segment are companies operating in other sectors of the telecommunications market.

The object of the research is the competitiveness of Russian operator in the global satellite communications market. The subject of the research is the selection of directions in the company's activities and the formation of a new range of services. Purpose of the study: on the basis of theoretical studies of the telecommunications market and identified new directions in the company's activities in the field of satellite communications, to develop a new marketing strategy for its development, including product policy, pricing policy, formation of demand and stimulation of sales and distribution policy.

3. Results and Discussion

The telecommunications market is a huge industry with $ 1.633 trillion in revenue, which is 1.2% of world GDP.

The telecommunications market is divided into several key segments:

- mobile communications (mobile) (53%);
- fixed voice (9.9%);
- broadband Internet access (broadband, fixed data) (22.8%);
- television (TV) (14.3%).

The classification was chosen based on the minimalism of the list and avoiding double counting of revenue, which is possible with B2B chain and then B2C.

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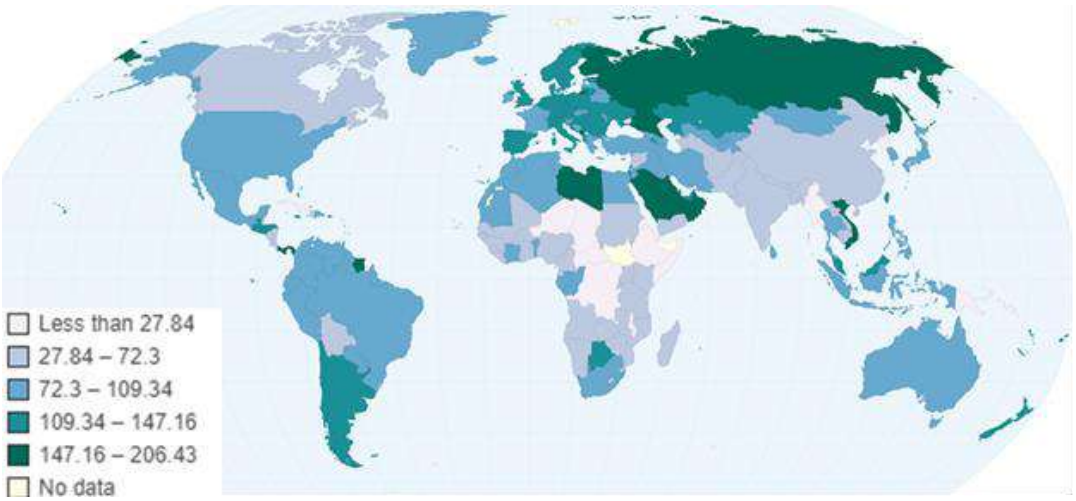
Satellite communications were not included in this classification due to the fact that in most cases it is B2B and is taken into account in the given data. The volume of revenue coming from all satellite communications is no more than 1.5%.

Figure 1. EMEA (Europe, the Middle East and Africa) region (Chartsbin.com, 2021)

We consider the distribution across global regions. The leader in terms of absolute and specific revenue is the Americas. At the same time, growth rates in EMEA region (Figure 1) are twice as high as in other regions.

The most rapidly developing segment is mobile communications. In some countries, there are 2 or more SIM cards for each person (Figure 2), which indicates the availability of mobile communications to a wide range of the population (Chartsbin.com, 2021).

Figure 2. Mobile introduction rate in the countries of the world (coefficient of 100% or more says that some residents have 2 or more subscriptions) (Chartsbin.com, 2021)



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The industry began a long time ago, but its explosive growth began with the advent of 2G technology in the 1990s, which heralded the beginning of the digital mobile era. Since 1998 to 2019 the price per minute of conversation has decreased almost hundreds of times: from 0.83 to 0.01 US dollars (taking into account inflation, this is approximately from 1.32 to 0.01 US dollars) (Vc.ru, 2021).

Today, mobile communication is not only voice messages, but also broadband Internet access. The Figure 3 shows the cost of 1 GB of Internet traffic for a mobile network (Chartsbin.com, 2021). It depends on the level of prosperity of the country's citizens and on the level of development of the mobile network. The worst of all is in African countries, where the cost of 1 GB of traffic can go up to hundreds of US dollars. In such countries, satellite communications can reduce the cost of mobile communications.

Mobile Internet access appeared in 2.5G networks. At the moment, active development of 5G technologies begins, which has a number of advantages over 4G networks:

- Latency has been reduced from 50 ms to 1 ms by reducing the size of the subcarrier and slots. This is the delay from the mobile station to the subscriber. In reality, the signal delay between two subscribers is greater (about 10 ms). For satellite communications it is from 240 ms or more;
- Speed increased from 160 Mbps to 11 Gbps (in theory, in reality, the microchip of the Snapdragon X55 5G modem allows achieving 7 Gbps speed when using MIMO 4x4, due to increase in spectral efficiency by 16.7% and bandwidth for one channel.

Increased subscriber density per sq. km. from 1 thousand to 1 million, due to the reduction of slots and cell sizes.

All this became possible thanks to a technological breakthrough in microelectronics, which allows increasing productivity with the same power consumption.

To implement 5G technologies, more frequency resource will be required, since wider carriers are needed, and at 900/1800 MHz it is impossible to work with such parameters and we need to climb "up". In this connection, 5G needs a frequency spectrum assigned to satellite communications: 3.4-3.8 GHz, i.e. half of C-band frequencies. The measures taken recently by Russian government (Dmitriev & Novikov, 2019a; Dmitriev & Novikov, 2019b; Dmitriev

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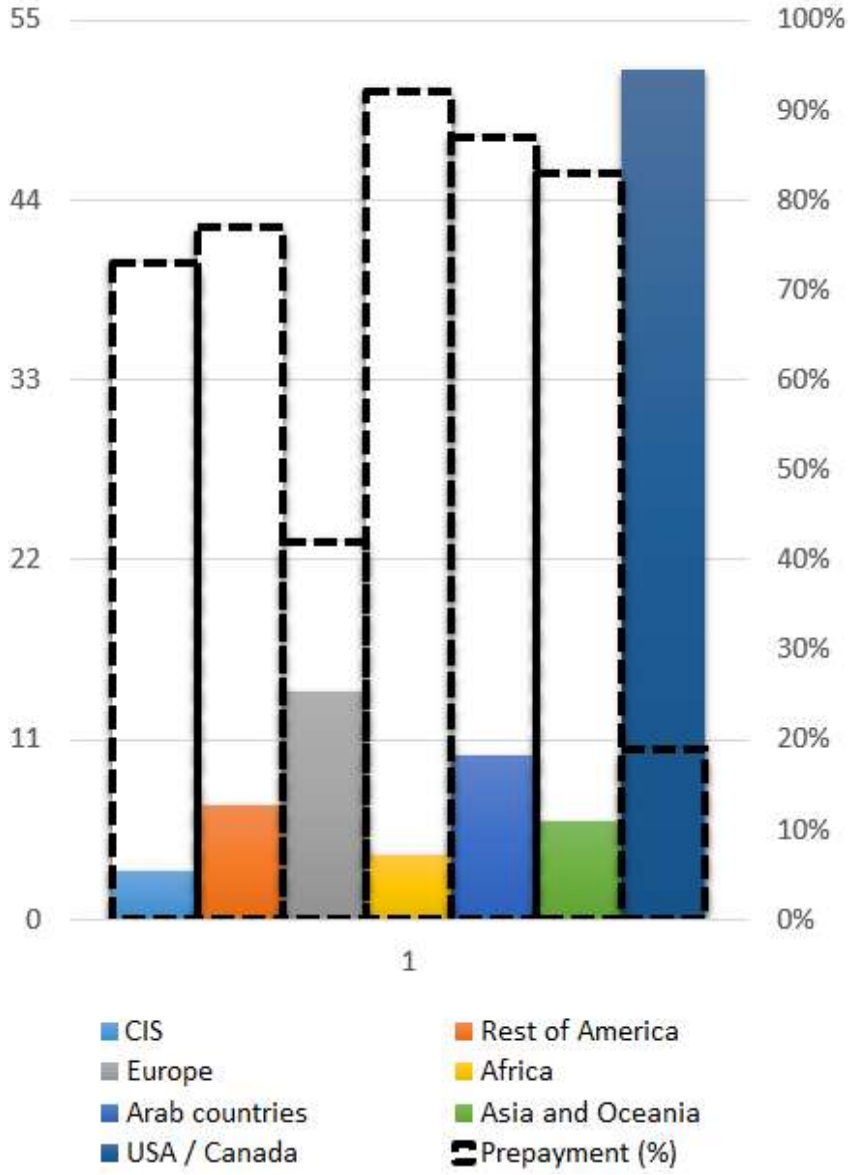
& Novikov, 2020) have helped to increase the amount of consumed frequency resource. Some operators are laying frequencies and Ka-band (20-30 GHz).

Figure 3. Estimated average cost of subscription in different regions of the world and percentage of prepaid tariffs (Chartsbin.com, 2021)



Future mobile networks may not be 5G compliant, just like current 4G networks. All technologies such as LTE and WiMAX are essentially 3.75G networks.

By its properties, mobile communication is a "last mile" technology. The range of mobile towers is usually from 0.5 km to 7 km. In theory, a 100-meter tower can “finish off” up to 37 km, but in practice there are many restrictions, including restrictions on power and

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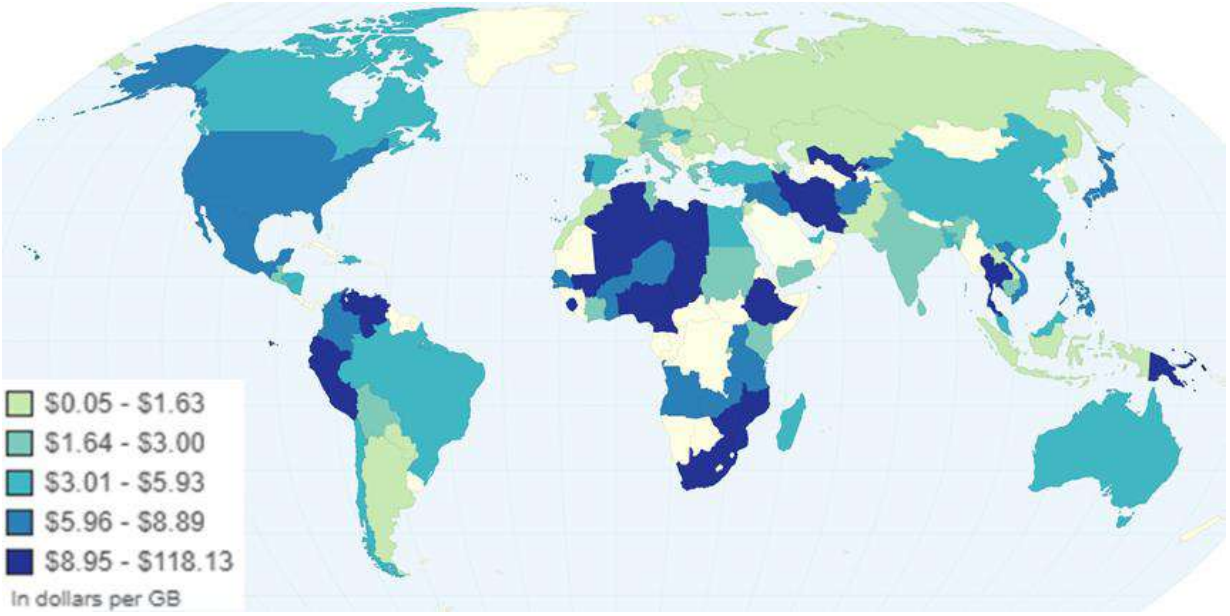
sanitary and epidemiological standards with a minimum quality of communication. The cost of mobile communications is highly correlated with the cost of signal delivery lines to base stations.

Figure 4. Cost of 1 GB of mobile Internet in the countries of the world (Chartsbin.com, 2021)



Satellite communication is used to deliver Internet traffic to base stations located in places where it is impossible to lay fiber optic communication lines or other communication lines. Also, satellite communication can serve as a backup communication line in those places where there is only one fiber optic communication line.

The Figure 4 illustrates data on ARPU (Average revenue per user) and percent of prepaid tariffs. The share of mobile Internet is growing, as voice calls using applications such as Scype, WhatsApp, Viber, etc. are cheaper.

The absolute leaders in terms of revenue from mobile communications are the United States (~30% of revenue worldwide). The share of Russia is just over 1% of the world, while before 2014 the share was almost 2%.

Fixed voice (telephone) communication is going through hard times and is a clear outsider among all markets. The decline in the fixed-line market began in 2006. In developed countries, this process began in 2001. Here, mobile communications and broadband access (VoIP) began to oppress long ago, in connection with which it is losing the position (Figure 5) (Chartsbin.com, 2021). Due to its low cost and optimized specifically for voice traffic, it is

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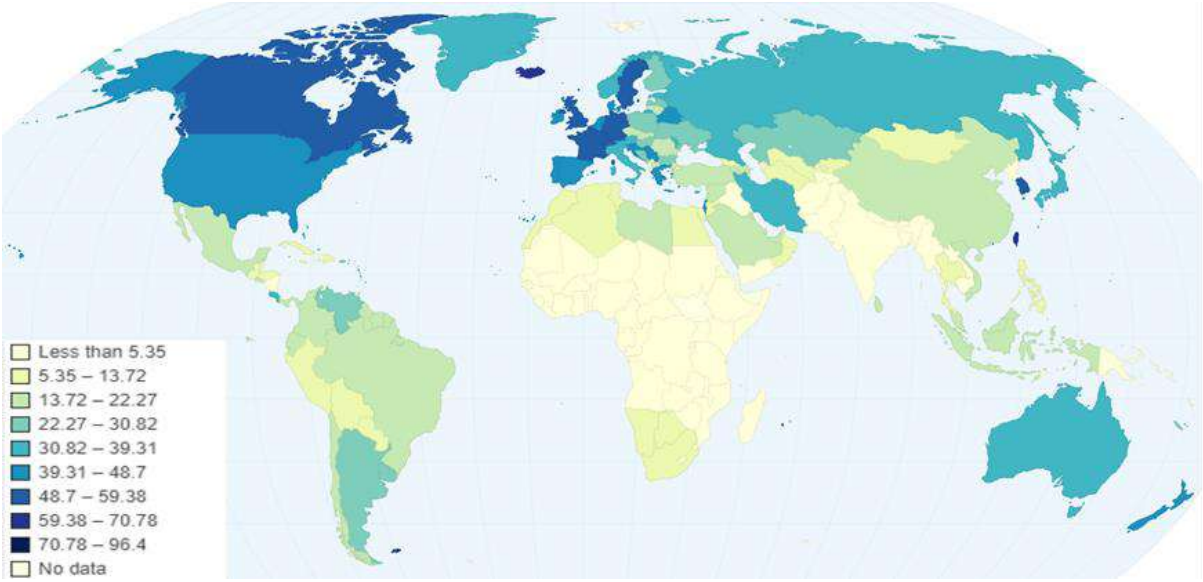
actively used in corporate networks. At the same time, they are combined with digital enhanced cordless telecommunication (DECT) radiotelephony technologies from mobile communications, using as the "last mile".

Figure 5. Fixed voice introduction rate in the countries of the world (Chartsbin.com, 2021)



Satellite communication with its large "ping" is not very convenient for these purposes. In the world of high-speed Internet, it makes little sense to invest in voice communication as a separate area. When accessing Internet, any device such as a PC, laptop and smartphone allows organizing free voice teleconferences (Skype, Viber, WhatsApp, etc.).

Broadband Internet access is also evolving, albeit at a slower pace than mobile communications. This term denotes broadband access provided by wired lines (fiber optic communication line, twisted pair, network power lines, etc.).

Fiber optic communication lines are being actively introduced using traditional technology, i.e. to the router at the entrance and from it via twisted pair (port speed 100-1000 Mbit/s, depending on the type of port) and GPON (optics to the apartment, does not require signal recovery at a distance of 20-40 km, i.e. it is passive), which allows one head-end station to provide Internet to 1024 subscribers (8 segments / ports for 128 subscribers) and more, at a speed of 2.4 Gbps per port (i.e. 18.75 Mbps per subscriber).

Broadband Internet access is well developed in America, Australia and Europe (Figure 6) (Tadviser.ru, 2020). African countries have the same problem as mobile communications.

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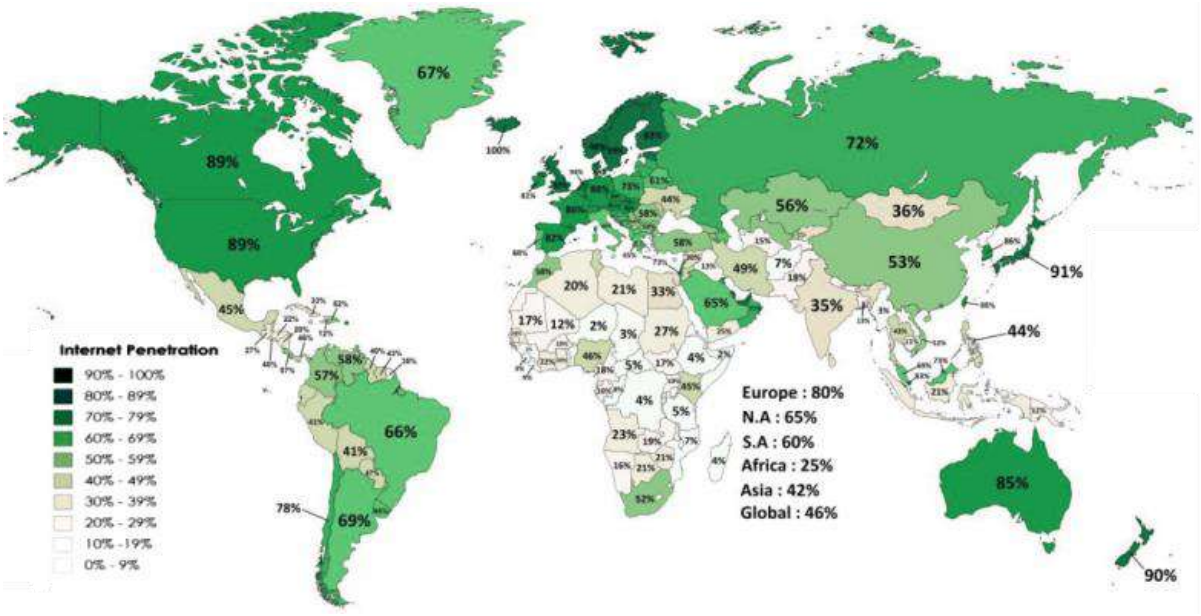
In this connection, satellite communications have a chance to occupy their niche in this region.

Figure 6. Coefficient of introduction of broadband access in the countries of the world (Tadviser.ru, 2020)



Optical communication lines drawn along the ocean floor connect only large centers (Figure 7). But it is through them that more than 97% of Internet traffic passes, since these fiber optic communication lines have a higher bandwidth than terrestrial ones and are much cheaper than land optical lines. On land, only large settlements are also connected by optical communication lines.

In Russia, a network of optical lines is developed in the European part of Russia and the border with China (Figure 8 shows the optical line of a telecommunications operator with state participation). The northern offshore line of the fiber optic communication lines, passing not far from the northern land borders of Russia, enters only at 3 points: 2 in the west and 1 in the east, that is, almost all territories of the far north of Russia are poorly developed in this regard.

Optical communication lines are actively used to deliver traffic to their head centers in mobile communications. In most cases, this is cheaper than any communication line. In this connection, the prevalence of mobile communication depends on the prevalence of fiber optic communication lines, which can be seen when comparing Figure 9 and Table 1 among themselves (Telesputnik.ru, 2019). Here satellite communication saves the situation. Many

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telecom operators have hubs in these territories connected through satellite communications with hubs located near the fiber optic communication line. But, since satellite communications are expensive, they are trying to lay fiber optic lines to many regions.

Figure 7. Map of fiber optic communication lines laid along the bottom of the oceans (Chartsbin.com, 2021)

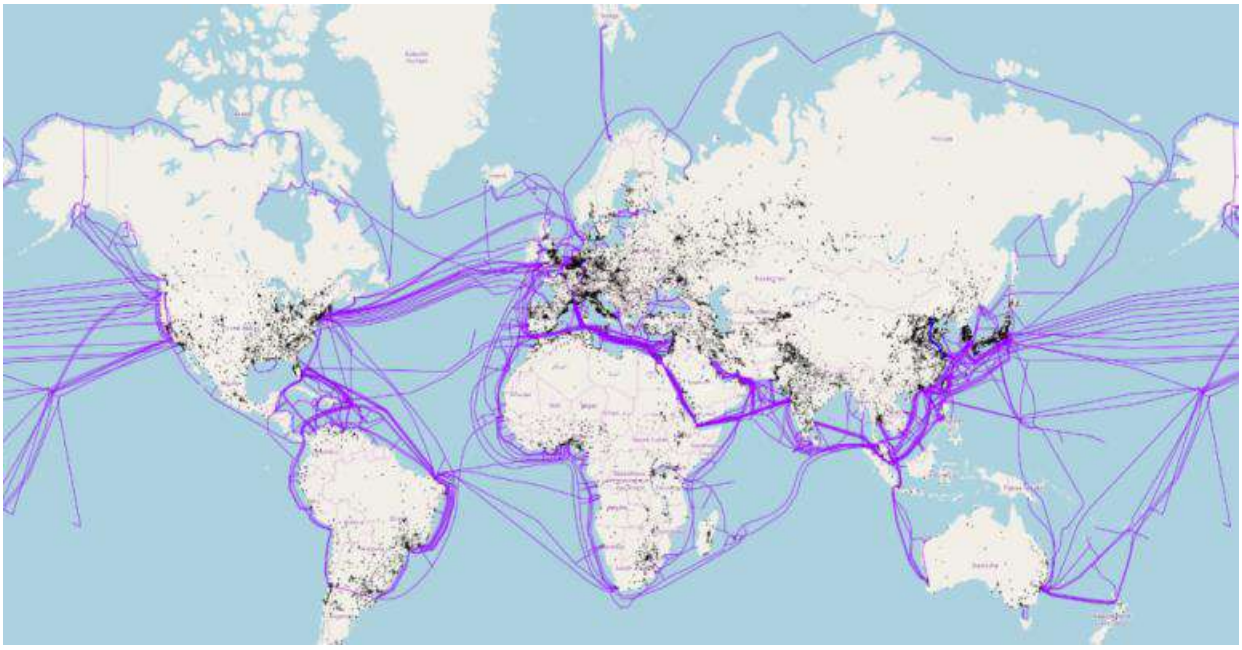

Figure 8. Backbone network Rostelecom (Chartsbin.com, 2021)

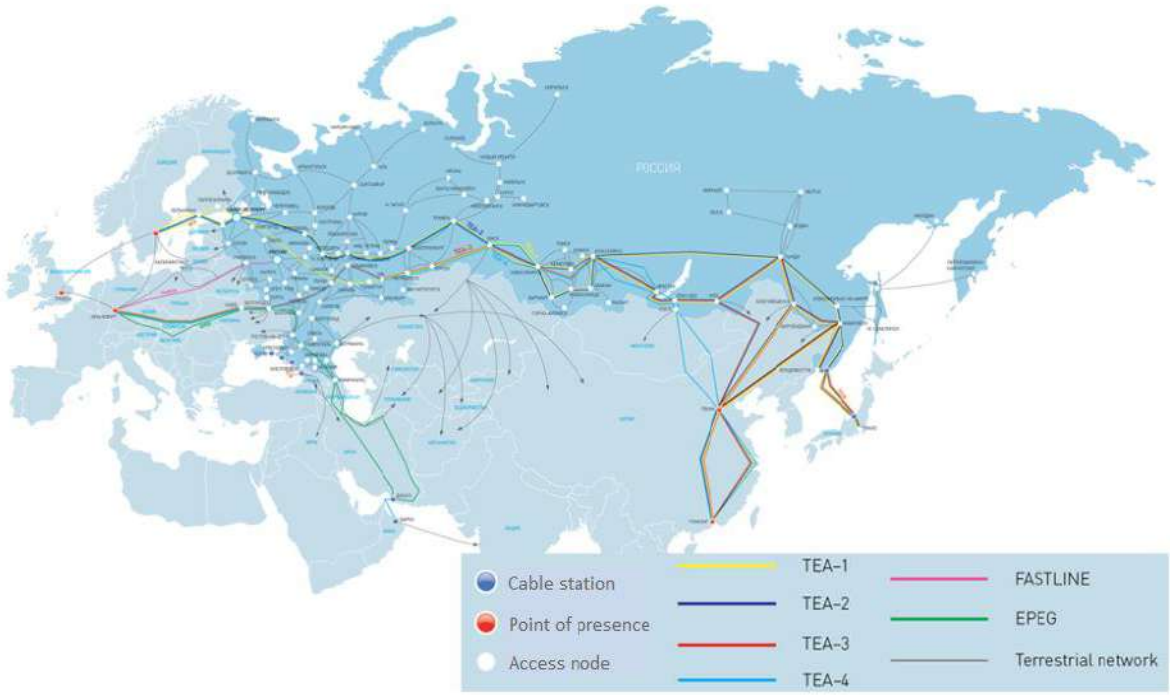

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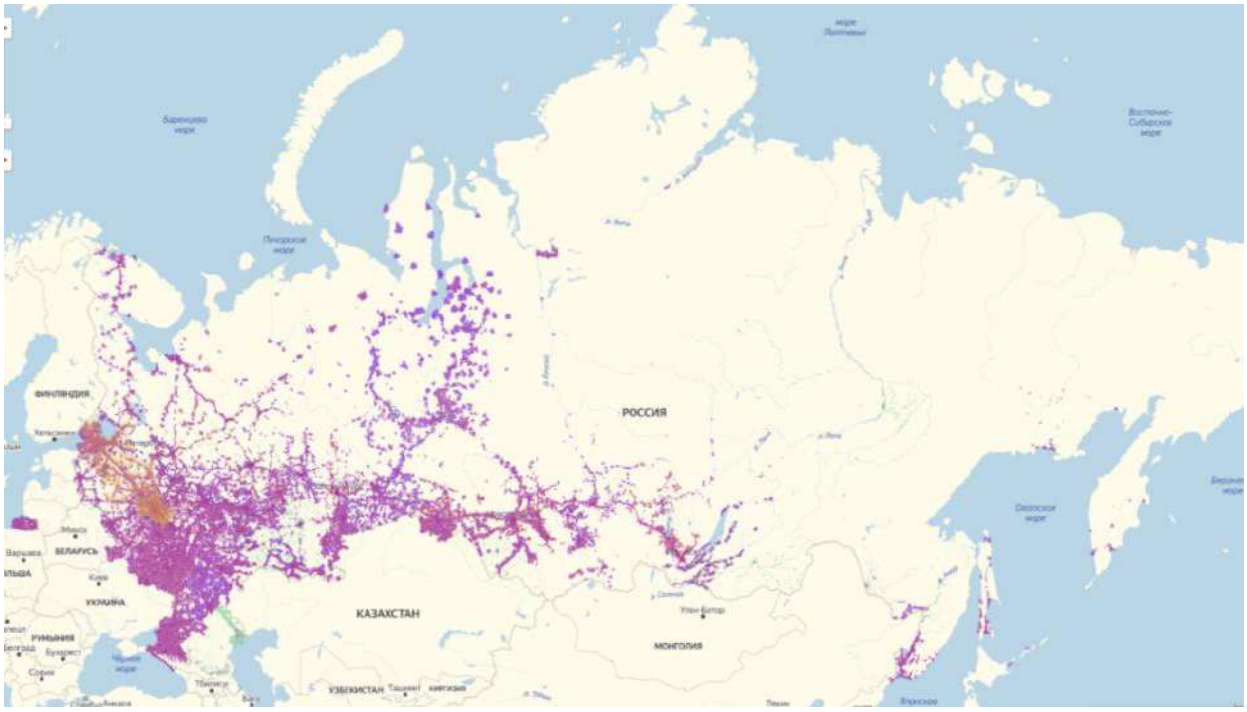
Figure 9. Mobile coverage map of the territories of Russia (Telesputnik.ru, 2019)



For the organization of satellite communication channels, we also have to use fiber optic communication lines. As it was mentioned earlier, all hubs of the company are connected by optical lines (2 nodes, each node has 10 GB).

Television consists of many types: terrestrial TV, IPTV, cable TV, OTT (video on Internet, for example, YouTube), SVoD (video on demand, so-called online cinemas) and satellite TV. Moreover, OTT (~60% of the revenue of the global TV market) and SVOD are the drivers of TV market, which in turn have a positive effect on mobile communications and broadband Internet access (Tadviser.ru, 2021).

Classic TV market is losing ground. The main problem is the lack of interactivity, which is inherent in OTT and SVoD, which works on the infrastructure of broadband and mobile communications.

Today, the standard of UHDTV 4K resolution (3840*2160 pixels) with a color depth of 3*10 bit (HDR) is actively spreading. When used for broadcasting MPEG4 (H.265 encoder), the stream rate is from 15 Mbps to 130 Mbps. The speed depends on the quality of the picture: from the required to Blu-Ray quality. Video bitrate on Internet can be from 11 Gbps. Video content is the main eater of Internet traffic. In this connection, the increase in the resolution and quality of the video sequence creates a demand for additional bandwidth of communication lines.

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In Russia, due to a national digital TV project offering free 20-30 channels (depending on the region), Pay TV market may be severely affected. Broadcasting of 20-30 federal channels is compulsory for all Pay TV operators, which creates an additional financial burden for them. And the problem is deeper than it seems. After all, the needs of many subscribers in television are fully satisfied by free TV channels.

Satellite communication through GSO is actively used for direct television broadcasting and for moving the video stream to central television stations (in most cases, these are backup lines).

The main segments were considered by the share of proceeds. Obviously, these data are not enough to understand the vector of development of the telecommunications market. It is necessary to consider the classification by the type of traffic. The simplest of them may be this: audio-video traffic and Internet requests (requests to websites, databases, etc., including IoT).

The share of video streams in Internet traffic is very large and amounts to around 60%. The share of video content will only grow. It is the video stream that will become the driver of the development of high-speed communication lines. For example, for video in SD (360p) resolution, the minimum required bit rate is 0.5 Mbps. For Full HD 2.5 Mbps and for 4K it is already 10 Mbps.

The share of the rest of the traffic, although it will fall, will only grow in absolute terms and at a very high rate (for example, from 2016 to 2018 the number of sites has doubled). The amount of data in IoT systems is also growing, which is used in smart homes and in industrial automation.

Today, the total average speed of all data in all types of communication is approximately 60 million Gbps. The need for the amount of information will only grow. Satellite communications can be one of the tools to reduce the digital divide around the world. For example, because of the relief or climate, it is not always possible to carry out fiber optic communication lines. In some cases, this is simply not possible, for example, for ships and aircraft.

After all that has been said, we can make a small analysis of the need for the company's services in the telecommunications market.

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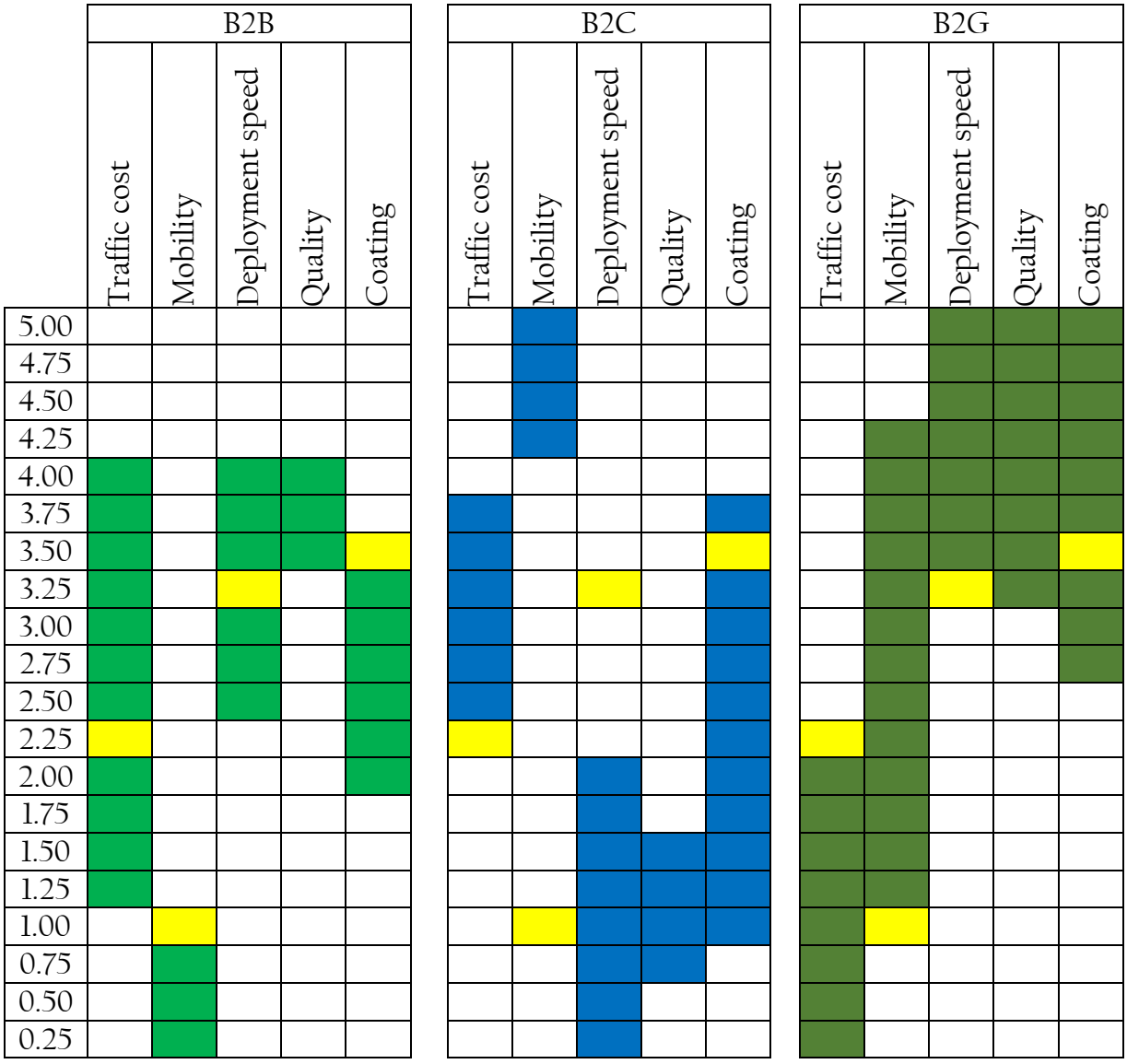
The most appropriate is Key Values Assessment (MPV). We divide clients by sectors: B2B, B2C, B2G (Table 1). Each of them has their own preferences.

Table 1. Assessment of key values (MPV) for the consumer of the space segment in GSO



We highlight the main consumer properties of satellite communications via GSO: traffic cost, mobility, network deployment speed, communication quality and coverage area.

This assessment clearly shows that satellite communication lacks mobility, therefore it is necessary to cooperate with companies of "last mile", for example, with mobile providers, whose market share is growing.

When developing a strategy for increasing the company's competitiveness, great importance is attached to the development of a functional marketing strategy for the purpose of implementing a business positioning strategy.

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We start by developing marketing goals and strategies for complex areas using 4P (product, price, place and promotion).

Products. It is important to correctly balance the product range, its characteristics and possibility of modification. It is necessary to change the product policy depending on the state of demand for products and services.

Price. It all depends on the demand for the product. Company's pricing policy changes depending on the product life cycle (Dmitriev & Novikov, 2020).

Place. Product marketing policy must be carefully considered. Service (after-sales) in cases of exchange, stimulating repeat transactions. Additional information on other products. It is not unimportant to organize the sale of goods through other channels, for example, through intermediaries.

Promotion. Promotion of products must be constantly dealt with. The buyer must know about the product, distinguish it from the rest, in accordance with his needs and beliefs.

It is required to convey full information to the consumer (Tikhonov et al., 2020) so that he makes a decision to make a purchase of the company's services. It is necessary to maintain contact directly with the consumer. If necessary, it is necessary provide background information about the product.

Contact with customers increases company awareness, strengthens consumer confidence in the brand. The content of the presentation message is very important.

Successful trading, increasing profits still depends on the correct unique selling proposition, which will reflect the distinctive features of the product from other offers on the market today.

Conclusion

The studies have shown the need for a Russian satellite communications company to conduct a strategic analysis of the demand for services in the telecommunications market and develop a marketing strategy to increase competitiveness in the global market.

The paper presents the stages of research of the telecommunications market in such key segments as mobile communications, fixed voice communications, broadband access and television. For each of the above mentioned segments, the coefficients of introduction into

the countries of the world and modern technologies of the organization were analyzed. It was revealed that the most rapidly developing segment is mobile communications. The close dependence of the development of other segments with the development of mobile communications was also determined.

Table 2. Marketing goals and strategies for complex areas

Complex directions	Marketing objectives	Marketing strategies
Product-commodity policy	Create an image of a high-quality product in the eyes of consumers	Design according to the requirements of the most sensitive segment: high attention to quality control; quick troubleshooting. Additional product strategies and conditions for their implementation. Focus on product quality, advanced engineering and customer service
Price policy	Product positioning by quality. Offer discounts for large distributors based on volume	Offering higher dealer discounts to maintain distribution channels. Using a pricing strategy to move price-sensitive buyers to the next level as the market segment becomes saturated. Additional pricing strategies and conditions for their implementation, if a large number of competitors appear on the market, change the pricing policy to match the prices of competitors
Distribution	Organize a large distribution system	Demonstration plan for dealers. Additional strategies and conditions for their implementation: providing dealers with large discounts
Product policy, pricing policy, formation of demand and stimulation of sales and distribution policy	Positioning a product as very reliable to convince the market to pay a high price. Maximizing market coverage	Selective use of media, personal sales, etc. Mass market notification of products and services. Using special promotion to increase the number of consumers. Additional promotion / advertising strategies and conditions for their implementation: as competition intensifies, focus on product differentiation strategies, focusing on product differentiation, company reputation and services and defensive advertising
Profitability	Minimum 30 percent return on investment over the life of the product	
Market share	Increase market share by 20% until 2034	Launch of new spacecraft
Volume of sales	Increase sales by an average of 20 percent by 2034	Due to the new product range of the company
After-sales service (preparation, services, customer relations)	Reduce the time to replace the unusable resource with a new one	Better monitoring of the resource, thus predicting the problem before it appears

It was revealed that Internet access in mobile communication appeared in 2.5G networks, but at present, active development of 5G networks is starting, which have a number of advantages presented in the work.

The frequency resource required for the implementation of the "last mile" technology in 5G networks has been determined.

It was revealed that the main consumer properties of satellite communications through GSO are: traffic cost, mobility, network deployment speed, communication quality and coverage area.

During the assessment of key values for the consumer of the space segment on GSO, it was revealed that satellite communications lack mobility, in this regard, it is necessary to cooperate with companies of the "last mile", for example, with mobile providers, whose market share is growing.

The paper proposes a marketing strategy for the development of the research object, the implementation efficiency of which is increased through the use of Industry 4.0 tools, network modeling, and the use of the motivational mechanism of network project groups.

The practical significance of the study is determined and confirmed by the fact that the conclusions of this study can serve as a guide for all enterprises in the satellite communications market, both defense and civil one, faced with the problem of competitiveness in the telecommunications market.

Economic calculations have shown that for growth while keeping prices for services down, it is necessary to increase the volume of the surrendered resource over 15 years at least 2 times. At the same time, the share of additional services should be increased to 85-90%. The average annual increase in profit from sales, while it is expected at the level of 4.5% and an average profitability in the region of 33.6%.

For a more significant increase in profit, it is necessary to increase the volume of the sold frequency resource more than 2 times in 15 years.

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Foreign experience and international legal standards for the application of artificial intelligence in criminal proceedings

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Nataliia Cherniak *****

ABSTRACT

The purpose of the research is to analyze the use of artificial intelligence in the justice systems of developed countries and the prospects for its use in criminal proceedings in Ukraine. Methodology: Research from the analysis of documentary sources; the basis is the dialectical method of knowledge of the facts of social reality, on which the formal legal and comparative legal approaches are largely based. Conclusions. In the near future, the accompanying organizational measures for the introduction of artificial intelligence and its regulatory support in public administrations (which are associated with the storage of big data, information processing based on mathematical algorithms and decision-making based on artificial intelligence) will be an integral component of life in our society. In fact, the use of artificial intelligence creates a model of digital decision automation. Such automation simplifies the decision-making procedure in similar procedures, which, of course, improves efficiency and simplifies the procedural decision-making procedure in terms of economy.

KEY WORDS: artificial intelligence; automation; computers; cybernetics; Legislation.

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Experiencia extranjera y normas jurídicas internacionales para la aplicación de inteligencia artificial en procedimientos penales

RESUMEN

El objetivo de la investigación es analizar el uso de la inteligencia artificial en los sistemas judiciales de los países desarrollados y las perspectivas de su uso en procesos penales en Ucrania. Metodología: Investigación a partir del análisis de fuentes documentales; la base es el método dialéctico de conocimiento de los hechos de la realidad social, en el que se basan en gran medida los enfoques jurídicos formales y jurídicos comparados. Conclusiones. En un futuro próximo, las medidas organizativas de acompañamiento para la implantación de la inteligencia artificial y su apoyo regulatorio en las administraciones públicas (que están asociadas al almacenamiento de big data, procesamiento de información basado en algoritmos matemáticos y toma de decisiones basada en inteligencia artificial) serán un componente integral de la vida en nuestra sociedad. De hecho, el uso de inteligencia artificial crea un modelo de automatización de decisiones digitales. Dicha automatización simplifica el procedimiento de toma de decisiones en procedimientos similares, lo que, por supuesto, mejora la eficiencia y simplifica el procedimiento de toma de decisiones en términos de economía.

PALABRAS CLAVE: inteligencia artificial; automatización; informática; cibernética; legislación.

Introduction

When analyzing the latest achievements in the sphere of Artificial Intelligence it must be recognized in the nearest future, accompanying organizational measures for introduction of artificial intelligence and its regulatory support in public authorities, which are associated with the storage of big data, information processing based on mathematical algorithms and decision-making based on artificial intelligence will be an integral component of life of our society.

Up to date artificial intelligence technologies are already being introduced in the judicial systems of China, the United States, Great Britain, France, and Argentina, they can with mathematical precision predict percentage of a court decision probability based on the respective algorithm and so they help to make court decisions in the respective proceedings. The mentioned artificial intelligence technologies use software and "machine learning" mathematical apparatus.

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Machine learning gives an opportunity to build a mathematical model of data, which includes a large number of variables unknown in advance. Parameters are configured gradually, during the learning phase, which uses learning data sets for search and classification. Various methods of machine learning are chosen by developers choose depending on the nature of tasks to be performed (grouped). These methods are usually classified into three categories: supervised learning (learning with a teacher), uncontrolled learning (learning without a teacher) and reinforced learning (learning with reinforcement). These three categories group different methods, including neural networks, deep learning, etc.

Paragraph P of the European Parliament's resolution concerning Civil Law Rules on Robotics 2015/2103 (INL) dated 16 February 2017 takes into account the fact that, in the long run, it is likely that artificial intelligence may exceed human intellectual potential. In the nearest future, the chance of using such technologies in courts of general jurisdiction of Ukraine and in the sphere of criminal proceedings of Ukraine can be assessed as extremely high, and the scope of its application is not limited to work of artificial intelligence in courts. We can also talk about work of artificial intelligence in the sphere of activities performed by prosecutor and police. Therefore, practice of using mathematical algorithms and software that processes big data in the sphere of criminal proceedings with further making proceeding decisions, requires a substantial research.

1. Literature review

Issues related to research of artificial intelligence in procedural activities, problems of criminal law and legal regulation of artificial intelligence were researched by Sartor, L. Karl Branting "Judicial Application of Artificial Intelligence" (Sartor, 1998), G. Hallevy "When Robots Kill: Artificial Intelligence under Criminal Law" (Hallevy, 2015), K. Brennan-Marquez, S. Henderson "Artificial Intelligence and Role-Reversible Judgment", Ronald J. Allen "Artificial Intelligence and Evidentiary Process: Challenges of Formalism and Computation" (Allen, 2001), T. S. Zaplatina "Artificial Intelligence in the Issue of Making Judicial Decisions" (Zaplatina, 2019), O. E. Radutnyi "Artificial Intellect as a Subject in Criminal Law" (Radutnyi, 2017) and others. The sphere related to artificial intelligence in criminal proceedings in Ukraine remains weakly researched.

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2. Materials and methods

The research starts from the analysis of documentary sources and is based on the dialectical method for the knowledge of the facts of social reality; This method largely forms the basis for formally legal and comparatively legal approaches.

Using the dialectical method the modern conceptual base and the issue of legal technologies as instruments of applying artificial intelligence in judicial systems of developed states is formulated and its use in criminal proceedings of Ukraine are analyzed. The officially dogmatic method contributed to the development of the author's explanation of the up-to-date state, problems, problems and practical role of legal technologies for further development and improvement of artificial intelligence application in the judicial systems of developed states and analysis of its use in criminal proceedings of Ukraine. The officially legal method gave an opportunity to offer directions and types of using legal technologies for artificial intelligence application in court systems of developed countries and to analyze prospects of its use in criminal proceedings of Ukraine.

3. Results and discussion

The European ethical Charter on the use of Artificial Intelligence in judicial systems and their environment dated December 3–4, 2018 provides a narrow definition of the following terms: artificial intelligence, algorithm, machine learning, big data, database, expert systems, neural networks, etc. Artificial intelligence is defined as a set of scientific methods, theories and techniques aimed at machine-based reproduction of human cognitive abilities. Modern developments seek to make machines perform complex tasks previously performed by humans. However, the term "artificial intelligence" is criticized by experts who distinguish between "strong" artificial intelligence, which can contextualize specialized and diverse problems completely autonomously, and "weak" or "moderate" artificial intelligence (which is highly effective in the sphere of "machine learning").

There are several legal services/systems in the world that use artificial intelligence:

– In France – Doctrine.fr (search system), Prédictice (analysts, except criminal cases), case Law Analytics (analysts, except criminal cases), Juris Data Analytics – LexisNexis (search system, analytics, except criminal cases);

– In the UK – Luminance (analytics), HART – Harm Assessment Risk Tool (analytics,

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criminal cases, risk assessment);

– In the United States of America – Watson/Ross – IBM (analytics), Lex Machina – LexisNexis (analytics), COMPAS – corrective offer Management Profiling for alternative sanctions are used by US courts to assess likelihood of defendant's recidivism and to analyze previous misconducts;

– In Argentina – Prometea (analysts, civil and administrative cases)

– In China – Compulsory Similar cases Search and Reporting mechanism (analytics) is used in the Supreme People's Court of the People's Republic of China.

The most powerful systems of the presented list work in courts and police and help judges make procedural decisions. In the United States of America there is a COMPAS (corrective Offshore Management Profiling for alternative sanctions) system, which was used by the state courts of New York, Wisconsin, California, Florida in Broward County as well as by courts of other jurisdictions in the United States. COMPAS software uses an algorithm to assess the potential risk of a repetition of crime. According to the COMPAS user manual, the scales were designed using behavioral and psychological constructions "which are very important for the recurrence of crimes and criminal careers." The COMPAS system *estimates not just the risk, but also nearly two dozen so-called "criminogenic needs"* that relate to the basic theories of crime, including "criminal personality", "social isolation", "drug abuse" and "living/stability". Defendants in each category are classified as low, medium or high risk personalities (Lu, 2019).

In Ukraine, similar work is performed by staff of the probation body within preparation of pre-trial reports, supervisory and penitentiary probations. It should be noted that in Ukraine probation programs have only just begun to develop and it is somewhat premature to talk about the use of artificial intelligence in the preparation of a pre-trial reports, but an analogy can be used for a comparative analysis of existing artificial intelligence technologies and work of probation staff. According to parts 1, 3 of Art. 9 of the Law of Ukraine "On Probation", pre-trial probation is the provision of the court with formalized information that characterizes the respective accused person, in order the court could make a decision on the level of his/her responsibility. A pre-trial report on the accused person must contain: Social and psychological characteristics; assessment of risks of repeated criminal offenses; conclusion on the possibility of correction without restriction of liberty or

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imprisonment for a certain period of time (Law of Ukraine, 2015). According to parts 1, 2 of Art. 314–1 of the Criminal Procedure Code of Ukraine in order to provide the court with information that characterizes the accused person, as well as for making a court decision on the level of punishment, a representative of the authorized probation body shall prepare a pre-trial report by court order. A pre-trial report shall be compiled concerning a person accused of committing a minor or medium crime or a serious crime with the lower limit of punishment never exceeding five years of imprisonment. A pretrial report on a juvenile accused aged 14 to 18 shall be compiled regardless of the gravity of the crime committed, except in cases provided for by the Criminal Procedural Code of Ukraine. (Law of Ukraine, 2012).

No doubt, for a court is an advantage when such reports are compiled by an artificial intelligence in automatic mode with an assessment of recidivism risks. But such a report cannot be a proof of guilt in committing a crime. The proof procedure based on objective evidence differs from the automated data analysis performed by a system of artificial intelligence. When assessing risks, artificial intelligence takes data on a certain accused person from the database, analyzes these data using mathematical algorithms, and makes a report providing assessment the relevant risks. The more data, the higher accuracy of the report is. However, if the artificial intelligence takes into account data that will be artificially created or falsified, will be based on incorrect translation, incorrect expert's conclusion and explanations, knowingly false testimony of a witness, victim, suspect, accused will be taken into account. All these circumstances may affect correctness of artificial intelligence's conclusion.

In May 2016, a *report*[5] was published in the United States; according to this report artificial intelligence was accused of racism. For example, a computer program used by an American court to assess risk was biased against African Americans ("black prisoners" is used in the original). The Correctional Offender Management Profiling for Alternative Sanctions (COMPAS) program was more inclined to mislabeling African-American defendants ("black defenders" is used in the original) with a possible repetition of offense almost twice as significant as in case with white people (45% to 24%), according to a journalistic investigation by ProPublica (Halaburda *et al.*, 2021). This was also stated in the European ethical Charter on the use of Artificial Intelligence in judicial systems and their

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environment dated December 3–4, 2018, which stated that ProPublica found discrimination in the algorithm used in the COMPAS software intended to assess the risk of offense repetition, when the judge must determine the sentence individually (Leheza et al., 2018).

Criticism of the COMPAS system is a critique of commercial algorithms for assessing the risk of rime repetition as well as for assessing work of artificial intelligence in courts. But *the main point is that the COMPAS system is applied exactly in criminal proceedings*, it simplifies the working process of judges on making proceeding decisions and improves efficiency of court work. The negative experience of applying artificial intelligence in courts will be used to correct future mistakes. An extract from the decision made by the Supreme Court of Wisconsin in the case of Wisconsin vs. Lomis states: "It is important to take into account such instruments as COMPAS, continue changing and developing. The problems we face today can very well be changed in future; better tools can be developed (Leheza et al., 2021). As data changes, our use of evidence-based tools must also change. The justice system should keep pace with the research and constantly evaluate application of these tools."

Harm Assessment Risk Tool (HART) artificial intelligence system is very interesting for this research (Leheza et al., 2021). HART (Harm Risk Assessment Tool) was developed in partnership with Cambridge University and is now being tested in the UK. This machine-learning technology used Durham Police Archives from 2008 to 2012 to study the decisions made by police officers during this period of time... Machine learning is expected to assess risks, taking into account about thirty factors, some of which are not related to crimes performed (for example, ZIP code and gender). Risks concerning suspects are divided into categories: low, medium and high level. In tests conducted in early 2013, HART forecasts found 98% effectiveness in predicting low risk and 88% effectiveness in predicting high risk of recidivism. In this experimental phase, the HART system will have a purely advisory value for judges. Auditing of HART functioning and reliability of its conclusions will be conducted regularly by police (Leheza et al., 2021).

Analysis of the HART system gave us an opportunity to conclude that using such a system of artificial intelligence in work of the Ukrainian police, risks identified by such a system could be transferred to courts for making proceeding decisions on suspects and accused persons. For courts, this is an additional information which can be taken into account by judges when evaluating the evidence and making a proceeding decision. An

advantage of working with big data is that the whole "history" of a suspect is recorded in a proper report (Hassani et al., 2020).

In his article "UK police are Using AI to Inform Custodial Decisions – but It could be Discriminating Against the Poor," M. Berges notes that in order to assess low, medium and high risks the HART system uses data from 34 various categories covering age, gender and history of offenses. These data categories contain information about the postal code. Police officers are now removing "data" with postal codes that include the first four digits of Durham's indexes from the HART system (UK Police are Using AI to Inform Custodial Decisions – but It Could be Discriminating against the Poor, 2018).

Again, one can see a discriminatory feature in operation of artificial intelligence, and this discriminatory feature is being worked on by the British police and scientists. When developing similar systems in Ukraine, it is necessary to take into account such mistakes and possibly take into account other social features in order to avoid discriminatory factors.

Prometea system of artificial intelligence should be considered separately. The presented information was taken from an article on LegalHub and it in the best possible way demonstrates operation of artificial intelligence in prosecutor's office and court concerning efficiency and procedural economy. For example, the Buenos Aires District Prosecutor's Office in Argentina summed up interim results of testing the Prometea software application, which can make and issue a court decision from a number of categories of civil and administrative cases in 10 seconds. Prometea analyzed about 300 thousand scanned court decisions from 2016 to 2017, including 2 thousand resolutions[3]. In Argentina, district prosecutors make decisions, and presiding judges either dismiss these decisions and write their own ones, or simply approve them. Now, as soon as a new case enters the prosecutor's office, Prometea compares the invoice with the most relevant decisions in its database - and this allows the program to guess in about 10 seconds how the court will react to the situation. As a result of applying the program, prosecutors were released from large arrays of routine activities. According to the head of the office, fifteen of his lawyers in just six weeks cope with the volume of work that before needed about six months to be done. Prometea is also highly praised by judges, who have so far approved 33 of the 33 decisions proposed by this system (it is now used in 84 other cases under consideration) (Leheza et al., 2021).

China is also making progress in using of big data and introduction of artificial

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intelligence technology in the justice system. The above information appeared on several resources. During the latest judicial reform of Chinese courts, from 2014 to 2017, China's Supreme People's Court promoted a system of "similar court decisions for similar cases" in order to ensure an effective judicial oversight. The system of similar court decisions for similar cases mentioned by the Supreme People's Court of China means that criteria for making court decisions must be in line with the case a judge is considering and previous cases, which have been completed by the respective court and the Supreme Court as well as in line with other similar cases. The Supreme People's Court of China hopes to achieve "similar sentences in similar cases" through the use of artificial intelligence (AI) technology. Such an aspiration to standardize court decisions "in similar cases" means a desire to automate court decisions and create a model of standard decisions in mass proceedings (Wamba-Taguimdje et al., 2020).

Unfortunately, this application only works with civil and administrative cases, but it is possible that in future, the developer of the Prometea application, programmer Ignacio Raffa will be able to supplement appropriate algorithms of the program for Prometea's operation in criminal proceedings. In Ukraine, such an application could help investigating judges in deciding on measures to ensure criminal proceedings or in choosing precautionary measures. The main point is that Prometea is not only able to determine a court decision in 10 seconds and the program is also able to execute it; and the result of Prometea's operation in court is thirty-three court decisions of thirty-three ones. In percentage it is 100% positive result of artificial intelligence operation. The above-mentioned program of artificial intelligence has become interesting for the UN and the World Bank, which is mentioned in the article. Thus, automation of Buenos Aires justice system has already attracted interest of the United Nations and the World Bank. The developer of the application Raffa said that he and his three colleagues hope to introduce similar systems in the USA and Europe by the spring of 2019 (Leheza et al., 2020).

The Supreme People's Court of China demands that before making decisions judges should search for similar cases and related cases in order to ensure that the criteria of such cases are met. This practice is called the Compulsory Similar Cases Search and Reporting Mechanism (Leheza et al., 2021). The Supreme People's Court of China considers the possibility to adopt this mechanism because of confidence in the technologies and artificial

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intelligence (AI) data of Chinese courts. First, Chinese courts have made significant progress in big data technology. Chinese courts have included all court decisions throughout the country in the database and are now digitizing case files that will make it easier to find a judge. Second, Chinese courts have tried to use artificial intelligence techniques to provide aid and supervise judges. Up to date this function is used mainly in criminal cases to monitor correctness of judges' sentences (Zaplatina, 2019).

But even such progressive measures to standardize similar court decisions according to the relevant criteria are criticized. Radutnyi notes that during communication with some judges who use these systems, their feedback is mainly as follows: First, "similar cases" prompted by these systems are not accurate enough, and the similarities with the cases heard by judges are not sufficient. This means that judges do not have a significant guideline. Second, experienced judges do not need such systems. However, inexperienced judges are willing to learn hearing cases using an artificial intelligence system. Therefore, this system is suitable for preparation of new judges. Third, the technology of artificial intelligence needed by judges most is "automatic generation of court decisions": An artificial intelligence system "reads" case materials, extracts key information from them, and then automatically generates judgments based on criteria of justice for similar cases (Radutnyi, 2017). Given the fact that in recent years Chinese judges have fallen into the "surge of load" courts should urgently use this technology to reduce the workload on judges.

Conclusion

Given the operation of the COMPAS and HART systems, artificial intelligence is able to assess risks of recidivism and can be successfully used in preparation of pre-trial reports in criminal proceedings, as well as in supervisory and penitentiary probations in Ukraine. When dealing with procedural issues regarding measures to ensure criminal proceedings or selection of preventive measures, artificial intelligence can help investigators, taking into account the operation experience of Prometea application. By means of using the experience of Chinese courts in generating big data and implementing artificial intelligence systems using the Compulsory Similar Cases Search and Reporting Mechanism, it is possible to create a project for automatic generation of court decisions in Ukraine.

In fact, the use of artificial intelligence creates a model of digital decision automation. Such automation simplifies the decision-making procedure in similar procedures, which, of

course, improves efficiency and simplifies the procedural decision-making procedure in terms of economy. For the use of artificial intelligence in the Ukrainian judicial system, it is necessary to take appropriate legislative decisions regulating public relations in a particular area of human activity. The European Ethical Charter on the use of artificial intelligence in judicial systems and their environment, from December 3-4, 2018, has already laid the foundations for future legislative decisions on the introduction of artificial intelligence in courts of general jurisdiction from Ukraine.

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The potential of applying blockchain technologies in various sectors of the digital economy

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ABSTRACT

The objective of the article is to determine the potential of blockchain technologies in various sectors of the digital economy, in the case of the countries of the European Union. Methodology. The research assesses the use of digital technologies to ensure the country's digital development, based on data from the European Commission and the Digital Economy and Society Index (DESI). On the basis of DESI, a cluster diagram was created to determine the potential for the use of blockchain technology in the countries of the European Union. Results. The potential for the use of blockchain technology in each country depends and is significantly connected with the introduction of different technologies and the availability of the Internet, the provision of digital services by the government, the development of human capital. The main potential advantages of the technology include the following: acceleration of globalization processes, ensuring the country's transition from real production to technological development, change of established business models, transformation and optimization of value chains of different sectors of the economy by reducing costs; transformation of the nature of mediation due to technological changes; the use of cryptocurrency to achieve the consensus of economic agents on the allocation of scarce resources on a global scale.

KEY WORDS: digital technology; digitization; Information and Communication Technologies; Economy.

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El potencial de aplicar tecnologías blockchain en varios sectores de la economía digital

RESUMEN

El objetivo del artículo es determinar el potencial de las tecnologías blockchain en varios sectores de la economía digital, en el caso de los países de la Unión Europea. Metodología. La investigación evalúa el uso de tecnologías digitales para asegurar el desarrollo digital del país, basándose en los datos de la Comisión Europea y el Índice de Economía y Sociedad Digital (IESD). Sobre la base de IESD, se creó un diagrama de clúster para determinar el potencial de uso de la tecnología blockchain en los países de la Unión Europea. Resultados. El potencial de uso de la tecnología blockchain en cada país depende y está significativamente conectado con la introducción de diferentes tecnologías y la disponibilidad de Internet, la provisión de servicios digitales por parte del gobierno, el desarrollo del capital humano. Las principales ventajas potenciales de la tecnología incluyen las siguientes: aceleración de los procesos de globalización, asegurando la transición del país de la producción real al desarrollo tecnológico, cambio de modelos de negocio establecidos, transformación y optimización de cadenas de valor de diferentes sectores de la economía mediante la reducción de costos; transformación de la naturaleza de la mediación debido a cambios tecnológicos; el uso de la criptomoneda para lograr el consenso de los agentes económicos sobre la asignación de recursos escasos a escala global.
PALABRAS CLAVES: tecnología digital; digitalización; Tecnologías de la Información y Comunicación; Economía.

Introduction

Blockchain as a technology has demonstrated the ability to eliminate intermediaries, streamlining transactions based on registers in various sectors of the economy, from cryptocurrency to centralized voting. In many countries, blockchain-based technologies ensure the transparency of transactions between different sectors and market participants, helping to reduce the level of corruption and increase the trust of various economic agents. "Blockchains as digitized decentralized ledgers make it possible to conducts records of single-rank transaction records, thus, eliminating the necessity for trusted third parties to intervene" (Bhimani, Hausken & Arif, 2021). Currently, the blockchain technology is considered as the most significant invention after the Internet. While the latter brings people together to implement business processes online, the former can solve the problem of trust through peer-to-peer networking and public key cryptography (Efanov & Roschin, 2018).

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The importance of the blockchain determines the relevance of studying the potential impact and applying the technology in different sectors of the digital economy, as well as identifying possible effects of the impact on digitalization.

The purpose of the academic paper lies in determining the potential of blockchain technologies in various sectors of the digital economy on the example of EU countries differing in the level of the ICT sector development.

1. Literature Review

Since the end of the twentieth century, a lot of scientific works explain the concept of digitization and the digital economy; however, since 1997, the relevant regional aspects have remained poorly understood. Herewith, there are no agreed definitions of the digital sector, digital products or digital transactions in the scientific literature (International Monetary Fund, 2018). Consequently, the conceptual paradigm of the digital economy envisages both activities based on online platforms and activities involving the use of digitized data. This ambiguous definition of the digital economy leads, among other things, to conflicting estimates of the size of the digital economy (Góźdź & Van Oosterom, 2016).

Scientists use various indicators to assess technological progress outside the digital economy. Initially, the digital economy was defined as an economic system characterized by the widespread use of ICT, covering basic infrastructure, e-business and e-commerce. Subsequently, the scope of the concept has expanded at the same pace as the development and evolution of digital technologies. Therefore, the digital density index, developed in 2015, contains 50 indicators grouped into 4 areas of activity and 18 groups of indicators (Szeles & Simionescu, 2020). In 2016, as part of the Europe 2020 Strategy, the Digital Economy and Society Index (DESI) was created in order to reflect the performance results of EU member states in the field of digital competitiveness. Currently, it is estimated that the size of the digital economy ranges from 4,5 to 15,5% of world GDP (UNCTAD, 2019). By lapse of time, a great number of investigations have examined the major drivers, dimensions and indicators of the digital economy, focusing on specific dimensions of the digital economy and using particular analysis between countries. E-commerce, Internet use and human resources in ICT are some of the variables commonly used to assess the digital economy, also included in the most popular digital economy indices such as DESI.

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Conceptually, blockchain is a distributed database containing transaction records that are shared by participants. Each transaction is confirmed by consensus of the majority of participants, making it impossible for fraudulent transactions to go through collective confirmation. Once a record is created and accepted by blockchain, it can never be changed or deleted (Efanov & Roschin, 2018). Blockchain, like the Internet, is an open, global infrastructure that provides an opportunity to companies and individuals, carrying out transactions, to eliminate intermediaries, reducing transaction costs and working times through third parties. The technology is based on the structure of the distributed book and the consensus process. The structure makes it possible to create a digital ledger of transactions and use it between distributed computers in the network. The register is not owned or controlled by a single central authority or company it can be viewed by all network users (Underwood, 2016).

Blockchain (Tripoli & Schmidhuber, 2018) is derived from the terms "block" and "chain", a list of transactions known as the block connected with the encryption method. Blockchain is a peer-to-peer blockchain managed by a network of peer partners used to store and retrieve information. The block header and transactions are included in each block. The hash, common measure, one-time value, and root value of the previous block header are stored in the block header. It is impossible to change the information in the block. The main use of blockchain is to eliminate inconsistencies (Baralla et al., 2018). Blockchain can be represented by digital public records documenting bitcoin exchanges or cutting-edge cash at record demand. Upon completion, the block enters blockchain as immutable information. Each block contains the hash of the previous block, the data of the current block and its own hash data. Taking into consideration that blockchain is a complex record with limited capabilities, when data is placed in a block, it is extremely difficult to change it; for this reason, this kind of innovation is used in programs such as money management and intellectual property. Blockchain provides the opportunity for customers to conduct their web applications on their local and primitive computers. The blockchain tool has no servers; it is restricted to any place where customers can have or manage their data or applications running on their devices. Blockchain is a distributed ledger of transactions. This makes it possible for community members to share data with other services without the involvement of a third party and to track the transaction. Instead of storing information on a single server,

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it is shared between multiple servers, making it extremely difficult to change or delete records. Protection against unauthorized access includes a trademark, as well as a method ensuring that all data entered into the blockchain is reliable, creating public confidence (Corallo et al., 2018). Peer-to-peer networks are used to distribute and support blockchains. A network can exist without a centralized authority or a server controlling it, forasmuch as it is a distributed ledger and its data quality can be maintained through database replication and computational trust. Blockchain technology is a type of distributed ledger technology. In order to create a secure and distributed consensus, not all distributed ledgers use a chain of blocks. The blockchain structure distinguishes it from other types of distributed registers. In blockchain, data is collected together and encrypted. A distributed ledger is a database covering multiple nodes or computing devices. Each node duplicates and saves a copy of the ledger. Each node-member of the network is updated independently. The cost of trust is greatly reduced by distributed ledger technology. Constructions and structures of the distributed ledger can help reduce dependence on banks, governments, lawyers, notaries and officials in compliance with regulatory requirements. Corda, developed by R3, is an example of a distributed ledger.

The scientific literature explores the issue of using blockchain technologies in the following areas of the digital economy, namely: the financial system at the macro and micro levels (in particular, financial and technological companies) (Vovchenko et al., 2017; Karapetyan et al., 2019), insurance system, public administration system (Babkin et al., 2017; Britchenko & Cherniavska, 2019), infrastructure (Abodei et al., 2019), e-commerce system, industry, agriculture (for supply chain management in agriculture) (Tripoli & Schmidhuber, 2018; Baralla et al., 2018; Sajja et al., 2021), intellectual property, education, health care (Dorofeyev et al., 2018; Muminova et al., 2020). Blockchain is also being actively implemented in the tourism sector, especially in island countries (Treiblmaier et al., 2020). For instance, the Caribbean countries have launched the first legal digital means of payment; Aruba has developed a blockchain platform in order to ensure the growth of tax revenues from tourism (Kwok & Koh, 2019). One of the sectors where blockchain technologies are being introduced at a rapid pace is the financial sector. Babkin et al. (2017) have systematized the features of different countries in the implementation of state regulatory mechanisms of blockchain as follows: creating a favourable climate for the development of new digital technologies

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(blockchain), applying technologies in the private, public sector (for instance, for the implementation of infrastructure projects of public-private partnership (Abodei et al., 2019); high growth rates of the cryptocurrency market and the lack of adaptation of tax legislation to the challenges of this trend (Crosby et al., 2016; Yeoh, 2017); for this reason, the potential for receiving revenues to budgets is reduced; the necessity to develop common standards for blockchain regulation at the international level.

Along with this, in the scientific literature, there are few empirical quantitative studies of the potential for using blockchain in the context of the digital economy development. Therefore, the present research is aimed at assessing numerically the potential of technology by measuring the development of digitalization aspects as follows: Connectivity, Digital Public Services, Human Capital, and Integration of Digital Technology.

2. Methodology

The first part of the research has identified the major tendencies in the development of the digital economy of the EU in three key sectors, namely: state, private and public. In order to assess the development of the digital economy, the indicators of the Eurostat database (section "Science, Technology and Digital Society", subsection "Digital Economy and Society") have been used by the categories as follows: 1) indicators of ICT use by households and individuals; 2) indicators of ICT use by enterprises; 3) indicators of ICT sector development. The second part of the research has assessed numerically the use of digital technologies in order to ensure the digital development of the country based on data from the European Commission (2021) on the Digital Economy and Society Index (DESI) taking into accounts the aspects as follows: Connectivity, Digital Public Services, Human Capital, and Integration of Digital Technology. Integration of digital technology measures the level of implementing the following indicators in countries, namely: 1) Digital intensity; 2) SMEs with at least a basic level of digital intensity; 3) Digital technologies for businesses; 4) Electronic information sharing; 5) Social media; 6) Big data; 7) Cloud; 8) AI; 9) ICT for environmental sustainability; 10) e-Invoices; 11) Blockchain. Thus, DESI serves as an assessment of the synergistic impact of blockchain together with other technologies on the digital economy. On the basis of DESI, a tree cluster diagram has been constructed in order to visually display the clusters of countries in the context of the digital economy

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development. A cluster analysis of the EU-27 countries according to DESI sub-index estimates in 2020 has been conducted.

3. Results

Accelerated use and expansion of the Internet as a means of communication, mobile Internet, social networks, commercial platforms, usually perceived as digitalization, has had a significant impact on the functioning and state of the economy, on the activities of enterprises, government agencies and individuals. The state of digitization of business and various sectors of the economy varies between countries and regions of the European Union (EU). Each EU country implements its own digitalization model in order to ensure economic growth, productivity and competitiveness.

The EU countries are characterized by the implementation of various models of digital transformation due to differences in the established economic and social policies (Szeles & Simionescu, 2020). The digital economy is growing rapidly, especially in developing countries; however, the values and indicators of the digital economy are limited and divergent. The core of the digital economy is the "digital sector": that is, the IT / ICT sector producing basic digital goods and services. The digital economy is defined as "that part of economic production that derives exclusively or primarily from digital technologies with a business model based on digital goods or services, including the digital sector and new digital services". The ICT sector, penetrating into all sectors of the economy, is defined as the "digital economy", the size of which amounts about 5% of world GDP and 3% of world employment (Bukht & Heeks, 2017; Barefoot et al., 2018).

The average value of the share of the ICT sector in the EU-27 GDP was 4,1% in 2008-2018, growing by 0,34% over ten years (Eurostat, 2021a). All countries can be classified according to the level of development of the ICT sector into three groups, namely:

1) high level of development with a share of ICT in GDP of more than 5%, which includes countries as follows: Malta – 7,97%, Bulgaria – 6,1%, Hungary – 5,95%, Sweden – 5,94%, Estonia – 5,38%;

2) average level of development with the value of the share of ICT in GDP in the range of 3,5-5%, which includes countries as follows: Latvia – 4,92%, Finland – 4,85%, the Czech Republic – 4,56%, Denmark – 4,56%, Croatia – 4,45%, Germany – 4,4%, France – 4,31%,

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Slovakia – 4,13%, Iceland – 4,03%, Belgium – 3,96%, Romania – 3,74%, Poland – 3,59%, Slovenia – 3,59%, Austria - 3,58%;

3) low level of development with the share of ICT in GDP less than 3,5%, which includes countries as follows: Norway – 3,37%, Italy – 3,29%, Spain – 3,28%, Lithuania – 3,13%, Greece – 2,49%.

Accordingly, in the EU countries the share of population employed in the ICT sector (Eurostat, 2021b; 2021c) and the needs of the labour market in ICT professionals differ. The average share of employment in ICT was 2,79% in the EU-27 in 2009-2018. The largest share of people employed in the ICT sector is observed in the following countries, namely: Malta – 4,77%, Sweden – 4,75%, Estonia – 4,3%, Latvia – 4,15%, which can be attributed to the group with the most developed digital economy, where the share of employed population exceeds 4%. The following group of countries with an average employment rate in ICT in the range of 3-4% is as follows: Finland – 3,79%, Hungary – 3,6%, Denmark – 3,51%, the United Kingdom – 3,43%, Slovakia – 3,31%, Germany – 3,16%, Switzerland – 3,16%, the Czech Republic – 3,13%, Norway – 3,08%, France – 3,07%. The group of countries with low employment in ICT (less than 3%) should include as follows: Belgium – 2,85%, Bulgaria – 2,85%, Slovenia – 2,72%, Lithuania – 2,64%, Austria – 2,63%, Croatia - 2,57%, Poland – 2,54%, Romania – 2,52%, Spain – 2,48%, Italy – 2,43%, Greece – 1,51%.

Over the last ten years (2011-2020), the share of the population using the Internet has increased significantly, which means that the digital economy is developing at a rapid pace, ICTs are penetrating into various spheres of social life. The average value of Internet use by individuals is 88% in the EU-27 with a deviation of 7,55%, reaching 99% in some countries (Figure 1).

For the period of 2010-2019, e-commerce has increased significantly: the share of individuals who made online purchases in the last 12 months in 2010 was 36%, in 2019 - 60%, in 2020 - 65%. At the same time, a significant differentiation of countries in the development of e-commerce is observed (Figure 2).

Thanks to ICT, e-government is developing, providing penetration into the public sector of technologies in order to facilitate the interaction of the private sector and individuals with public authorities (Figure 3). Therefore, the share of people using the Internet for interaction with the authorities increased from 41% in 2011 to 57% in 2020.

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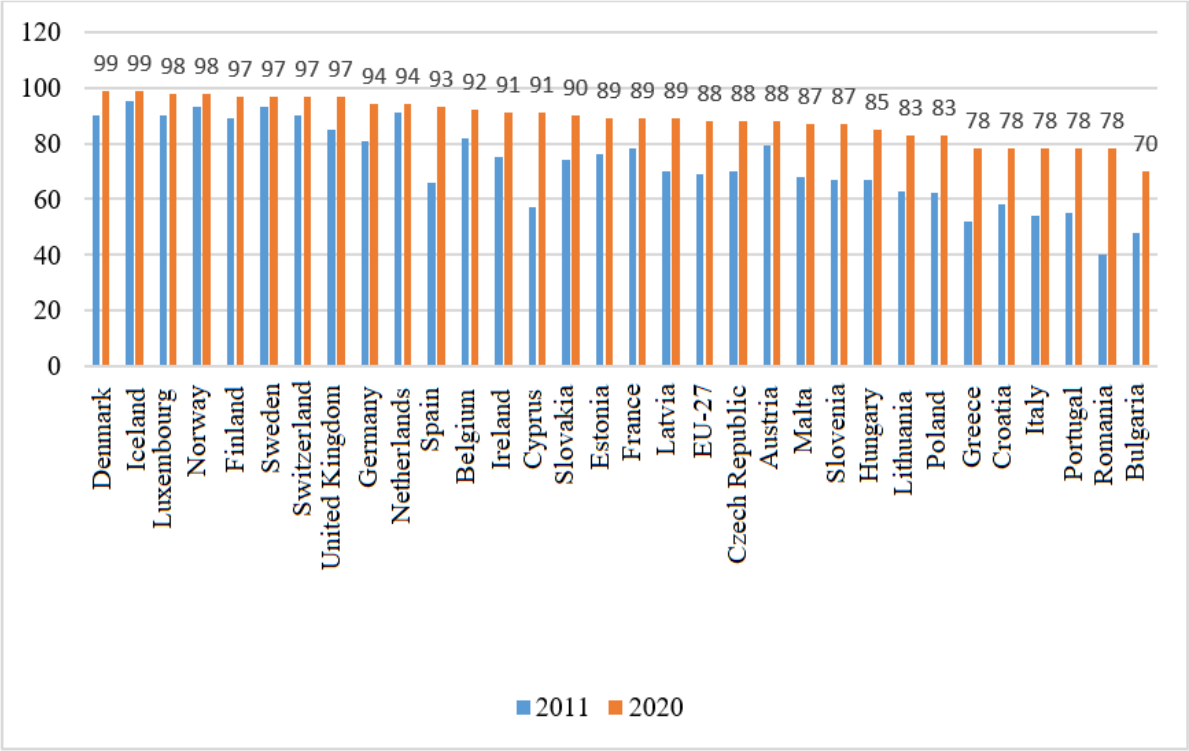
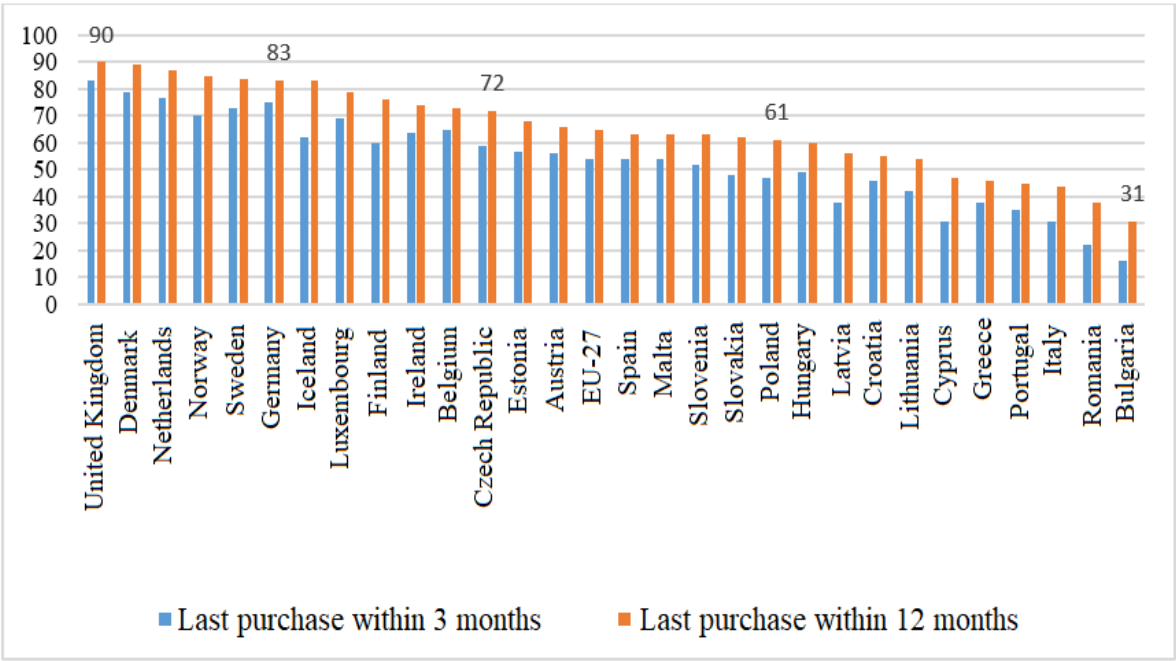
Figure 1. Individuals - internet use, 2011-2020, EU--27, %



Source: compiled by the authors according to the Eurostat data (2021d).

Figure 2. Internet purchases by individuals (2020 onwards) for last 3 or 12 months in EU-27, 2020 y 2020



Source: compiled by the authors according to the Eurostat data (2021e).

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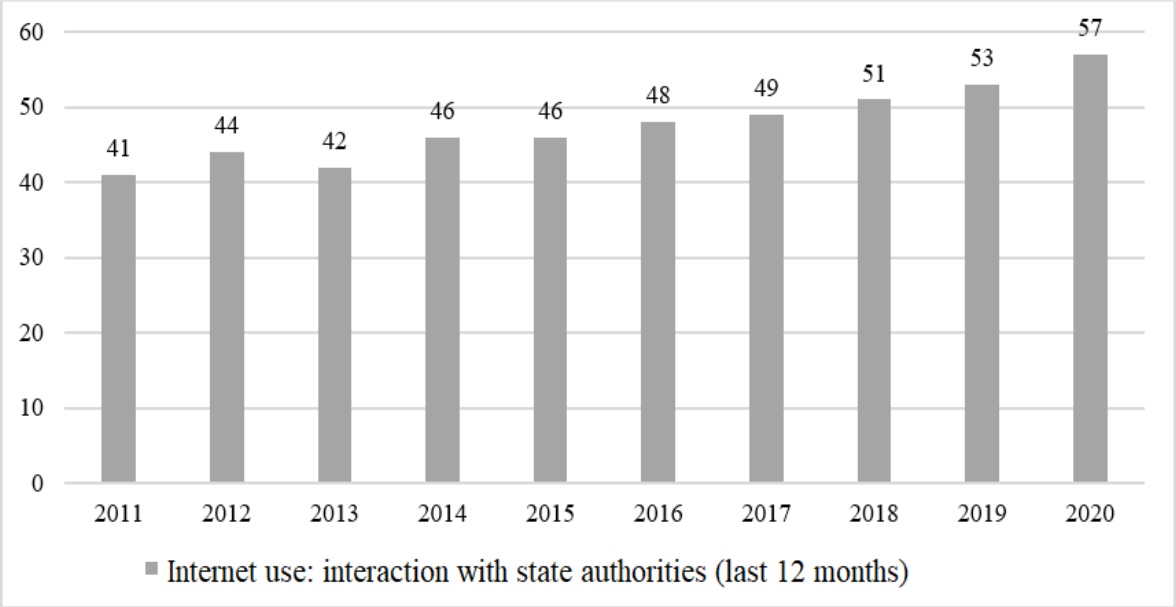
Figure 3. Use of ICT at work and activities performed (the share of the population of EU countries using the Internet to interact with the authorities, % of the total population)



Source: compiled by the authors according to the Eurostat data (2021d).

The most advanced EU countries are characterized by higher assessments for the sub-indices of the digital economy development (Table 1).

The simultaneous priority of two high marks is typical for different EU countries. For instance, the quality of digital public services is highly assessed in Estonia, Finland, and Sweden; high estimates of human capital and Internet availability are observed in Denmark, Malta, Ireland, Spain, and the Netherlands.

The cluster diagram makes it possible to visually highlight 3 clusters of countries in the context of the digital economy development, depending on the level of their digital proximity, assessed on the basis of DESI (Figure 4).

The first cluster includes the countries as follows (Table 2): Belgium, Croatia, Cyprus, the Czech Republic, France, Germany, Italy, Latvia, Lithuania, Portugal, and Slovenia. In these countries, the average value of the Connectivity sub-index is 11,91, Digital Public Services – 16,76, Human Capital – 11,45, Integration of Digital Technology – 9,49 (Table 2). The second cluster includes the countries as follows: Austria, Denmark, Estonia, Finland, Ireland, Luxembourg, Malta, the Netherlands, Spain, and Sweden. The average values of the subindexes of this cluster are as follows: Connectivity – 14,66, Digital Public Services – 20,90, Human Capital – 14,43, Integration of Digital Technology – 12,11.

The third cluster contains 6 countries as follows: Bulgaria, Greece, Hungary, Poland, Romania, and Slovakia. The average values of the subindexes of the third cluster are as follows: Connectivity – 11,35, Digital Public Services – 11,56, Human Capital – 9,53, Integration of Digital Technology – 6,29. The conducted clustering suggests that the potential for using blockchain technology depends on different indicators of the

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development of the digital economy. In countries with a higher level of implementation of digital public services, the average indicators of Internet accessibility, human capital development, and integration of digital technologies are simultaneously higher.

Table 1. The Digital Economy and Society Index (DESI), EU countries, 2021

Country	Connectivity	Digital Public Services	Human Capital	Integration of Digital Technology
Austria	13,2476	19,9584	13,3373	10,3259
Belgium	12,0994	16,4566	12,6955	12,4435
Bulgaria	9,52411	14,012	8,17517	5,12099
Croatia	11,3528	12,993	11,6806	9,99231
Cyprus	10,4539	15,4553	9,91849	7,63476
Czechia	11,1606	14,6472	11,7883	9,7681
Denmark	18,5098	21,7714	15,2997	14,4818
Estonia	11,6392	22,9407	14,4793	10,3657
European Union	12,5403	17,0132	11,7649	9,39214
Finland	12,817	21,679	17,7771	14,8735
France	11,8522	18,248	11,8399	8,69166
Germany	14,499	16,8684	13,8103	8,88743
Greece	9,43265	10,4854	10,2603	7,13132
Hungary	12,9993	12,2897	10,1201	5,82488
Ireland	14,1027	20,652	13,5186	12,0052
Italy	10,5877	15,7985	8,77886	10,3619
Latvia	12,5948	19,9076	10,2772	6,6998
Lithuania	10,4286	19,5123	11,5356	10,3024
Luxembourg	15,2424	19,8404	14,046	9,85591
Malta	13,5281	21,0487	12,2737	12,7111
The Netherlands	17,1111	19,9755	15,3872	12,6746
Poland	11,3289	13,775	9,4245	6,46908
Portugal	12,1309	17,2369	11,3915	9,14354
Romania	13,2932	5,37211	8,26281	5,93985
Slovakia	11,5633	13,4307	10,9381	7,27292
Slovenia	13,2983	16,9984	11,9508	10,5799
Spain	15,5073	20,169	12,0832	9,68769
Sweden	14,8928	20,9863	16,1388	14,0838

Source: European Commission (2021).

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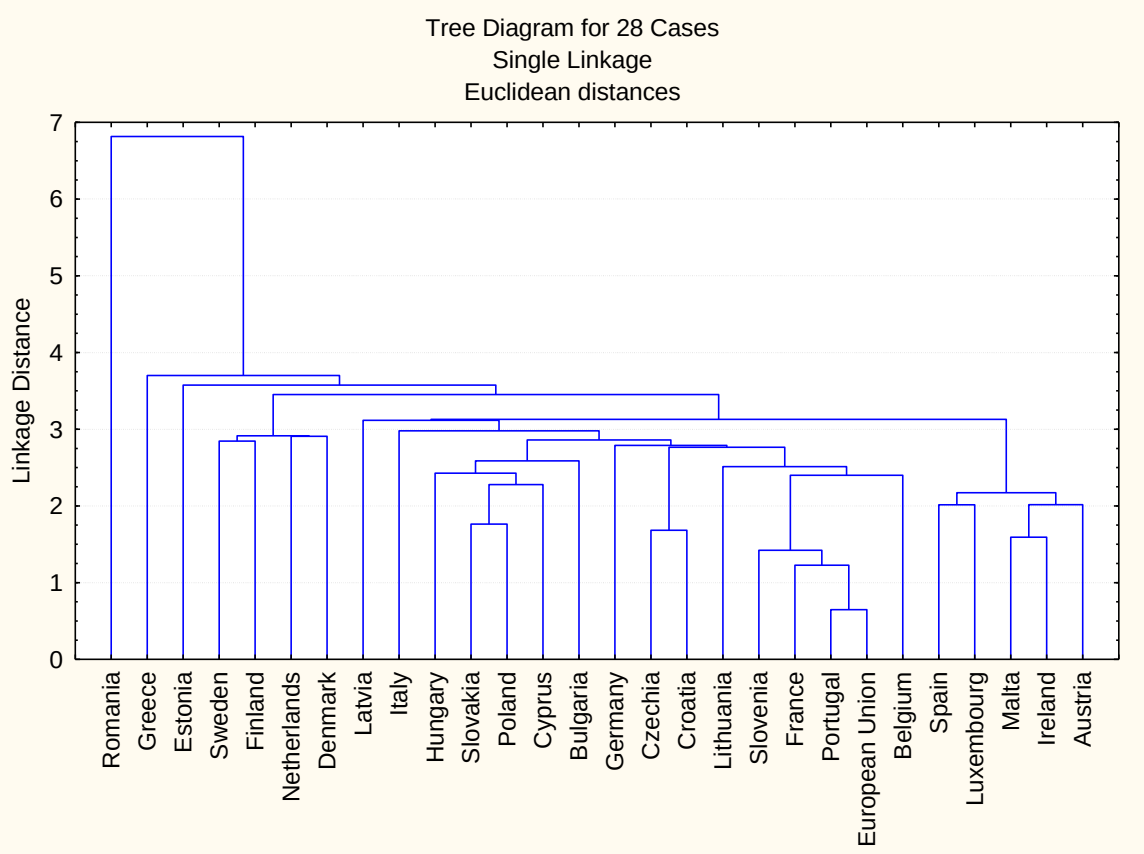
Figure 4. Tree cluster diagram for visual representation of clusters of countries in the context of the digital economy development



Source: compiled by the authors based on the European Commission (2021).

Table 2. Average values of indicators of digital economy development of the countries of various clusters

	Mean	Standard	Variance
1 cluster			
Connectivity	11,91654	1,225463	1,501759
Digital Public Services	16,76128	1,940707	3,766344
Human Capital	11,45266	1,302394	1,696230
Integration of Digital Technology	9,49145	1,477654	2,183460
2 cluster			
Connectivity	14,65980	2,056121	4,227632
Digital Public Services	20,90214	1,001115	1,002231
Human Capital	14,43409	1,767834	3,125239
Integration of Digital Technology	12,10652	1,972683	3,891479
3 cluster			
Connectivity	11,35691	1,646328	2,71040
Digital Public Services	11,56082	3,298341	10,87905
Human Capital	9,53016	1,123990	1,26335
Integration of Digital Technology	6,29317	0,826013	0,68230

Source: compiled by the authors based on the European Commission (2021).

The conducted cluster analysis of the digital economy development of the EU countries proves that the potential for using blockchain technology in each country depends on and is associated with the introduction of different technologies, the availability of the Internet, the provision of digital services by the government, and the development of human capital.

4. Discussion

Blockchain as a new technology accelerates globalization processes, ensuring the country's transition from the real sector to the network sector of the economy, thereby contributing to the digital economy development (Vovchenko et al., 2017). Catalini (2017) highlights the following key transformations of the digital economy through blockchain, namely: changing established business models and existing value chains; a radical change in the nature of mediation due to a new wave of technological change; significant reduction in the cost of verifying transaction attributes that can be recorded on the blockchain and the cost of the network; the use of cryptocurrency in order to achieve consensus by economic agents on the allocation of scarce resources on a global scale.

Harris (2018) systematizes the risks of blockchain technology in underdeveloped countries as follows: risks of damage or failure, security risks due to attacks, the trend towards centralized technology management, limited user access, privacy and autonomy, legislative problems due to the need for concluding contracts, regulation and taxation, problems of scaling and storage, speed and verification. From among the main problems of blockchain implementation, Karapetyan et al. (2019) have identified as follows: gaps in legislative regulation; a significant number of projects at the development stage that have not proven their own economic feasibility; lack of full understanding of the potential for the introduction of blockchain technology, the expected results in terms of the number and timing of their receipt by government officials, business representatives, society; discussions on the circulation of cryptocurrencies in countries, their potential impact on the national economy.

The potential impact of blockchain technology on the collaborative economy (CE), or the sharing economy, may be manifested in the rapid integration of the latest technological advances, including artificial intelligence, big data analysis, augmented reality, smart grid, and blockchain technologies into different sectors of the economy (Ertz & Boily, 2019). It

may be expected that blockchain will ensure the revolution in industry and commerce; it will drive economic change on a global scale forasmuch as the technology is immutable, transparent, redefining trust between economic agents, providing safe, fast, reliable and transparent solutions that can be of public or private nature (Underwood, 2016). Technology provides people in developing countries with a recognized identity, asset ownership and affordability. At the same time, blockchain prevents a recurrence of the 2008 financial crisis; it supports effective health care programs, as well as improves, optimizes, and transforms supply chains. In the future, the technology can eliminate unethical high-cost, high-value business behaviour, leading to significant intermediary costs or fraudulent risks.

Conclusion

The present research has analysed and systematized the core quantitative indicators of the digital economy of the EU countries, determining the potential of applying the blockchain technology in the EU states. The conducted cluster analysis of the digital economy development of the EU countries proves that the potential for using blockchain technology in each country depends on and is associated with the introduction of different technologies, the availability of the Internet, the provision of digital services by the government, and the development of human capital. Consequently, in countries with a high level of social-economic development, high ratings for the quality of digital public services, the development of human capital and the availability of the Internet, the simultaneous high level of integration of technologies into different sectors of the digital economy is observed (Austria, Denmark, Estonia, Finland, Ireland, Luxembourg, Malta, Netherlands, Spain, Sweden should be noted). In the future, the potential of blockchain technology will be manifested in the acceleration of globalization, technological development of countries, especially countries with a high quality of human capital, transformation of doing business and elimination of intermediation, optimization of value chains by reducing transaction costs. In the most advanced countries, economic agents will be more optimal in allocating available resources, forasmuch as the blockchain effect as a tool of eliminating the risks of corrupt fraudulent schemes will enhance the effects of a low level of corruption and a high level of trust in institutions in such countries.

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Assessment of the efficiency of using information modeling technology for buildings and structures as a construction security planning tool

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ABSTRACT

Objective: presentation of an innovative method for the development of organizational and technological solutions, economically supported, that allow to provide an optimal response regarding the time and cost of construction production, the method of its use, the economic support for the application of this method in the development and implementation of the construction organization plan (COP) of industrial facilities. Methods: systems approach, statistical and comparative analysis, national and international developments in the field of construction production organization, economic and visual modeling, construction information modeling. Results: the tests of buildings and structures were analyzed in order to study the elements of the quality systems of BIM technologies in planning, security management of construction production. An algorithm for the operation of this model is presented for the development of a construction organization project (COP). Conclusions: Construction research shows that 4D Building Information Modeling (BIM) can improve the planning, control and management of security at a construction site.

KEY WORDS: 4D technology; economic and visual mathematical models of buildings and structures; security; construction organization project; mathematical models of building information; master plan.

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Evaluación de la eficiencia del uso de tecnología de modelado de información para edificios y estructuras como herramienta de planificación de seguridad en la construcción

RESUMEN

Objetivo: presentación de un método innovador para el desarrollo de soluciones organizativas y tecnológicas, sustentadas económicamente, que permitan brindar una respuesta óptima en cuanto al tiempo y costo de producción de la construcción, el método de su uso, la sustentación económica para la aplicación de este método en el desarrollo e implementación del plan de organización de la construcción (POC) de instalaciones industriales. Métodos: enfoque de sistemas, análisis estadístico y comparativo, desarrollos nacionales e internacionales en el campo de la organización de la producción de la construcción, modelado económico y visual, modelado de información de construcción. Resultados: se analizaron las pruebas de edificios y estructuras con el fin de estudiar los elementos de los sistemas de calidad de las tecnologías BIM en la planificación, gestión de seguridad de la producción de la construcción. Se presenta un algoritmo para el funcionamiento de este modelo para el desarrollo de un proyecto de organización de la construcción (POC). Conclusiones: la investigación en construcción muestra que el modelado de información de construcción 4D (BIM) puede mejorar la planificación, el control y la gestión de la seguridad en un sitio de construcción.

PALABRAS CLAVE: tecnología 4D; modelos matemáticos económicos y visuales de edificios y estructuras; seguridad; proyecto de organización de la construcción; modelos matemáticos de información de edificios; plan maestro.

Introduction

One of the main research instruments is Building Information Modeling (BIM). The concept of BIM technology and controls are considered in relation to construction safety. The use of 4D BIM opens up opportunities for the development of digital control systems that provide a solution to a complex of events in the construction production. As objects of research, industrial facilities were considered, the development of which was carried out in compliance with the current regulatory documents of the Russian Federation. The subject of the study is technologies and methods of developing COP for industrial facilities from the point of view of economic efficiency and feasibility, the use of 4D planning methods for the

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purpose of modeling, management, as well as construction safety control. Study of the role and place of the construction organization project in the investment and construction process, the regulatory framework for the organization of construction production; analysis of modern foreign experience in the use of leading methods that are used to reduce the time and estimated cost of construction production, including project control, 3-4D-design, network planning method, mathematical modeling of in-line construction, visual planning of the organization of construction production, rationing, and also the estimate of the cost of labor.

Advanced information modeling (BIM) is a method that allows designing objects for various purposes in the information field, high-quality management of work carried out at each stage of the building's life cycle. This technology makes it possible to display in detail the internal and external views of the object using images, as well as to control construction equipment in automatic mode. BIM-modeling makes it possible to create architectural concepts, which, in their essence, are as close as possible to the capabilities of modern technologies, and also allows making a real time forecast of the probability of building objects with certain parameters in the process of preserving a real architectural idea (Adnan Enshassi et al, 2016; Aleksandrova, 2018; Akinci et al, 2002). The problem that is relevant for the design and organization of construction production is the consideration of variable factors in real time. BIM technologies provide accounting using modern innovative 4D modeling methods. Using of BIM for the subsequent operation of buildings and structures goes beyond the three-dimensional spatial model and uses 4, 5, 6 dimensions. Each level provides the accumulation of new volumetric information corresponding to the level of the element base for measuring information by analogy with system quanta (Sulankivi, 2014; Sulankivi, 2015; Vitaliy et al, 2020). Thus, the developed 3D information model is the basis for 4 -, 5 -, 6D - models and is the starting point for the development of working documentation, design and manufacture of building structures, creation of technical conditions, for economic assessment and organization of construction of buildings and structures (Fig.1).

3D BIM is an integrated data model from which various interested parties, such as architects, design engineers, builders and project owners, can extract and enter information according to their needs. 3D BIM's visualization capabilities allow participants not only to see a building in three dimensions, but also to automatically update those views during the

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project lifecycle. *3D BIM* helps participants more effectively manage their interdisciplinary collaboration in modeling and analyzing complex problems.

4D BIM is a design method that considers a construction object not only in the space of the information field, but also in time. It is used for site planning activities. The fourth dimension of *BIM* allows participants to extract and visualize the progress of activities throughout the entire life cycle of a project. The use of 4D BIM technology can lead to better control over identification of conflicts or the complexity of changes occurring during the construction process.

5D BIM is an information model that also includes the cost of the project. It is used for budget tracking and expense analysis. The fifth dimension of BIM, related to 3D and 4D (time), allows participants to visualize the course of their activities and associated costs over time. The use of *5D BIM* technology can result in greater accuracy and predictability in design estimates, changes in volume and material, equipment or labor.

6D BIM model gives complete information about the project. It is used to monitor the state of the building and allows effective management of the facility during construction, scheduled and routine repairs, reconstruction (Adnan Enshassi et al, 2016; Aleksandrova, 2018; Akinci et al, 2002; Bachurina et al, 2015; Churbanov et al, 2018; Sulankivi, 2014; Sulankivi, 2015; Vitaliy et al, 2020; Chulkov et al, 2020).

Nowadays, the attention to advanced technologies and methods of control over construction projects is increasing all over the world. For example, EVM is currently used in 58 countries, mainly in projects related to the construction of civil, transport, infrastructure, energy, oil and gas facilities. McGraw Hill Construction (Smart Market Report 2012: "The Business Value of BIM in North America: Multi-Year Trend Analysis and User Ratings (2007-2012)) provided a report that outlines the extent to which BIM is being applied. According to this data, the USA uses this technology for 71%, and in the UK - 54% (according to the NBS National BIM Report 2014). In 2014, in the EU countries, when placing orders for construction production, which are financed from the state budget, it was recommended to use a EVM. The area of potential applications is constantly expanding (Fig. 1).

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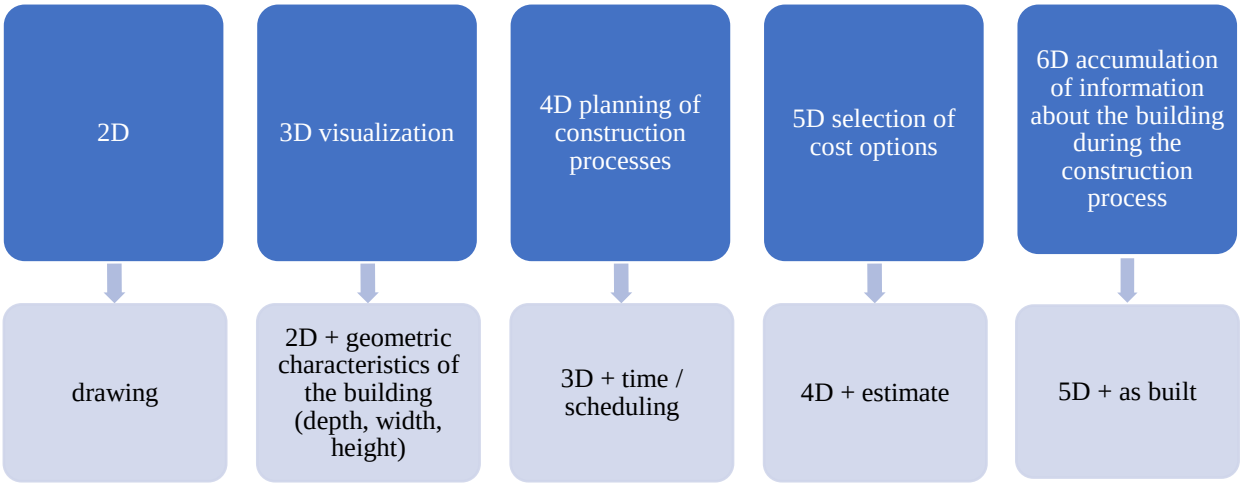

Figure 1. BIM cycle of buildings and structures

Before starting construction and installation work, it is necessary to prepare an operational business plan for the construction site, showing the main parameters for using the area of the site for construction. In this regard, the project is subject to systematic analysis in order to identify the dangers and risks that are associated with the organization, practical restructuring and the use of a certain construction plan, with subsequent elimination (if necessary), with the use of appropriate management tools. In the process of designing a master plan, the following basic elements of the organization should be considered:

1. Number and location of office and other premises required for personnel and warehouses;
2. Location of cranes, construction machines and equipment;
3. Location of the embankment;
4. Location of places for loading, unloading and storage of building materials, structures and prefabricated elements;
5. Traffic in the area of the construction site;
6. Entrances, ramps and transport routes, as well as their maintenance;
7. Collection, storage, removal and disposal of waste and materials that are harmful to the health and safety of workers;
8. Fire extinguishing;
9. Organization of special storage facilities using materials and substitutes that cause negative impact on the health and safety of workers.

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The above issues are subject to precise control in full compliance with the elements of ISO-9000, ISO-14000 quality systems. The risks of accidents, fire hazards and other force majeure situations at the construction site must be minimized (Khoshnava et al, 2012; Korabelnikova et al, 2019; Lu Y. et al, 2021; Kazaryan, 2019; Kazaryan, 2020). With the traditional method of developing a construction plan, a 2D site layout plan is prepared, the purpose of which is to plan operations on the site and the necessary measures to maximize the efficiency of the planned work at all stages of construction. Nowadays, building information modeling (BIM) in the construction industry is seen as a tool that provides an opportunity to improve occupational safety. BIM can be used in the design, training and education on safety engineering, the formation of the initial requirements of the tasks to find the most optimal solution for the cost of the construction of the facility, taking into account the organizational and technical elements of planning, the investigation of accidents, as well as ensuring the safety of facilities and maintenance in full compliance with the requirements of ISO-9000 (Hartmann et al, 2007; Hiravennavar et al, 2020; International Labour OYce, 1985; Sulankivi, 2014).

1. Methods

The theoretical, methodological and informational basis of the study is international and domestic developments in the field of organization of construction production, visual modeling, BIM. The scientific basis of the work is the regulatory framework of the Russian Federation in the field of organization of construction production, studies by Russian and foreign authors. Literary analysis revealed that BIM technologies can be used to monitor and manage the safety of workers on a construction site and to combine safety with other construction planning processes. Turner Construction (Downey, 2012) has established a standard procedure to ensure compliance with safety standards. BIM specialists have developed a set of rules based on the Solibri Model Checker. This system is based on the application of the theory of project management, 3D modeling methods, in-line organization of construction, rationing and assessment of labor costs, scheduling and network planning, EVM. The solution to this problem entailed the use of methods of economic, statistical and comparative analysis. The Finnish Technical Research Center has developed an integrated structure for modeling the protection from force majeure situations. The introduction of 4D visualization, including the simulation of temporary protective structures and equipment

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necessary to ensure the safe conduct of construction and installation works, multiplies the capitalization of the project (simulates the permanent installation of security equipment in a building during construction, operation and maintenance). The technological cycles for the introduction of best practices in joint planning procedures between the general contractor, designers and subcontractors are being improved. Thus, on the basis of research on the implementation of BIM technologies, intelligent approaches to ensuring the verification of safety rules in an *automated and time-saving way multiply the capitalization of the project, the possibilities of safety planning and detection of hazards* (Bachurina et al, 2015; Churbanov et al, 2018; Gambatese et al, 2005; Hartmann et al, 2020).

2. Results

As a result of the analytical study, it was revealed that BIM technologies offer completely new opportunities for planning a construction site and visualizing information. A BIM-based construction master plan (CMP) is like a snapshot of a construction site at a specific point in time. Of course, additional models of site planning are needed, given the continuity of changes in site configurations at different stages of construction. The ultimate goal is to be in sync with these dynamic changes using 4D site models in the future. An important application of BIM to ensure safety when planning a construction site can be the modeling of formwork equipment and technological cycles during the construction process, namely, viewing plans based on BIM in order to obtain a general understanding of the management organization, timely identification of the results of safety checks, as well as information about the product and quantity. In total, six different tests were carried out within the framework of one project, the results of which are shown in Table 1 (International Labour OYce ,1985; J.P. Zhang et al, 2011; Kazaryan, 2020;Kiviniemi et al, 2012).

The first test showed that the planning of a construction master plan, which is based on 2D planning, does not allow designing and taking into account all factors. Therefore, does not meet the needs of the designers. The site layout model should not be static or two-dimensional, but *dynamic, encapsulating the entire 3D site*. For example, BIM can be used to assemble a tower crane for planning lifting and safety checks during construction. 3D modeling will allow checking the reach and ability of a tower crane during the construction and installation works (CIW). In addition, it becomes possible to analyze the risks

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associated with an arrow crash or a fall of a load (Khoshnava et al, 2012; Korabelnikova et al, 2019; Lu Y.,et al, 2021; Kazaryan, 2019). The importance of this expertise becomes obvious when the space around the construction site is limited and collisions are possible (Fig. 2).

Table 1. Tests for the study and demonstration of BIM technologies in planning and management of construction safety

BIM application for safety in construction site planning	Results
Site layout plans and visualization of crane reach associated with crane collapse	BIM-models of facility planning (spatial location of temporary and permanent structures), as well as visualization of risk zones associated with any possible collapse of the crane at the facility
Visualization of wall demolition procedures	BIM model for visualizing wall demolition work
Expert analyzes of building fencing with a virtualized construction site	Experiment to visualize a collapse prevention plan
Automatic security analysis using BIM technologies	Knowledge of automated security checks of buildings under construction using model checker software (SMC)
Modeling of formwork equipment and procedures during construction	Gaining general understandings, visualization of details, product information and quantity
Site security and BIM	Pilot use of information displays on a construction site for the transmission of safety information

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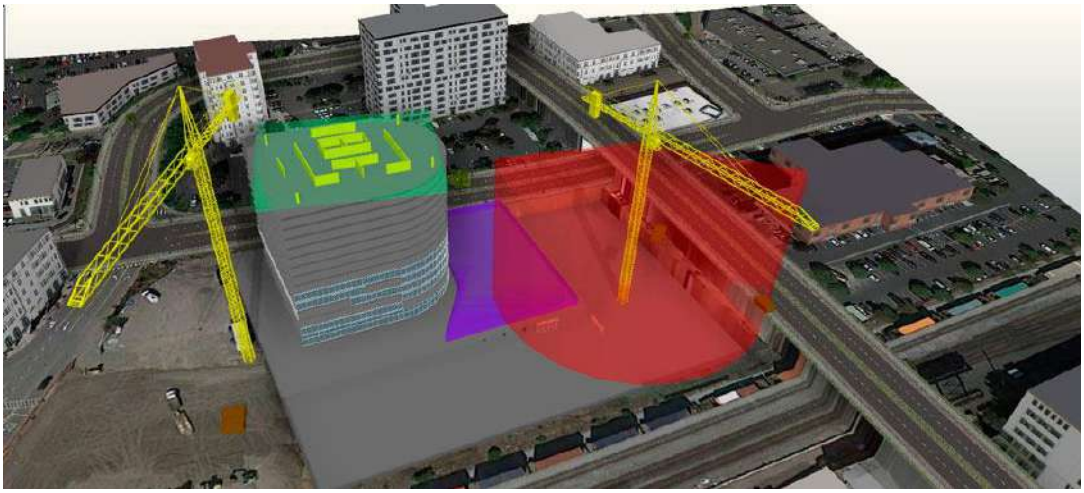

Figure 2. Crane reach visualization

It is also possible to clearly assess the difference in visualization between a 3D plan developed using information technology and a common 2D master plan (Fig. 3).

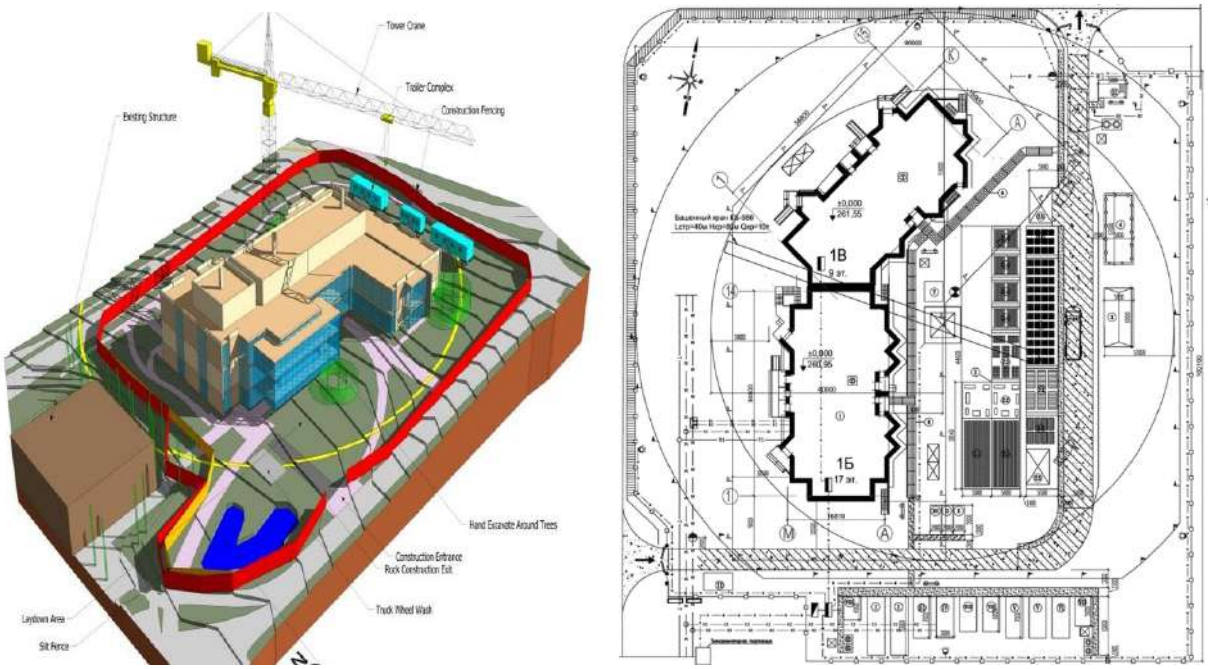

Figure 3. Comparison of visualization of 3D and 2D design of a master plan

In tests for the demolition (dismantling) of walls, BIM technologies provide a clear color scheme of the technological sequence, providing a comfortable digitalization of the element base of the control quality system in comparison with 2D drawings. Automatic safety analysis allows assessing how the project meets the safety requirements using the model checker software (SMC) (Khoshnava et al, 2012; Korabelnikova et al, 2019; Lu Y.,et al,

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2021; Kazaryan, 2019; Kazaryan, 2020). The considered method makes it possible to identify inconsistencies in the created interconnections of the object's processes, approaching the solution of the problem systematically at the organizational and technological level. This model allows identifying space-time collisions at the level of management decisions and design solutions. Thus, risks are minimized at the planning stage and in the process of operation, including facilities that are technically complex and especially dangerous (Fig. 4).

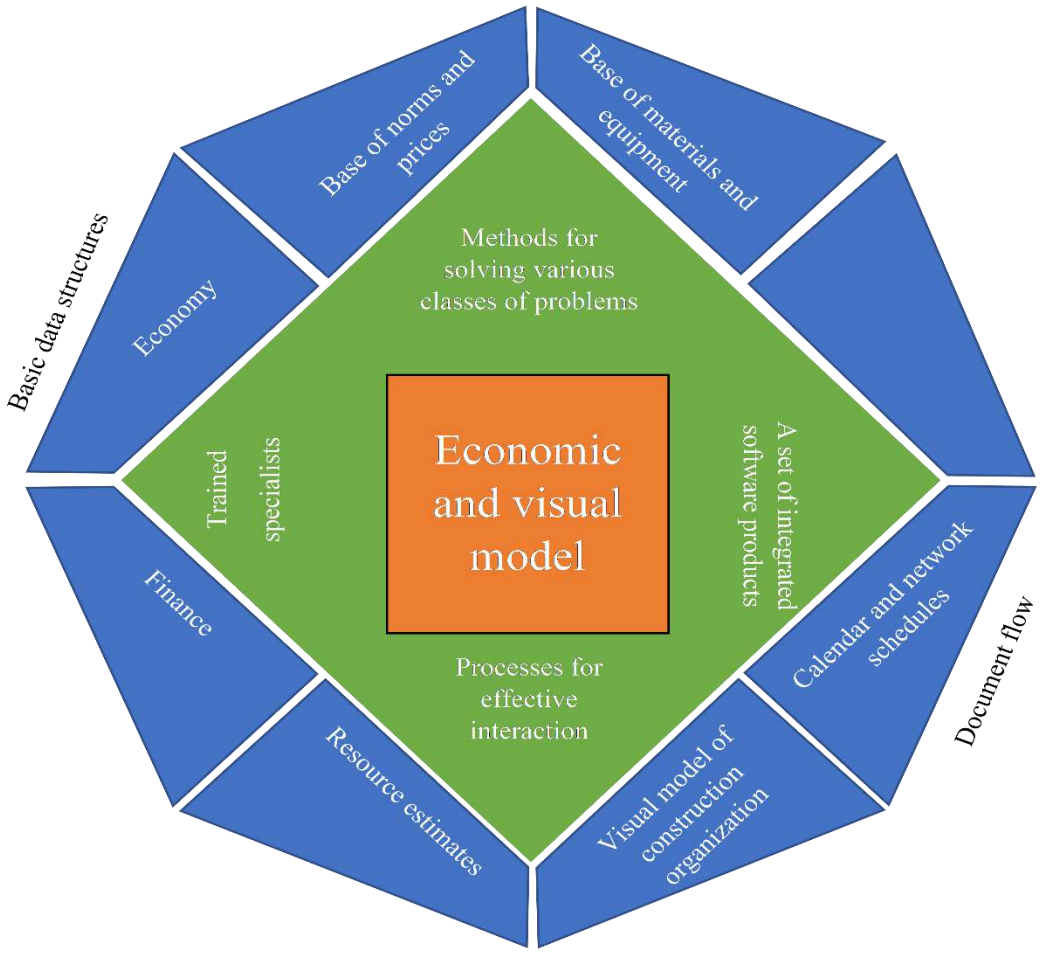

Figure 4. Schematic diagram of the economic and visual model

3. Discussion

The main task of the EVM is formed as follows (the algorithm in the diagram 1):

$$pref\ (D, C)\{E, S, Q = const\} > f(b, v, i, j, d, m, p, r, a, t, w),$$

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where:

- Basic parameters of the construction project:

✓ D - the total planned duration of the construction of the facility from the beginning of the development of working documentation to the handing over of the facility to the balance of the Developer;

✓ C - the total planned cost of the construction of the facility from the beginning of the development of working documentation to the handing over of the facility to the balance of the Developer;

- Main limitations of the construction project:

✓ E - planned operational characteristics of the facility under construction;

✓ S - safety requirements for the facility under construction;

✓ Q - quality requirements for the facility under construction;

- Variables:

✓ b - number and composition of temporary buildings and structures;

✓ v - cost of work according to current standards and statistics;

✓ i - the number and composition of interfaces between the main participants in the construction project;

✓ j - number of operations related to intrasite logistics;

✓ d - number of operations related to supply logistics;

✓ m - number of construction equipment;

✓ p - the number and composition of operations at the construction base;

✓ r - number of labor resources;

✓ a - number of spatial collisions;

✓ t - number of spatio-temporal and temporal collisions;

✓ w - cost of raising financial resources.

Handling the formalities of a construction project begins with the study of an investment feasibility study, in other words, the discovery of the usefulness and feasibility of erecting a specific building on a specific territory. In the technical part, the conditions for the planned operational features of the building being constructed (E), the quality requirements for the constructed object (Q), and the requirements for its safety (S) are substantiated. The requirements approved in the terms of reference for the construction object remain

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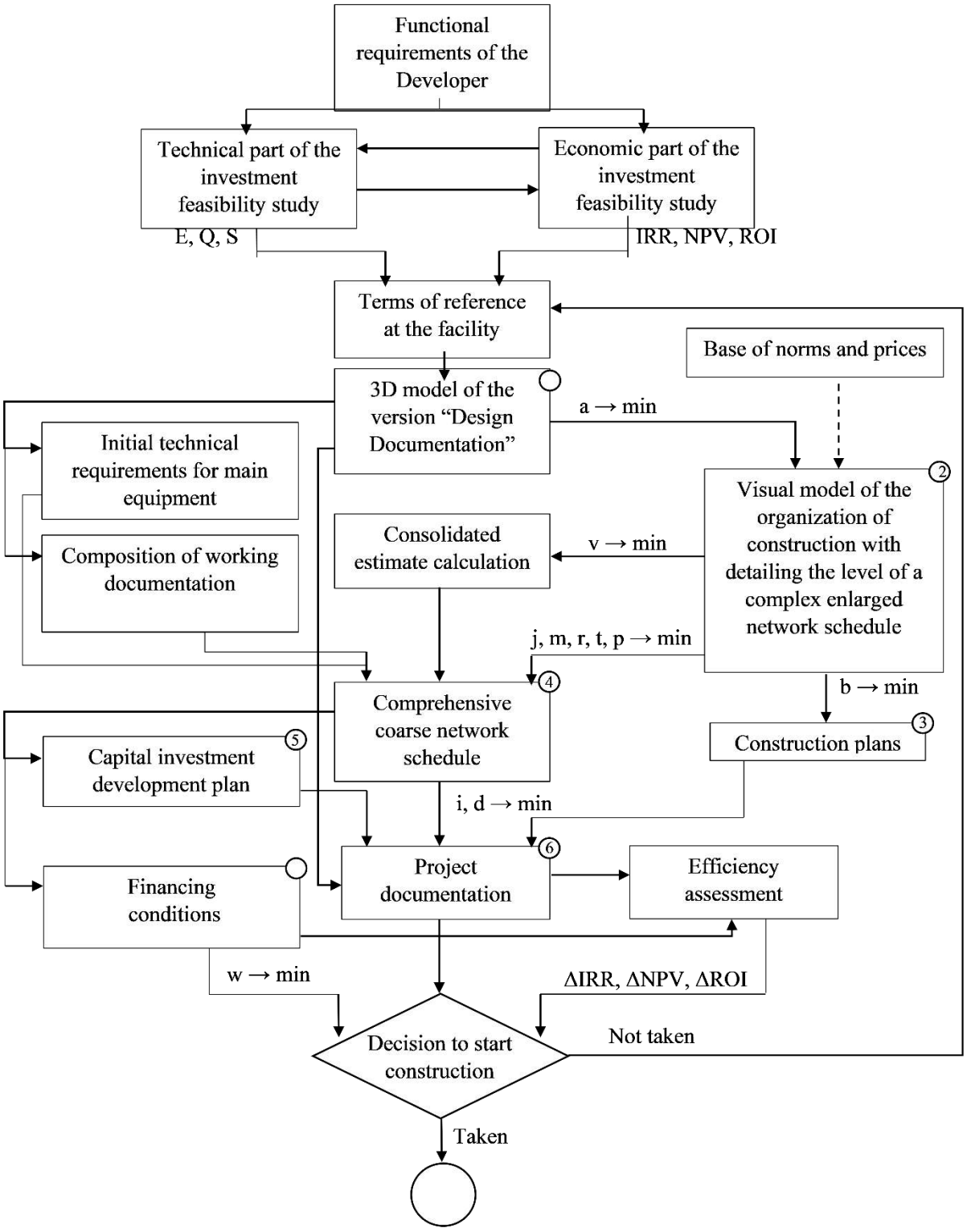
unchanged in the future during the further development of the design documentation. These requirements can only be changed by the developer, if the general contractor makes the corresponding decision. Within the economic part of the investment substantiation, IRR, NPV and ROI estimates are made (shown in ***Scheme 1***).



Scheme 1. Algorithm of EVM functioning

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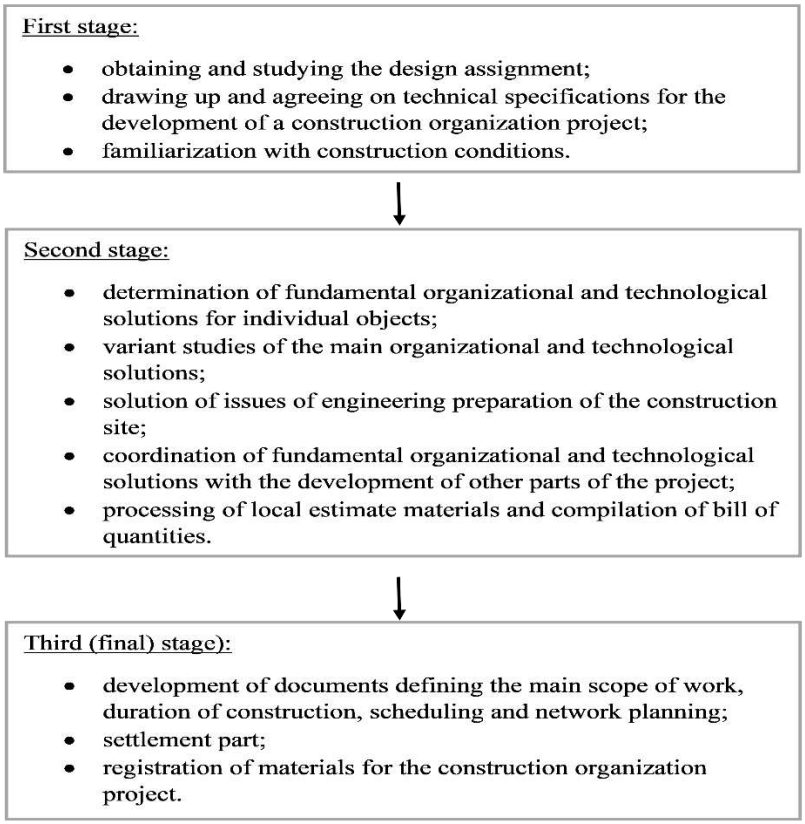
A typical process for developing a COP, taking into account the requirements provided for by SNiP 3.01.01-85 for the development of a COP and (or) WPP for industrial facilities, for the development of projects for organizing construction work for industrial facilities using the nodal method, as well as departmental building codes for the development of a COP (electric power industry) consists of the stages that are shown in ***Scheme 2***. In order to determine the efficiency of using this method in further studies, it is planned to consider an algorithm based on calculating the difference in the cost of organizational and technological solutions before and after using an EVM, which, in accordance with scientific the technical hypothesis of the authors, will provide a reduction in the cost of key performance indicators and organizational and technological solutions incorporated in the original construction organization project. The algorithm for determining the efficiency of using an EVM for the purpose of developing a COP is considered in ***Scheme 3***. A detailed study will be considered at the facilities using atomic energy, created within the framework of the federal target program "Nuclear Energy Technologies of a New Generation".



Scheme 2. Stages of development of a construction organization project

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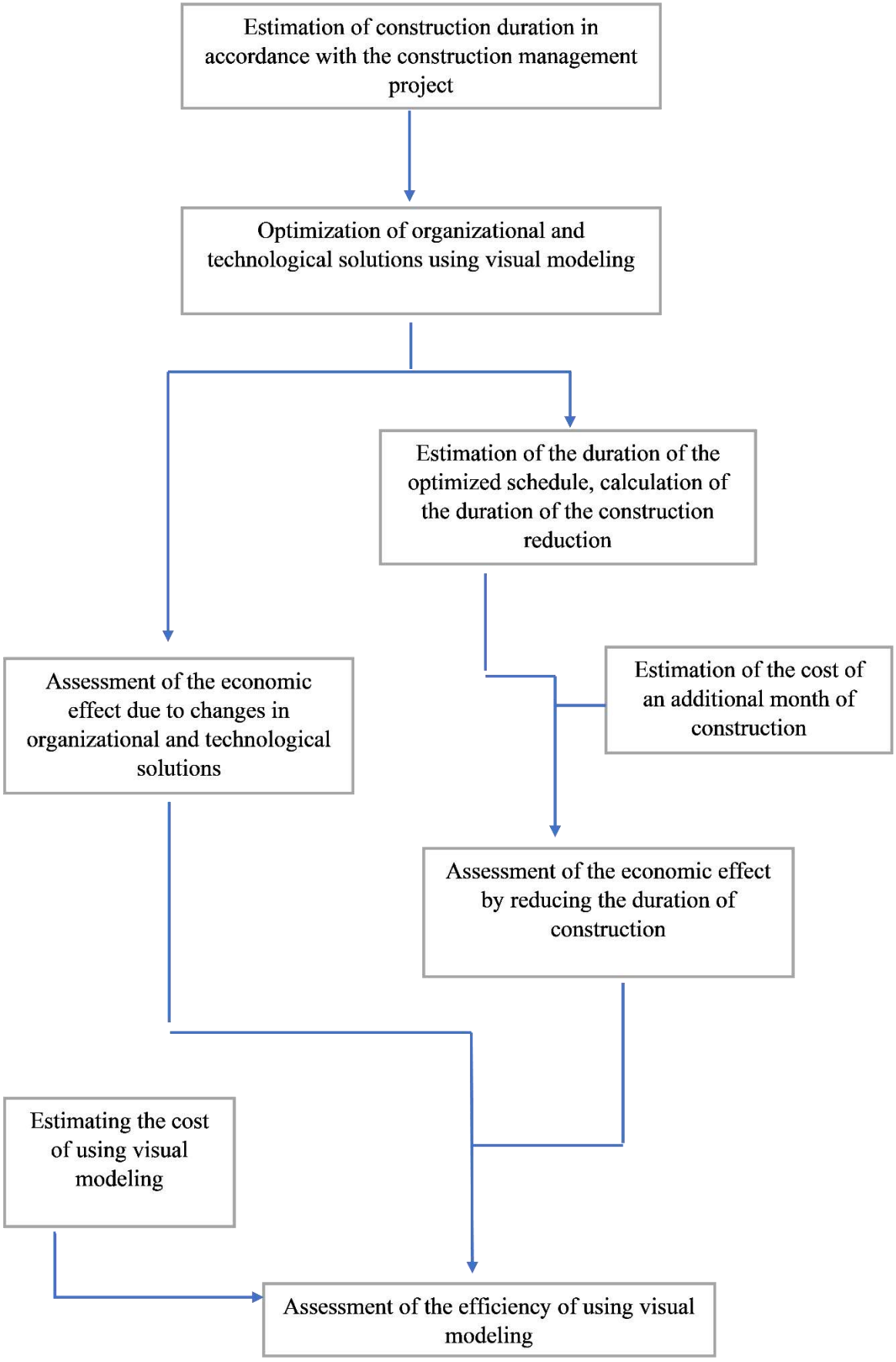

Scheme 3. Algorithm for assessing the economic efficiency of using EVM of a COP

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Security monitoring using 4D modeling opens up completely new possibilities for the analysis and assessment of safety in the framework of construction work. BIM technologies can also be used in training and education on worker safety, safety engineering, safety planning (analysis of work hazards and pre-planning of tasks), accident investigation, as well as at the stage of ensuring the safety of facilities and maintenance (Khoshnava et al, 2012; Korabelnikova et al, 2019; Lu Y.,et al, 2021; Kazaryan, 2019; Kazaryan, 2020; Kazaryan, 2021; Sijie Zhang et al, 2015; Sudakov et al, 2013; Sulankivi, 2014; Sultanova, 2015; Chulkov et al, 2020).

Conclusions

Planning of a construction master plan using BIM technologies proves to be a useful tool and versatile visualization solution for ensuring the safety of various projects. The preparation of such an information model of a construction site requires appropriate professional competencies and thinking that provide a high-quality production plan for a construction site compared to traditional approaches that do not allow careful study of all the necessary activities due to the huge amount of information on one plane sheet. Safety planning can be part of the 4D planning production process, which will provide an opportunity to shape safety planning practices, detailing elements of different levels of planning and management. The full implementation of information modeling technologies in the practice of construction production is hampered by the lack of funding sources in the structure of the consolidated estimate calculation in order to introduce and apply such innovative technologies, which is a constraining factor in the implementation of investment and construction projects that are carried out at the expense of the state budget. As a result, an appropriate funding basis should be provided in the structure of the consolidated estimate calculation as part of the work on revising the provisions on the composition of sections of project documentation and requirements for their content.

The introduction of economic and visual modeling (EVM) in the development of a project for the production of work will provide a solution to the initial requirements associated with the tasks of finding an optimal solution for the cost of a building being erected on the basis of architectural, structural, engineering, economic, financial, resource, organizational and technological characteristics (Adnan Enshassi et al, 2016; Aleksandrova

et al, 2018; B. Akinci et al, 2002; Bachurina et al, 2015; Churbanov et al, 2018; Gambatese et al, 2005; Hartmann et al, 2007; Hiravennavar et al, 2020; International Labour 1985; J.P. Zhang et al, 2011; Kazaryan, 2020; Kiviniemi et al, 2011; Kazaryan, 2020; Kazaryan, 2019; Kazaryan, 2021; Sijie Zhang et al, 2015; Sudakov et al, 2013; Sulankivi,2014; Sultanova , 2015; Chulkov et al, 2020; Vitaliy et al, 2020).

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Environmental security issues in mining areas

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ABSTRACT

In today's economy, it is necessary to explore the environmental impact of mining. Coal mining greatly affects all environmental parameters of the environment: home, production, hydrodynamics. The environmental situation in the area of the mining company can be changed if environmental contamination is monitored and environmental protection plans and measures are developed. The purpose of this work is the analysis of systems and models of these processes in the ecosystem. The main systemic hypothesis of the research is that the variety of criteria and methods of risk assessment is a necessary condition of order in the system. The main results of the work are the following: 1) a systematic analysis of the problems of environmental security, geodynamics of the mining areas, aspects of the balance of the sustainable process and the cause of the increase in danger was carried out; 2) Proposed approaches (models) for the assessment of evolutionary ecological potential and health risks, as well as adaptive situational modeling of the ecosystem. It is important to note, the study results do not suggest complex environmental monitoring studies.

KEYWORDS: Environment; Environmental degradation; Coal mining; Environmental impact assessment.

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Problemas de seguridad ambiental en áreas mineras

RESUMEN

En la economía actual, es necesario explorar el impacto ambiental de la minería. La minería del carbón afecta en gran medida todos los parámetros ambientales del medio ambiente: hogar, producción, hidrodinámica. La situación ambiental en el área de la empresa minera se puede cambiar si se monitorea la contaminación ambiental y se desarrollan planes y medidas de protección ambiental. El propósito de este trabajo es el análisis de sistemas y modelos de estos procesos en el ecosistema. La principal hipótesis sistémica de la investigación es que la variedad de criterios y métodos de evaluación del riesgo es una condición necesaria del orden en el sistema. Los principales resultados del trabajo son los siguientes: 1) se realizó un análisis sistemático de los problemas de seguridad ambiental, geodinámica de las áreas mineras, aspectos del equilibrio del proceso sostenible y la causa del aumento del peligro; 2) enfoques propuestos (modelos) para la evaluación del potencial ecológico evolutivo y los riesgos para la salud, así como el modelado situacional adaptativo del ecosistema. Es importante destacar que los resultados del estudio no sugieren estudios complejos de monitoreo ambiental.

PALABRAS CLAVE: medio ambiente; deterioro ambiental; minería de carbón; evaluación del impacto ambiental.

Inroduction

Environmental security problems (hereinafter referred to simply as "safety") in mining areas are related both to changes in the biosphere and the noosphere. Everything should be considered taking into account the biosphere and noosphere, forest losses, the disposal of large pastures and arable land. Safety is growing with the growth of plowing of land in river floodplains, indiscriminate construction of dams, forest fires, deforestation and mining, for example, the production of limestones, dolomites, etc.

Mining, coal burning seriously affects the biosphere, the whole nature. The coal industry and coal-fired thermal power plants cause the greatest environmental damage.

With the growth of construction and engineering work, negative processes of a geodynamic nature attract the attention of scientists, for example, note Brussels, Pepper and Gerba (2019:219), Sklarew (2018), Kolesnikova and Kovalchuk (2021). During rock development, dust, gases are released into the atmosphere during drilling and blasting operations, as well as during transportation, pollutants are discharged into wastewater.

Geodynamics of mining areas is formed by karst depressions, tectonic disorders and weakening of the earth's crust. In conditions of non-equilibrium physical and chemical processes, mining areas themselves become unstable, the cause of negative geoprocesses of increased danger.

Contamination of the mining area is dangerous not only for the biosphere, but also for agricultural products falling on our table. Various impurities (pollution factors) come both from natural-anthropogenic sources and from human life and production. These are dust (desertification), salt (salinization), smoke-gas (forest and steppe fires), etc.

Anthropogenic pollutants from numerous sources of emissions pose a threat to health and human life. The list of pollutants includes more than 4,000 impurities, specific, regional and regional, near the point.

The safety of the area is based on the prediction and elimination of hazardous and risk situations of various types to identify the unacceptable level of impact of environmental pollution factors (Shafiquzzaman and Alharbi, 2020; Liang and Xiao, 2020). In Russia, the share of coal production was more than 75% (Tarazanov and Gubanov, 2020) and there is a stable balance in the mining region, which is a strategic advantage of economic and environmental safety (Kulikova and Balovtsev, 2020).

In Russia, coal waste reserves are estimated at 80-120 billion tons (an annual increase of about 7 billion tons), and only 5-10% of them are processed (State report, 2019:389). In the world - the picture is similar. South, South-East and West Asia are the most polluted parts of the world, especially cities (the countries of this Asia are located in the 30 most polluted cities in the world). For example, according to (Statistical Review, 2021:47), you can construct the histogram shown in Figure 1.

The use of fuel coal in thermal power plants seriously affects the environment, with all its 278 different impacts, and this is the monthly cause (Kobylkin and Musina, 2019) of more than 7 million premature deaths in the world: from lung cancer (29%), acute respiratory infection (17%), stroke (24%), ischemia (25%), chronic lung disease (43%).

The purpose of this work is system analysis-synthesis and simulation-forecasting of key processes affecting environmental safety and pollution risks in mining. A procedure for assessing its evolutionary potential, "ecological debt", mathematical models and expert heuristic procedures are also proposed. The application of Big Data, Smart Mining, AI,

situational modeling and other intelligent technologies in decision making is emphasized, for example, remote control, production dispatching, compensation of "environmental debt" (damage).

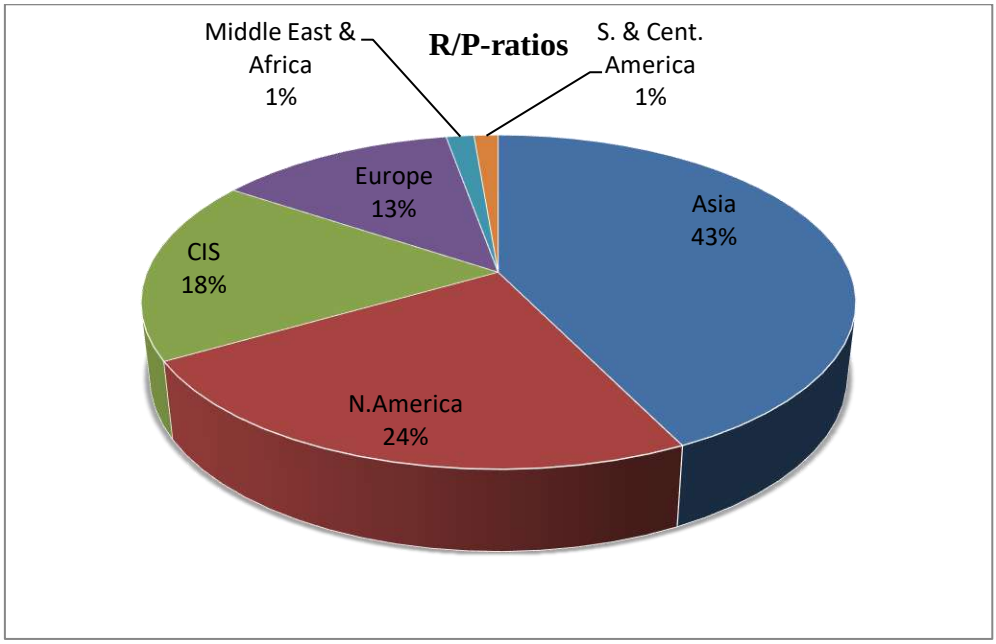

Fig.1. Distribution of proved reserved in 2020 (R/P – Reserves-to-Production)

1. Materials and methods

Structural factors affect tectonics, terrain, geological structure, and rock composition. Water stiffness increases, mineralization changes, rock vulnerability decreases, safety decreases. For example, karst features and hazards appear in the sulphate rocks of the Western Urals (Gayev and Kilin, 2018). Mountains reduce negative geodynamic processes. Scientists study processes using remote methods: topographic, hydrogeological and geophysical observations.

Hydrogeochemical methods of forecasting safety in hydrodynamic areas allow building maps of safety, tectonic movements, and increased stresses (depression) of the earth's surface. It became possible to monitor the erosion-tectonic and stress dynamics and introduce effective safety measures.

The rock array is a complex hierarchical structure, characterized by variability in stresses and properties. In order for geology and hydrogeology data arrays to become active

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and be used for technical decisions, Big Data will be required with survey data, starting with the operation of the deposit and completing the process of computer modeling of the state of stresses. Such modeling allows taking into account the processes of mountain pressure, stress, critical state of rocks. This allows you to prevent mountain strikes, follow the rules and rules of development.

We use general (system) methods and private methods (experimental dependencies, models, etc.).

2. Systems approach, trends and digital transformation in mining security

The development of mining projects is carried out through the opening of new horizons, development, the use of new technologies, research. The development of production is also a complication of mining. The natural trend is to increase the efficiency of enterprises and mines.

There is a systemic problem - there is no single technological infrastructure, environment of settlements and projects, and the one that is - morally, technologically obsolete quickly, and the consequences of risks, dangers, poor security policies are increasing.

The reasons for the risks are as follows:

1) qualitative (quantitative) development of forms and structures of subsoil use and development of subsoil;

2) development of deep, therefore complex and inaccessible deposits;

3) geodynamic (seismic) activity;

4) intensive technologies with uncertain parameters of mining and excavation of structures, stress relaxation, large volumes of rocks;

5) synergistic processes and stable equilibrium states, increasing seismic activity.

Geodynamics and mechanics of mining processes complicate these causes, deterrent factors. Their systemic analysis/synthesis aimed at improving technology and safety and reducing environmental response time is needed. Systematization, regulation, intellectualization and modeling will allow you to move to a new, systemic (high-quality) level.

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Optimizing or, at a minimum, rationalizing the use of coal deposits can help preserve natural resources from pollution and depletion, and people from social, economic, environmental and even production problems. Many companies reduce emissions to the atmosphere from the coal industry (Skopintseva, Balovtsev, 2021), use biotechnology and renewable or low-waste raw materials. Moving and deformations of the earth's surface at coal mining enterprises are being studied (Batugin, 2020).

Improving the environmental situation in the surrounding mining area is a systemic problem that is being addressed at the state level. But the analysis we have done makes it possible to note the priority problems on which the systemic solution of the problem in the regions depends, namely:

1) create joint environmental programs of enterprises, private business and public partnership;

2) ensure the freedom of investors, turn it into an advantage of free cooperation in conditions of ecological "non-freedom";

3) include the creation of a comfortable environment focused on quality of life, growth drivers and optimal parameters;

4) take into account the characteristics of export-import;

5) implement relevant forms of cooperation with stakeholders;

6) forecast prospects of trade liberalization (reduction of tariffs, duties);

7) provide logistics flows and build transit capacity;

8) develop activities and expand niches in markets, including the national market;

9) ensure safety in all its important aspects;

10) assess consumer interests and corporate risks of greening;

11) record, classify and compare geological and production data, etc.

In forecasting pollution in mining areas, the following are important:

1) organized and verifiable monitoring;

2) carefully prepared mathematical (numerical) modeling;

3) presence of representative methods, models (systems), especially, not requiring numerous and expensive, complex verification procedures.

From the point of view of the systemic approach to the problem, it should be taken into account that depressive funnels arise in the mountain range, leading to deformation

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processes, increased seismic hazard, the formation of stored waste ("tailings", dumps). All this is a step towards irreversible bifurcations of environmental processes, the onset of global environmental changes and crises.

3. Ecological potential of a sustainable mining area

Industrial mining regions, coal mining areas need technological progress. It helps to combat the decline in environmental potential and disruption of equilibrium processes in the environment. Especially, on processes that lead to pollution, the strengthening of factors that dominate such processes (Kaledina, Kobylkin, 2016).

Mining, mining and mining in regions with ore reserves should be regulated by monitoring the potential for sustainable development, regulating the so-called "environmental debt". Environmental damage is limited to the relevant objective function, the area is charged with natural restoration work or compensation for damage with fines, depending on the intensity of pollution.

The maximum damage is determined according to regional policy, law and environmental and economic standards. In the assessment of environmental debt, the primary is not even the magnitude, but the dynamic increase in damage from economic activities.

The state of stability of the area is based on the actualization of connections with the environment, with the environment. Self-organization of production structures, evolutionary potential and prediction of the evolutionary capabilities of the system are a prerequisite for a systemic approach. As well as the need for situational modeling of interactions with the environment.

Effective criteria, indices for assessing potential and sustainability are needed to Pareto-optimize relations environment. This is important for long-term forecasting, development planning (Batugin, Musina and Golovko, 2017) taking into account doses of key pollutants (Figure 2).

It is necessary to decompose the production and processing system into subsystems. This ensures structural activity and reduced complexity, increased manageability of the system. It is important to have procedures that flexibly take into account the integral connections of subsystems. For the subsystem, as part of the structure, a vector of basic

factors is specified (without which it is impossible to study the functioning of the subsystem) and the functionality of the subsystem activity.

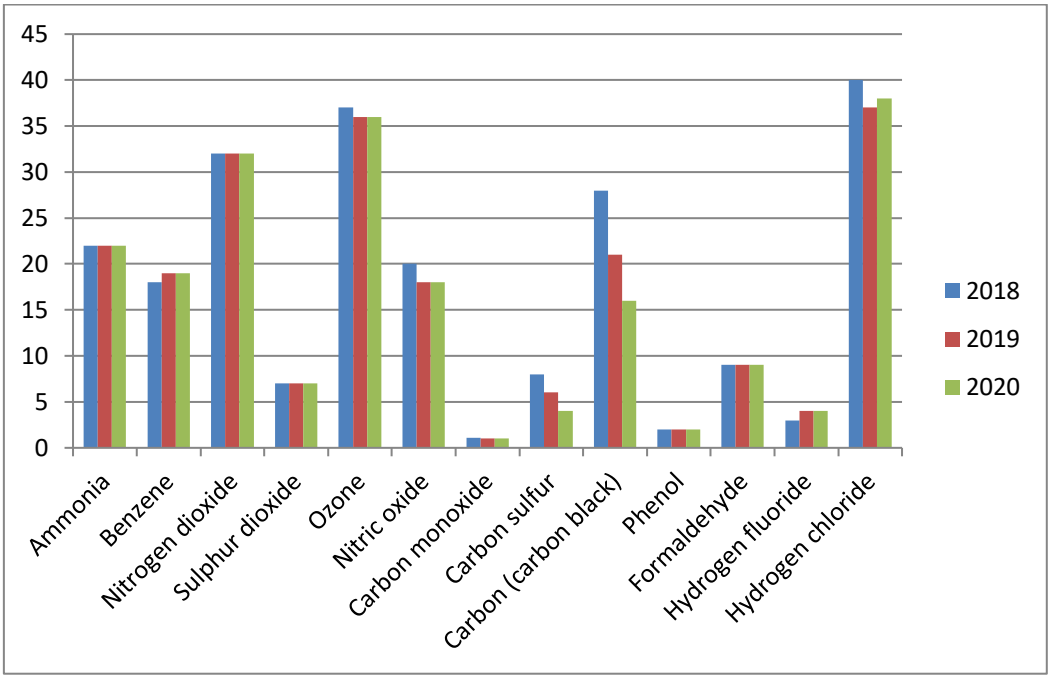

Fig. 2. Concentrations in the Russian Federation, μg/m³

For the whole system, the state vector x and the activity $s(x)$ are identified. In natural systems, speaking of management, we should talk not only about activity, but also about fatigue of the entire system. Fatigue potentials inform the potential for sustainable development.

For example, if the environment resumes system resources, at the rate of view renewal:

$$\alpha(\tau) = a(\tau) + b(\tau)x(\tau),$$

$$0 < t < T,\ 0 < x < X,\ 0 < \tau < T,$$

then the evolutionary potential of the system can be set by functionality:

$$\boldsymbol{\varphi} = \int_0^T \boldsymbol{\alpha(\tau)} e^{-\int_0^\tau k(s)ds} \boldsymbol{d\tau},$$

where $k(s)$ is the natural resource change factor.

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Above the pace - above the potential. And vice versa. No matter how high resources are at the beginning, they are depleted if the potential is less than one.

It is also important to consider that it is necessary to specify a certain set of factors and a set of permissible controls in which there is an achievable optimal (rational according to the selected criterion) value.

The efficiency, sustainability of the mining area depends on the priorities of goals (production, environmental, economic, etc.), the interests of the region, innovation and investment attractiveness.

We offer the following target factors:

1) rational use of land, water and raw materials;
2) recreational opportunities;
3) demographic parameters (fertility, mortality, age-sex structure, etc.);
4) requirements for qualifications, postgraduate education;
5) budgetary financing, increased regional funding;
6) investment opportunities, return on investment;
7) frequency and amplitude of environmental threats, emissions and pollution;
8) dynamism and expansion of production;
9) level of logistics, standardization and unification, production quality;
10) information openness, social activity, unemployment, etc.

An adequate numerical measure is comparable to most criteria. Based on these indicators and their importance (objectivity of accounting), the potential and sustainability of the mining area can be assessed integrally. This is important for the formation of evolutionary functionalities.

In the polluted ecosystem, representatives of both flora and fauna and even technospheres suffer. Everyone experiences an adaptation load in such a system. A systemic sign of restoration of the environment after contamination is, for example, the density and stability of the grass, permissible values of MPC.

These are important criteria for the self-regulation of the ecosystem.

4. Mining areas, geological structures, risks, assessments and their accounting

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The forecast of risk in geological structures, systems is a problem that is relevant in modern geological studies. It is necessary to analyze the instrumental support of systems, communications with the habitat, build appropriate models, identification algorithms and procedures.

In particular, it is necessary to:

1) adaptation techniques, research and development tools;

2) models of accounting and assessment of geological risks in the environment of development and assessment of sustainability of model solutions and forecasting of development and risks;

3) algorithms for modeling and identification, testing, and derivation of causal relationships during work.

The forecast of the business risks, the assessment of possible damage, and the formation of accurate and calculated solutions is a feasible task. Here will help many-agent models (Kaziev, Kazieva, 2019), maximum likelihood criteria (Mazalov, Nikitina, 2018) discrete-event and computer modeling.

Risk - the probability of harm to health, life, environment, next generations and new generations of structures. This is a socio-economic and environmental-economic problem (Trusov, Zaitseva, 2012).

Preventive measures are necessary to adequately counter.

The category "risk-situation" is determined by quantitative indicators of danger, a measure of damage. For example, in absolute (specific), direct (indirect) dimensions.

The infological "portrait" of the environment, the system is determined by the tasks:

1) geoinformational;
2) ecologic-systemic;
3) problem-oriented (concentration of pollutants), etc.

Individual (potential) and regional risks should be considered. Individual risks are assessed by indicators of single pollution (for example, emissions). They are found by experimental dependencies, for example, according to Onishchenko (2002):

$$R_i = 1 - exp(ln(0.84)(C/PK_z)^b t),$$

where *C* is the average daily concentration, *P* is the pollutant MPC; K_z - medium reserve of "self-cleaning" (7.5, 6.0, 4.5 and 3.0 - respectively, at 1-4 hazard classes); *b* - coefficient (2.40, 1.31, 1.00 and 0.86); *t* - exposure time, for example, equal to average life expectancy, 76 years (Deryabin and Unguryanu, 2019; Sorokin and Sedykh, et al., 2021).

Individual risk can even be affected by sound pressure during rock explosions (asthenic syndrome, vegetative dysfunctions, etc.). Such risks can be considered integrally by distribution:

$$R_z = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{P_t} e^{-t^2/2}\, dt\ ,$$

where

$$P_t = -4.555 + 0.0853\ L,$$

L is the noise level (decibel).

The population risk of the *i*-th in the order of exposure for the *j*-th factor is found, for example, by the formula:

$$R_p = R_{ij} N,,$$

where R_{ij} is the individual risk, *N* is the population of the risk area.

Damage to health in the area can be determined multiplicatively:

$$Y = \sum_{i=1}^{N} a_i \sum_{j=1}^{M} R_{ij} \sum_{k=1}^{K} N_{ijk}\ ,$$

where a_i is the cost of damage for the *i*-th single impact, *k* is the point number on the evolutionary trajectory of the ecosystem.

Especially important are the surroundings of bifurcation points (Muzica, 2011).

You can replace the multiplicative representation with an additive representation to highlight time characteristics (highlight trends by region). In the time series of safety observations (pollutants), seasonal cycles can be distinguished and extrapolated using the maximum likelihood method.

To plan preventive measures, discounted income is found in risk areas:

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$$NPV = \sum_{i=0}^{N} \frac{P_i + \Delta Y_i - C_i}{(1+r)^i},$$

where i is the serial number of the year, P_i is the income for the year, ΔY_i is the avoided damage, r is the rate of profit, C_i is the cost of sale.

Activities with NPV are less costly to consider, although they are important sometimes in social aspects. For the NPV measures selected as they rise, we calculate the IRR, find the measure with the maximum IRR, calculate the net income and form the action plan.

Adaptive manageability and tracking evolutionary functionality change is the path to effective decision-making.

The main thing is to analyze the parameters of the environment, take into account the connections, and flexible selection of the optimal control mode. Relies on adaptive planning, situation testing, and risk states (Figure 3).

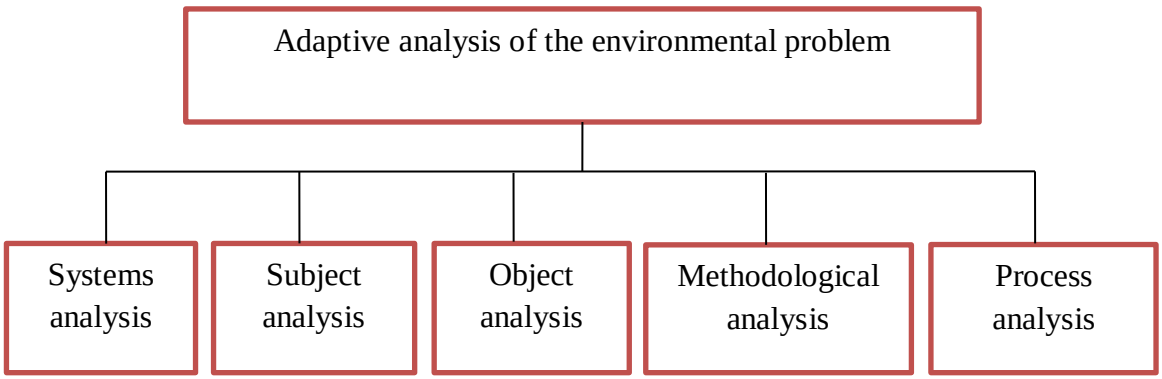

Fig. 3. Levels of adaptive ecosystem analysis

Adaptive modeling allows you to iteratively adjust the strategy (trajectory) of the geoecosystem behavior using control influences and learning the adaptive model in various situations. The study of complex ecosystems is associated with multicriteria, uncertainty in the environment, so manageability and sustainability are the most important and complex problems.

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In the development of adaptive mechanisms, the use of accurate (formalized) models and procedures is difficult. Non-classical approaches are involved, in particular, expertise, heuristics.

Expert and heuristic assessments of mining areas are important for assessments:

1) resource capacity of production;

2) negative impact and self-healing potential;

3) forecast of production volumes, etc.

Such areas are characterized by a variety of types of potential impacts, so system analysis involves expert and heuristic tools, procedures. Dynamic characteristics will need to be analyzed separately and with the effect of their integral effects (Korobov, 2008). But, in our opinion, the methodology of integral estimates is practically absent or they are complex, poorly structured.

Therefore, expert and heuristic assessments in mining areas are given great attention. Researchers, especially practitioners, seek to learn full and relevant analytics about the environment.

Data analytics are the basis of all new technologies that allow you to extract and collect useful information from ore mining data sets and mining areas that would otherwise be impossible to analyze.

The systematic analysis-synthesis will help change the environmental situation for the mining enterprise. Only monitoring of environmental pollution, the availability of relevant measures to improve production safety for the environment is important.

Conclusions

Applied system analysis is a theoretical basis for modeling (forecasting) not only industrial, but also socio-domestic processes in the ecosystem. Analysis of problems of system safety and geodynamics of mining areas, sustainable process equilibrium is applicable in practical problems, for example, automation of drilling operations, dispatching of production and situational modeling of risk situations.

The evolutionary approach to forecasting the risk situation, adaptability of production to the effects of factors of the mining area provides new practical opportunities. This is facilitated by the application of the results of the system analysis.

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In Industry 4.0, Big Data, Data Mining, and other intelligent decision-making technologies can be used effectively. This will help the proposed approaches to assessing evolutionary potential and risks, the emphasized capabilities of expert and heuristic procedures.

The main information and logical support for predicting the stability of a contaminated environment can be provided by technologies (methodologies): Big Data, Data Mining, classifications, neuro-network, visualization and virtualization, cognitive and geographic information (GIS).

In the management of pollution risks, such integrating and versatile technologies enable rapid decision-making, such as the introduction of full-fledged Smart mining processes into production. Such production, for example, is implemented by the Norilsk Nickel group of companies under the Technological Breakthrough program.

Russian environmental standards are strict, exclude the maximum risks of pollution entering the environment adjacent to the mining enterprise. Reclamation allows the involvement in the economic circulation of land with restrictions on the regimes and conditions of use (in the process of self-restoration). It is in this direction that our results are especially interesting.

As a result of the system studies of processes, it can be concluded that the development of risk situations is influenced by the inherited dynamics from large areas of concentration of mine workings. Such processes also impede the socio-economic development of the territory. It is important to use remote methods to assess situations and developments, degradation of ecosystems and their evolutionary potential. This will help to assess destructive actions, possible damage (environmental debt) and plan appropriate practical measures.

The plan focuses on safety monitoring, long-term interactions, and promising areas of environmental safety.

The variety of criteria and risk assessment methods is a necessary condition of order in the system.

Further development of our research can take various ways. In our opinion, the information-entropy approach is interesting, when the evolutionary potential (functional) is based on the entropy of the system. If the entropy of the current state of the system is large,

the pollution process is underway. If it is so large, then the given system may not become cleanable at all.

Our approach and procedures are technological, simple and flexible. They do not involve complex monitoring studies, they allow you to enter the regimes of self-organization and self-purification of vegetation cover and land subsoil.

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Legal analysis of implementation of the traffic accident monitoring system

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ABSTRACT

Purpose. The study aims to establish positive changes after the introduction of traffic accident monitoring systems implemented by government agencies in China, India, Germany, the United States, the United Kingdom, Finland, Beijing and Sweden. Methods. The research was carried out in stages, based on the logical presentation of the material. The following methods were implemented in the study: direct observation, comparison and analysis of the content and the form of advanced traffic accident monitoring systems. Results. The study of international best practices and experiments about the implementation of various options for traffic accident monitoring systems gave preference to an intelligent system. A study conducted in the United States, India and Portugal shows the effectiveness of different approaches to use mobile applications on smartphones to transmit reliable information to the traffic accident registration system. Accident data collection should be standardized and structured, and police officers should benefit from the statistical reports they complete for each traffic accident.

KEYWORDS: Education; transport policy; justice; dignity; responsibility; schoolchildren.

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Análisis legal de la implementación del sistema de monitoreo de accidentes de tránsito

RESUMEN

Propósito. El estudio tiene como objetivo establecer cambios positivos después de la introducción de sistemas de monitoreo de accidentes de tránsito implementados por agencias gubernamentales en China, India, Alemania, Estados Unidos, Reino Unido, Finlandia y Suecia. Métodos. La investigación se llevó a cabo por etapas, en base a la presentación lógica del material. En el estudio se implementaron los siguientes métodos: observación directa, comparación y análisis del contenido y la forma de los sistemas avanzados de seguimiento de accidentes de tráfico. Resultados. El estudio de las mejores prácticas y experimentos internacionales sobre la implementación de varias opciones para los sistemas de monitoreo de accidentes de tránsito dio preferencia a un sistema inteligente. Un estudio realizado en Estados Unidos, India y Portugal muestra la efectividad de diferentes enfoques para usar aplicaciones móviles en teléfonos inteligentes para transmitir información confiable al sistema de registro de accidentes de tránsito. La obtención de datos sobre accidentes debe estar estandarizada y estructurada, y los agentes de policía deben beneficiarse de los informes estadísticos que completan para cada accidente de tráfico.

PALABRAS CLAVE: educación; política de transporte; justicia; dignidad; responsabilidad; escolares.

Introduction

Every year, almost 1.3 million people in the world die as a result of road accidents, and another several million are injured or disabled. At the same time, most road accidents (90 percent) occur in low- and middle-income countries (Kitamura et al., 2018). The fact that the death rate in high-income countries decreased between 2000 and 2015, but increased in low-income countries, indicates the seriousness of transport problems in developing countries. If government action is not taken, the number of people injured in road accidents in most parts of the world will increase exponentially over the next two decades.

The fact that the death rate in high-income countries decreased between 2000 and 2015, but increased in low-income countries, indicates the seriousness of transport problems in developing countries (World Health Organization, 2009). If governments take no action, the number of people injured in road accidents in most parts of the world will increase exponentially over the next two decades (Government of Nepal, 2015).

In 2004, the World Health Organization and the World Bank identified the importance of collecting accurate and reliable data that determine the extent and problems of road accidents. In particular, the need to create data systems to collect information on the state of traffic on the roads and implement them primarily in countries with a large number of accidents was emphasized. Based on the accumulated data on the monitoring of accidents, it is proposed to implement appropriate road safety practices for.

An automated monitoring system is created to mitigate the consequences and reduce the number of accidents. Such a system can be useful for the timely provision of emergency care, which can increase the chances of immediate treatment to save the victims of a road accident.

The introduction of the road accident monitoring system is urgent at the national level as well, it corresponds to the 2024 State Strategy for Improving Road Safety (Cabinet of Ministers of Ukraine, 2020). According to the statistics of the National Police for 2019 and 2020, there were approximately 450 accidents on the roads every day (Patrol police, 2021). In this regard, by 2023 it is planned to introduce and improve the analytical system of registration and analysis of accident data based on the European Common Accident Data Sets (CADAs) (Ministry of Infrastructure of Ukraine, 2020).

The correct scientific approach to the registration of accidents and their analysis is important for the implementation of effective countermeasures for road safety. Information about the accident location is important for engineering improvements to road infrastructure. Accident monitoring reports can provide the information not only about the total number of accidents, but what accidents, where and when they occur, objective circumstances about the condition and cause of people's behaviour in a particular place and on all roads, their injuries and deaths. Besides, road accident data can help develop generalized road safety theories (Abdulhafedh, 2017).

Data collection at the accident scene is crucial (Wach, 2013), because the subsequent stages of the accident rely on these data: investigation (reproduction of the circumstances of the event), insurance, compensation for material damage and other legal aspects (Padua et al., 2020). In the event of an accident, the driver is obliged to stop (Cabinet of Ministers of Ukraine, 2001) and provide his/her data (or information identifying the vehicle) to another driver who is involved in an accident to compensate for material damage (Legal Services

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Commission, 2021). However, irresponsible drivers do not always do as required by law and leave the scene arbitrarily.

Therefore, further research on the implementation of road accident monitoring systems is necessary and relevant to take into account and reduce the factors and consequences arising from road accidents.

The aim of this study is to conduct a legal analysis of international experience and the results of the introduction of road accident registration and monitoring systems in China, India, Germany, USA, UK, Finland, Beijing, and Sweden.

The aim of the study involves a number of objectives that will help to understand the features and difficulties that exist in the implementation of road accident registration systems, in particular: study the international practice and best practices on technical and legal significance of road accident monitoring system; identify problems that arise during the interpretation and use of data accumulated in the database of the accident monitoring system; try to develop a functional diagram of a modern accident monitoring system; outline the advantages and disadvantages of different types of accident monitoring systems.

1. Literature review

At the national level, the Centre for Road Safety and Automated Systems at the Ministry of Internal Affairs (2008) analyses the causes and state of road accidents in the country based on statistics or accident databases, monitors and proposes measures to control the road traffic situation, prevent accidents and mitigate the severity of their consequences. The results of studying such statistics of Ukraine allow identifying the shortcomings that exist in road traffic conditions. By studying the causes of road accidents, it is possible to identify dangerous areas of their location and reasonably develop a strategy to eliminate such shortcomings (Oznyuk, et al., 2019).

In 2018, India ranked 1st in the number of fatalities in road accidents among 199 countries, which is 11 deaths per million people, that is less than in Iran (20), the Russian Federation (14) and the United States (12) (Ministry of Road Transport and Highways of India, 2018). A study conducted in India showed that the country's rating is the worst in the world, each year about 150 thousand people die as a result of road accidents, and 80% of victims of accidents in India do not receive timely emergency care. In this regard, it is

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proposed to introduce a smart accident registration system. However, the peculiarity of this system is that it consists of a database and a module that is installed on the car. Such a module includes GPS, GSM transmitters and an impact sensor that can be activated during an impact, vibration or the airbag deployment. Bluetooth technology is used to activate the module. In the event of an accident, the information contained in this module (full name of the driver, blood type, telephone number, e-mail, medical history, date of birth) is automatically sent to the appropriate telephone number and downloaded to the database of the main monitoring system (Sharma et al., 2020). In this case, the experimental work and suggestions of experts were taken into account in this system in terms of troubleshooting. It has been found that the proposed system will work well in a variety of situations. The detection hardware can detect an accident and a collision and accurately send a message to the rescue service with the help of three sensors and a software application (Parmar et al., 2019). With the development of wireless technologies in their mobile applications, motor transport is being transformed into smart vehicles that can be accessed through intelligent traffic applications (Rath, 2018). Another group of Indian researchers proposed an algorithm for registering accidents only for cases in which there are any victims (Sharma & Shoney, 2019).

Research conducted in Beijing is worth mentioning. The spatial analysis of road accident data based on the WaveCluster system showed that the entire road accident area in Beijing is divided into 5 categories: hotspot space (high traffic area), space with different quality of drivers or intersection of urban and rural roads, and information system about vehicles. It has been found that accidents usually change in stages as they are dealt with. However, the adoption of laws and establishment of mechanisms for accidents can improve the ability to anticipate new cases (Zhang & Shi, 2019).

Modelling the number of road accident data is of particular importance for road safety analysis, and over the past few decades a significant number of tools have been proposed for the analysis of road accident data (Abdulhafedh, 2016), but the choice of the necessary monitoring system depends on the specifics and financial capabilities of the country.

The CADaS system is considered as a recommendation for the collection of road accident data for the police of the EU countries in a common database. The list of variables for CADaS should be comprehensive and concise, and the level of their detail is chosen by

each EU country. The list of CADaS variables is divided into four main categories: A — for accident-related variables, R — for the road-related variables, U — for variables related to the traffic unit, P — for variables related to a person (for example, A-2 Date of the accident) (Petros Evgenikos National Technical University of Athens, 2009).

2. Methods

The research involved the following methods: direct observation helped established the opinion of modern scientists and researchers on the implementation of accident monitoring systems; the method of comparison was used to identify the difficulties faced by public authorities of different countries during the implementation of the accident monitoring system; the main international trends and advanced technical experience on this issue were identified using the content analysis.

So, the main sources of input data generation are established, which are transmitted to the accident monitoring system, and the main parameters of accident data in all types of road accidents are outlined through the direct observation.

The method of comparison helped reveal common trends among developing countries (Ukraine, India, China) and developed countries (USA, Germany, UK) in the use of devices and software to transmit statistics and receive them from the accident monitoring system.

The experience of the implementation of the accident monitoring systems in Europe and the world was studied: RADMS (in India), WaveCluster (in Beijing), CADaS (for European countries), TARS (in the UK), NASS (in the US), STRADA in Finland and Sweden), CrashMape (in Germany), CVIS (in China).

A total of 50 sources and references were used: statistical reports on the state of road accidents.

3. Results

Since 1979, the United States has implemented a National Automotive Sampling System (NASS) for collecting data about road accidents which occurred during the year. NASS provides an effective and useful resource to collect data necessary for society. Over the past 10 years, the basic set of NASS components on road accidents has created a reliable resource for a number of departments and agencies. Personal information about individuals, names, addresses, driver's licenses, vehicle registration certificate and even specific places of the

accident are not contained in publicly available NASS files. The NASS consists of two parts: the Crashworthiness Data System (CDS) and the General Estimates System (GES). Both systems collect information from police accident reports in randomly selected regions of the country (National Highway Traffic Safety Administration, 2020). One of the disadvantages of NASS-GES data is that they use an aggregate data element that provides overall national estimates that may differ from true values at the state level because they are based on the probable choice of accident in the country and cannot provide accurate estimates at the state level, which reduces the reliability of the data. Another disadvantage is that NASS-GES data is obtained either directly from the police accident report (PAR), or by interpreting the information presented in the PAR, by viewing the accident diagram or a combination of data elements in the PAR (National Highway Traffic Safety Administration, 2021).

An empirical study conducted in the United States shows the effectiveness of different approaches to the use of mobile applications on smartphones to transmit reliable information to the accident registration system. So, built-in accident reporting systems are not available in all vehicles, and they are expensive to upgrade for older vehicles. Alternatively, smartphones can automatically detect accidents using accelerometers and acoustic data, immediately notify the central emergency server after an accident, and provide situational awareness through photos, GPS coordinates, VOIP communication channels, etc. (White et al., 2011). The results of the experiments show that the microphones in smartphones are not able to distinguish sounds such as screaming from the airbag deployment (White et al., 2011). Therefore, the use of various sensors can help in more accurate detection of accidents (Bhatti et al., 2019).

In the UK, the TARS system is used to assist in the management, review, analysis and display of accident information. Anyone can request TARS for information about the accident and, using the TARS2 software, see the accident sites on the map, as well as a detailed report on accidents. The information obtained from TARS is useful for policy development, monitoring and evaluation of road safety efforts in the country (CDR Group, 2020).

The Indian state of Himachal Pradesh has launched its first Road Accident Data Management System (RADMS) for data management, analysis and evaluation. This system was developed by a research laboratory in the UK. RADMS optimizes and centralizes

accident data management, making it easier to detect and take action to reduce the number and severity of accidents (ITS International, 2021). In Greece, a web geographic information system (webGIS) has been introduced since 2004 to register, store, visualize and analyse road accidents (Vaitis et al., 2019).

The German Statistics Office has also solved the problem of accident registration using a web application, which is public and shows only accidents in which people were injured and the police arrived on call. Assessment of the condition of the motor road for the absence of accidents is calculated by the number of accidents on one section of the road. It is planned that the map will have information on accident statistics from all 16 federal states of Germany, not from 9 as it is currently the case, as not all states register geographical data on accidents (European Transport Safety Council, 2018). In the Czech Republic, there is a website created in collaboration with the Transport Research Centre and the police. The CrashMape map shows accidents from 2007 to date and is updated monthly. Compared to England and Germany, it has the widest filtering of accidents by identification number or criteria. Criteria that have not been indicated in previous versions are: blood alcohol content, substance use, visibility during the accident, the cause of the accident, information about the road (highway) and many others (Kmet & Kvet, 2021).

A group of German researchers also proposed a different and inexpensive accident monitoring system. This system uses a multi-level IoT-based automotive environment through V2X and Edge/Cloud Computing. A video camera is built into the vehicle for reliable detection of accidents together with the GPS module. As soon as an accident occurs, the vehicle sends a notification to the receiving device. The receiving device, in turn, finds the nearest hospital and immediately makes a request to send an ambulance to the scene of the accident. A dynamic interface visualization, which is hosted on the server, is also proposed in order to assist the relevant authorities in conducting a full analysis of the road accident. The generated charts help the police officers to make the corresponding legal decisions on their basis. Besides, when an accident occurs and the accident monitoring system registers it, it can ensure that relevant data is passed to rescuers and doctors, which can improve the likelihood of survivors. Accumulated accident data is sent to a central database for long-term storage. These data can later be obtained for analysis. Data stored in the cloud can allow

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relevant authorities to develop policies and take effective measures to reduce the number of injuries and deaths caused by road accidents (Abdul Khali et al., 2019).

A smartphone that contains inertial sensors can be used as an additional data source to better understand the events of the accident. These are the results of a study using sensors in smartphones to detect the acceleration of the torso associated with the risk of falling in the elderly who have suffered a stroke (Isho et al., 2015).

The comparative analysis of accident statistics in the system of Finland and Sweden (STRADA, Swedish Traffic Accident Data Acquisition) for 2009-2013 is also noteworthy. A study of the causes of fatal accidents has shown that the use of detailed data provides more opportunities for analysis than computer programmes on accidents across Europe (Peltola & Luoma, 2017).

That is, the main parameters of all types of accidents can be reduced to the following categories (Table 1).

Table 1. The main parameters of all types of accidents (author's development).

General information	Date, week, hour, working day or day off, etc.
Accident location	Street number, intersection number, geographical (GPS) coordinate, number of kilometres from the settlement, name of the district, etc.
Participants in the accident	Age, sex, type of road user, signs of alcohol consumption, use of seat belts, placement of passengers inside the car, category of driver's license, date of issue, driver's medical data, etc.
Details of injuries	Volume, number of injured, data on injured, ambulances and evacuations, etc.
Traffic conditions at the time of the accident	Road type, road category, weather conditions, lighting conditions, type and condition of the road surface, availability of means of control and video recording of traffic, etc.
Vehicle	Vehicle type, age of the vehicle, etc.
Information about the mechanism of the accident	Accident type, type of manoeuvre, causes, etc.

Video surveillance systems that receive data through video mining can provide additional information about the causes of accidents. In this way, it is possible to better understand which sections and infrastructure of the road are dangerous or those that cause accidents (Battiato et al., 2018). At the same time, it is proved that the use of unmanned aerial vehicles (hereinafter — UAVs) as a video surveillance camera for traffic condition provides accuracy of 80%, and the use of stationary video cameras for traffic control has 50-75% accuracy. Besides, UAVs combine the capabilities of both stationary and mobile traffic detectors (Shan et al., 2021). With good visibility from above (without clouds, high-voltage cables and good lighting), UAVs provide the ability to collect more data, with greater accuracy and speed in relation to traditional approaches to recording/registering accidents. Therefore, in real conditions, a group of Portuguese researchers proposed to use a full set of tools to obtain data on the accident. In particular, they include: UAVs, terrestrial video cameras, tacheometers, artificial lighting units and photogrammetry, measuring tape, receivers of the Global Navigation Satellite System (GNSS).

However, CVIS methods were the most effective in collecting data on road accidents. The CVIS system is not cheap, it consists of a set of intelligent devices of road infrastructure, which showed the shortest time of detection of a car accident, namely, 0.0461 seconds with a probability of 90.02%. The accident detection model is based on the use of a deep neural network (YOLO-CA) based on a set of auto image data (CAD-CVIS) and self-learning algorithms (Tian et al., 2021). Given the high cost of intelligent road devices, it is proposed to use them on the most dangerous intersections of smart streets of the city (Iqbal and Khan, 2018). Taking into account the above, the author proposes to use the following functional diagram of a smart accident monitoring system for analysis (Figure 1).

At the same time, the collection of data on road accidents should be standardized and structured in practice. For completeness and objectivity, the procedure for obtaining data on an accident should be synchronized with the process of its investigation, reconstruction and simulation of the circumstances of the events. It is advisable to fully computerize and automate the data accumulation procedure in the monitoring system. It is also proposed to conduct a survey of victims about their health in 1 month. In turn, police officers who receive primary accident data should benefit from reporting work (European Commission, 2019).

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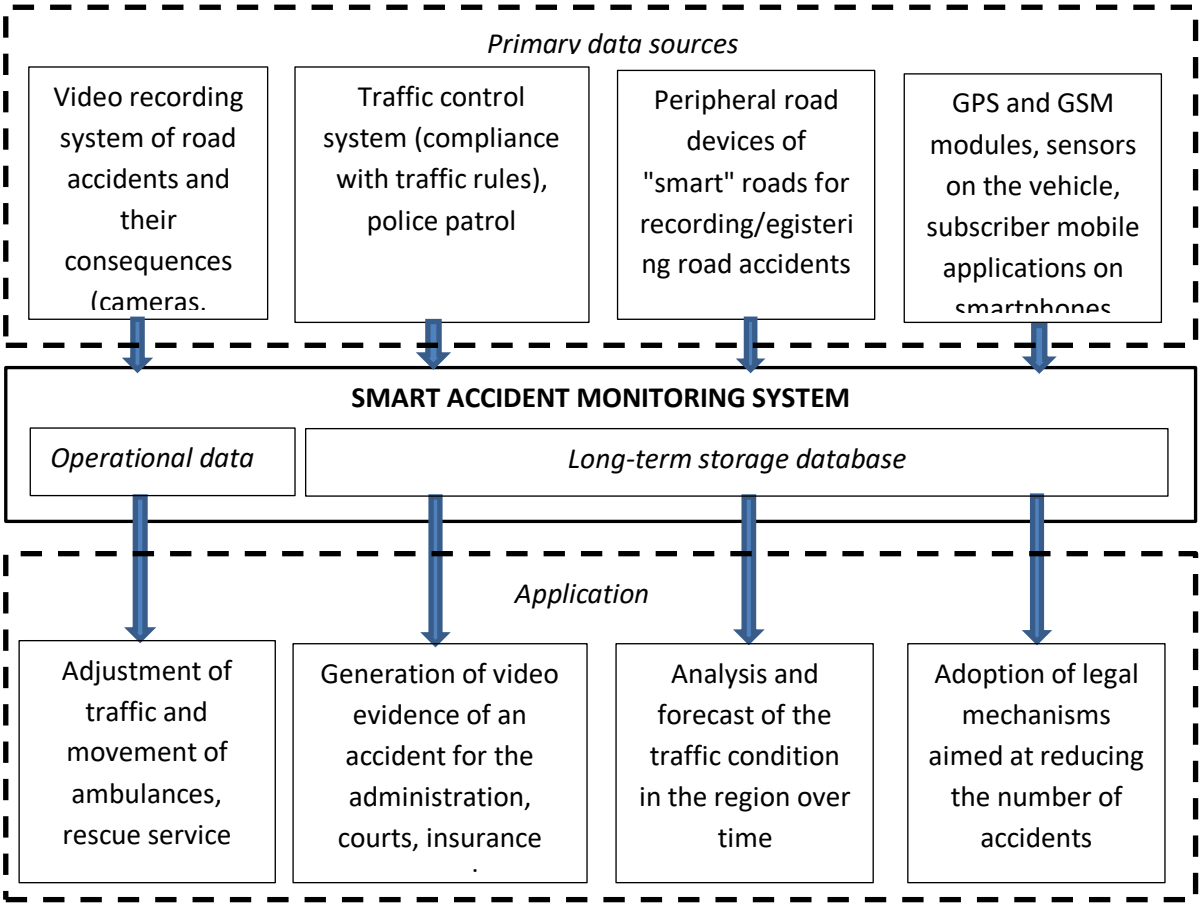

Figure 1. Functional diagram of a smart accident monitoring system (author's development).

Road safety analysis, based only on registered accidents, often suffers from underestimation of data, which can lead to biased conclusions and an ineffective accident prevention strategy. An additional method of obtaining information about the accident is to send accident reports yourself. The combination of the two methods can provide a more accurate idea of how safe a driving should be (Kamaluddin et al., 2018). Common problems in the use of consolidated statistics obtained from the database of accident monitoring systems are given in Table 2.

4. Discussion

An overview of the current situation and practice in Abu Dhabi, as well as in the Kingdom of Bahrain, UAE, UK, Sweden, Australia, New Zealand, USA contains other information that is worth noting. With the exception of the Persian Gulf, most countries require only the presence of the police when injuries or serious material damage are caused

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at the scene of an accident, whereas all accidents in the Persian Gulf must be reported to the police.

Table 2. The main problems in the use of consolidated statistics obtained from the accident monitoring system (author's development).

Excessive or insufficient variance	When the data is excessively scattered (excessive variance), the estimation of the accident model may lead to a bias in the estimation of the parameters. As a result, there will be incorrect conclusions about the factors that determine the frequency of accidents. When there is a lack of data (insufficient variance), the accident forecast will be incorrect.
Small sample size	Given the fact that the process of collecting data and collecting a sample of accidents can be financially costly, the calculation and forecast of accidents is often not comprehensive and incomplete.
Changing the time interval	The period for collecting data on accidents is usually one, three and five years. Instability of the time interval can lead to incorrect estimation of parameters and forecast of road accidents. The accuracy of the forecast directly depends on the duration of the time interval: the longer the time interval of the obtained sample, the more accurate the forecast.
Temporal and spatial dependences	Roadway objects may be mistakenly taken into account several times in a few years or not taken into account at all because they were near the scene of the accident.
Skipping variables in the forecast	Modelling of accident forecasts according to the methodology with insufficient number of variables can lead to simplification of models and incorrect conclusions.
Not complete reporting	Because of minor accidents, police reporting is incomplete.

One of the priority areas for reducing the number and severity of accidents is to improve road infrastructure. To this end, it is necessary to improve the organization of road traffic and develop measures to improve road safety. Statistics on accidents should be used to eliminate the shortcomings of traffic condition. Therefore, the introduction of a modern and intelligent system of accounting and monitoring of accidents remains more relevant than ever.

The smart monitoring technology includes the processing of streaming data (photos, videos, telemetry data, user information), data mining, machine learning, processing and forecasting, and the implementation of existing traffic models in practice. At the same time,

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a comparison of time characteristics showed that changes in traffic conditions and the concentration of accidents in controlled areas are highly dependent on weather conditions (Finogeev et al., 2018).

Given the constant growth of the number of road vehicles owned by citizens, the existing system is difficult to ensure road safety for all its participants. Therefore, a long-term strategy to improve road safety must be implemented (Gurzhiy, 2012). One of the directions of such a strategy should be traffic optimization. The proposition of alternative routes to avoid accidents significantly increases the overall efficiency of traffic. However, the main problem is how to do it in the shortest time and with the least financial cost (Souza et al., 2017).

Monitoring of traffic violations significantly affects the drivers' behaviour in the control area. Monitoring traffic violations can effectively reduce the likelihood of accidents. Therefore, monitoring of traffic violations has a positive effect on road safety (Zhu et al., 2012). In order to maintain order on the roads and reduce the number of accidents on high-risk roads (for example, on school and main road sections), it is advisable to install traffic violation monitoring systems (Pan et al., 2020).

Besides, the ability to use artificial intelligence to analyse and provide information about the situation in the event of a road accident significantly increases the efficiency of road accident response operations. The analysis and reporting module should be further improved to adjust the information and images obtained from other possible sources about the accident site and to create one final agreed report (El Barachia et al., 2020). When analysing statistical data from the database of accident monitoring systems, it is necessary to take into account the problems in their use.

Conclusion

The introduction of accident monitoring systems is an urgent need for middle- and low-income countries. The best option is a smart monitoring system with a focus on smart city, smart street and so on. Such a system can increase the chances of the necessary treatment of persons injured in an accident, to adjust traffic. Besides, data from the long-term storage database can be used to generate video evidence of an accident for the administration, courts, insurance companies, analysis and forecast of accidents on a particular section of road and the adoption of legal mechanisms to reduce the number of accidents.

There is no doubt that a promising area for the development of monitoring systems are systems based on artificial intelligence with the possibility of machine learning.

Experiments conducted in India, Germany, USA, Sweden, Finland, Portugal and China have shown high efficiency from the use of databases of long-term and operational storage of accident data based on data obtained from various sources: GPS and GSM modules, sensors on the vehicle, mobile subscriber applications on smartphones, UAVs, radars, photo and video recording systems. The most effective accident data collection system was CVIS (proposed in China), which consists of a set of smart road infrastructure devices.

Based on the results of evaluation and analysis of statistical data, it is logically correct to implement an adequate policy and strategy to reduce the number of accidents and mitigate their consequences.

Although the CADaS system is part of the 2024 State Strategy for Improving Road Safety, CADaS is seen only as a recommendation to collect accident data for the police of the European Union into a common database. Therefore, taking into account international best practices on this issue will not be superfluous. However, the question of time and financial costs for the implementation of a smart accident monitoring system arises in such a case.

It will be useful to further study the features of the introduction of a smart monitoring system for road accidents into the legislation of Ukraine.

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Formation of a rational technology for service cargo points at railway connecting lines of industrial enterprises

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ABSTRACT

The aim of the article is to define of rational technology for service cargo points at railway connecting lines of industrial enterprises taking into account possible penalties. To solve this problem, the authors used methods of analysis of statistical data of dynamically changing parameters, methods of simulation modeling, mathematical statistics, probability theory and methods of combinatorial analysis. In the work is formalized the rational technology for service at railway connecting lines of industrial enterprises in the form of a mathematical model. The objective function of the model uses the criterion of total operating expenses and takes into account the probabilistic nature of the waiting time for dispatching of wagons to the cargo point. The mathematical model is designed to determine the rational number of wagons in the dispatching to the cargo point at railway connecting lines of industrial enterprises. The proposed technology takes into account penalties for violation of the delivery time.

KEY WORDS: railway transport; appropriate technology; railway connecting lines of industrial enterprises; operational expenses.

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La formación de la tecnología racional del servicio de los puntos de carga para las vías férreas de las empresas industriales

RESUMEN

El propósito del artículo es determinar la tecnología racional de servicio de los puntos de carga de las vías férreas de las empresas industriales, teniendo en cuenta las posibles sanciones. Para resolver este problema, los autores utilizaron métodos de análisis de datos estadísticos de parámetros que cambian dinámicamente, métodos de simulación, estadística matemática, teoría de la probabilidad y métodos de análisis combinatorio. En el trabajo se formaliza la tecnología racional del servicio de los puntos de carga de las vías férreas de las empresas industriales en forma de modelo matemático. La función objetivo del modelo utiliza el criterio de los costos operativos totales y tiene en cuenta la naturaleza probabilística del tiempo de espera de los vagones para alimentar a los puntos de carga. El modelo matemático está diseñado para determinar el número racional de automóviles en el suministro al punto de carga de las vías férreas de las empresas industriales. La tecnología propuesta tiene en cuenta las sanciones por incumplimiento del plazo de entrega.

PALABRAS CLAVE: transporte ferroviario; tecnología adecuada; vías férreas de empresas industriales; costos operativos.

Introduction

Railway connecting lines of industrial enterprises are an important element in the logistics network of material flows. They provide direct interaction in the transfer of goods between the main railway transport and cargo owners. Ukraine's transport system includes more than 7,000 railway connecting lines of industrial enterprises with a total length of more than 27,000 km (Shumik et al., 2016). The maintenance of railway connecting lines of industrial enterprises consists in the dispatching of wagons for freight operations and the picking of loaded or empty wagons from cargo points.

Analysis of the work at the railways of Ukraine shows that more than 90% of all freight work is performed on the enterprise's railway connecting lines (Miletska, 2010). Circumstances that arise between the adjacent station and the railway connecting lines of industrial enterprises when processing wagons can lead to breaches of contractual obligations and significant penalties. Today's level of transport service of production units does not fully meet the requirements of all participants in the transport and production chain of cargo transportation (Baulina et al., 2021). Even in the presence of a reserve of railway

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rolling stock, industrial enterprises and railways incur production losses due to late transport services and penalties for non-compliance with the terms of the contract. Therefore, the task of improving the technology of interaction between stations and railway connecting lines of industrial enterprises, which combine organizational issues with the problems of rational technical equipment and the number of technical means, is urgent. This approach reduces the length of stay of wagons on the railway connecting lines of industrial enterprises and stations. And, as a consequence, the reduction of downtime and turnover of the freight wagon while reducing operating expenses.

In this regard, the aim of this study is devoted to define of rational technology for service cargo points at railway connecting lines of industrial enterprises taking into account possible penalties.

1. Literature review

One of the important conditions for the successful development of freight traffic on the railways is the constant improvement of technology for managing traffic flows while reducing the operating expenses of the railway and meeting the needs of cargo owners. This will speed up the delivery of goods and eliminate obstacles to infrastructure capacity (Butko et al., 2019).

Today, the existing system an organization for service at railway connecting lines of enterprises demonstrates its inefficiency. The existing procedure for the distribution of empty wagons at enterprises leads to an imbalance in the existing fleet of wagons with the need for transportation of goods or export of finished products and their irrational use (Baulina and Zakharova, 2017). In modern conditions, there is improper use of railway wagons on the enterprise's railway connecting lines, especially at coal and metallurgical companies. At these enterprises sometimes the residence time of wagons exceeds the norm by several times. As a rule, the most time is spent waiting to be picked up from the adjacent station. Sometimes wagons are used as warehouses on wheels or for internal movement goods in the absence of its own rolling stock (Zapara and Garbuzov, 2015). The technological aspect of the problem interaction between stations and enterprise's railway connecting lines requires the need to perform operations of processing cars on a single technology. This

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requires consistency of technological processes performed at railway stations, enterprise's railway lines and ports (Baulina and Bohomazova, 2020).

Baulina H. proposed in her study a model that will determine the number of dispatching of wagons on the freight front. This will reduce unproductive wagons idle time at the station and increase the processing capacity of the freight front. The developed model can be considered rather universal in the structure and to use it at receipt of wagons on a goods shed of station for performance of freight operations (Baulina, 2013). To substantiate the choice of effective modes of interaction between railway stations and non-public railway lines, the functional dependences have been improved to determine the optimal values of the intervals between the dispatching of wagons to the loading and unloading fronts. Formulas for determining the duration of shunting operations with wagons that depend on certain parameters are also obtained (Yelovoy and Potylkin, 2016).

To solve the problem of optimal distribution of empty wagons in railway transport hubs, it is proposed to use a model that takes into account the requirements of wagon owners for their use. The model also takes into account the operational level to loading of railway stations in the node and the possibility to including groups of empty wagons in the composition of transfer, removal trains and trains that run on the contact schedule (Rakhmangulov et al., 2014). Fukasawa R. proposed a method for determining the optimal flow of loaded and empty wagons in order to maximize profits, income from the tonnage transported, taking into account the train schedule together with traction capabilities (Fukasawa et al., 2002). A space-time model of network flows can be used to plan rail transportation from suppliers to customers (Lawley et al., 2008). The model uses a variety information, including consumer demand, railway network characteristics, loading and unloading times, and the capacity of stationary devices to handle incoming wagon traffic. The proposed model is based on the maximum level of loading of goods shed while minimizing the waiting time for loading and unloading of the main freight.

The model, optimizing the purpose of heterogeneous empty freight wagons, presented by Narisetty A., allowed to optimize transport expenses. And also strictly adhere to the delivery deadline, which allows to achieve a significant reduction in transportation expenses (Narisetty et al., 2008). Sayarshad H. and Marler T. presented the development of an analytical solution for the size of the fleet of wagons. Their analysis tool includes

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opportunities to optimize the use of rolling stock, assess the profitability of efficient promotion of goods and check the quality for services provided to customers (Sayarshad and Marler, 2010).

Improving the technology of interaction between the station and the adjacent enterprise's railway connecting lines is possible with a differentiated approach to the sender and recipient. When establishing the order of customer service, it is proposed to take into account the number of wagons of different types arriving or departing, the volume of loading and unloading on the enterprise's railway connecting lines, the uneven arrival of local wagons at the station and other factors (Shumik et al., 2016).

Freight wagons spend a significant part of their time under freight operating stations and loading points of access roads. These are the most time-consuming, complex and expensive jobs, the efficiency of which is significantly affected by the technology of work. To reduce the costs incurred during cargo operations, it is necessary to determine the most rational technologies of work with the optimal distribution of loading and unloading resources, the use of which will determine the most rational technology of work by reducing operating costs. But the paper does not consider the number of feedings on cargo fronts (Prodashchuk et al., 2017).

The analysis of scientific works showed that a significant part of them is aimed at solving the issue of regulating the movement of wagons at stations, taking into account the minimization of downtime and increase capacity. For cargo stations, the methods of operational dispatching influence on the congestion of station facilities were proposed, and on the railway connecting lines of industrial enterprises the technologies of interaction with the adjacent service stations were proposed. The interaction of cargo stations and railway connecting lines was considered from the standpoint of maximum loading and unloading capacity at cargo points. In modern conditions it is necessary to take into account the ability of infrastructure to handle the growing volume of wagon traffic. As well as take into account the random nature of the arrival of wagons at stations and cargo points, as well as possible fines associated with breach of contractual terms of transportation of goods for service railway connecting lines of industrial enterprises.

2. Methodology

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This work uses the analysis methods of statistical data of the local wagon idle time at the railway station from 2016 to 2020. There were used the data of time-based field observations of the duration of technical and commercial inspections of wagons, time for dispatching-picking of wagons at cargo points, waiting time for dispatching-picking of wagons and doing cargo operations, other parameters to determine the duration of the main technological operations and their waitings.

Simulation modeling methods were used for formalizing the rational technology for service cargo points at railway connecting lines of industrial enterprises. Methods of processing the results of monitoring with the subsequent application of probability theory and mathematical statistics were also used to define the waiting time for the dispatching of wagons to the cargo point. Combinatorial analysis methods were used to determine the rational technology for service cargo points at railway connecting lines of industrial enterprises, taking into account possible penalties.

Application of the specified methods allows to organize work for service of cargo points on the most effective technology thanks to rational distribution of existing technical means at maintenance of the minimum operational expenses.

3. Results and Discussions

The authors conducted a detailed analysis of one of the most significant factors in determining the efficiency of the station, namely the comparison of planned and actual values of local wagons idle time (Figure 1). The analysis of actual and planned indicators of local wagons idle time showed that the implementation of the plan with the smallest excess is observed only in 2016. The longest local wagons idle time at the station can be observed in 2020, it amounted to 82.76 hours - this is 38% more than planned. The reasons for this are significant wagons idle time in anticipation of various technological operations, namely: waiting for the dispatching of wagons on the enterprise's railway connecting lines, waiting for unloading and loading operations, waiting for picking wagons from the enterprise's railway connecting lines to the station. As the analysis of the duration of wagons idle time proved, for the whole analyzed period there is a tendency to increase this indicator.

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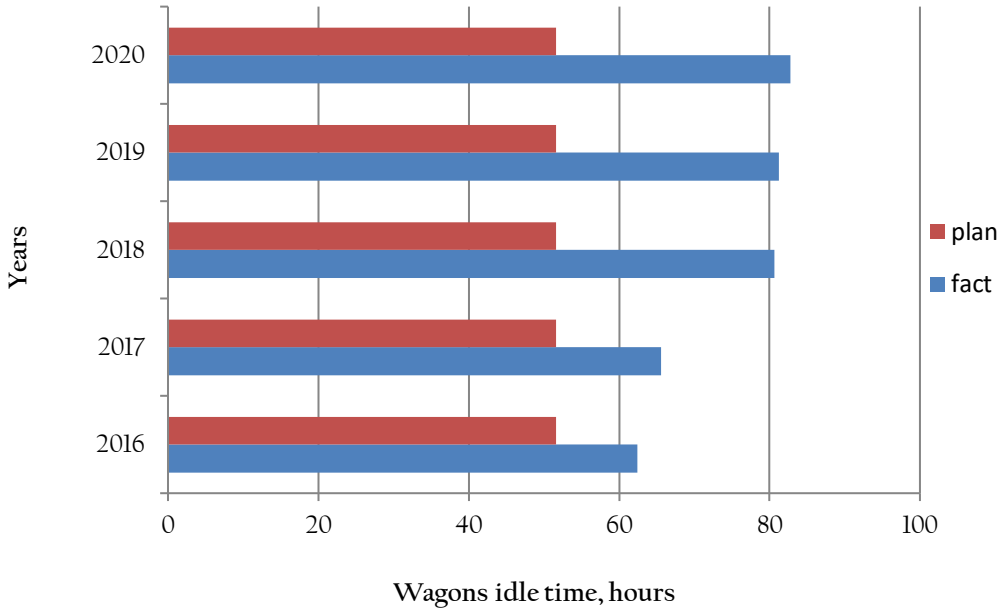

Figure 1. Dynamics of local wagons idle time at the railway station

Source: authors

Studies of the components of local wagons idle time have shown that we can identify three main elements, taking into account the relevant operations (Table 1). It was determined that the downtime from arrival to dispatching on the railway connecting lines of industrial enterprises for cargo operations was 51% and this is more than half of the total time spent by local wagons at the station (Figure 2).

Table 1. Components of local wagons idle time

The name of the local wagons idle time element	Component of the element
1. Downtime from arrival to dispatching on the railway connecting lines of industrial enterprises for cargo operations	Duration of technological operations during processing of trains with local wagons that arrived at the station for processing, wagons idle time for waiting to be disbanded, wagons idle time for waiting to be dispatching to the railway connecting lines of industrial enterprises

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2. Downtime under cargo operations	Wagons idle time for waiting to cargo operations and wagons idle time under cargo operations
3. Downtime from the end of cargo operations to departure from the station	Duration of technological operations with local wagons after the end of cargo operations before their departure from the station, wagons idle time for waiting to be picking from the railway connecting lines of industrial enterprises to the station and wagons idle time for waiting to departure

Source: authors

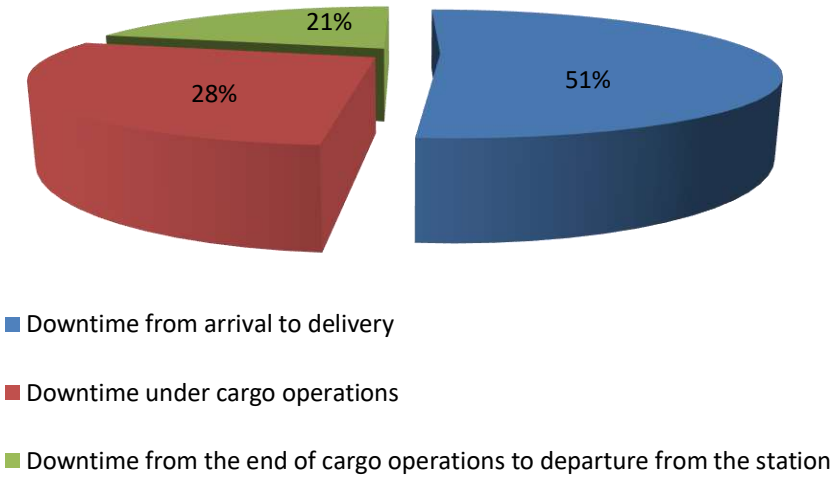

Figure 2. Diagram of the distribution of local wagons idle time by elements

Source: authors

The authors conducted a study of the distribution of local wagons idle time under the operations and in anticipation of them. It was determined that the wagon was waiting for technological operations 61% of the total time of stay the local wagon at the station, which indicates the inefficient technology of interaction between the station and the railway connecting lines of industrial enterprises (Figure 3).

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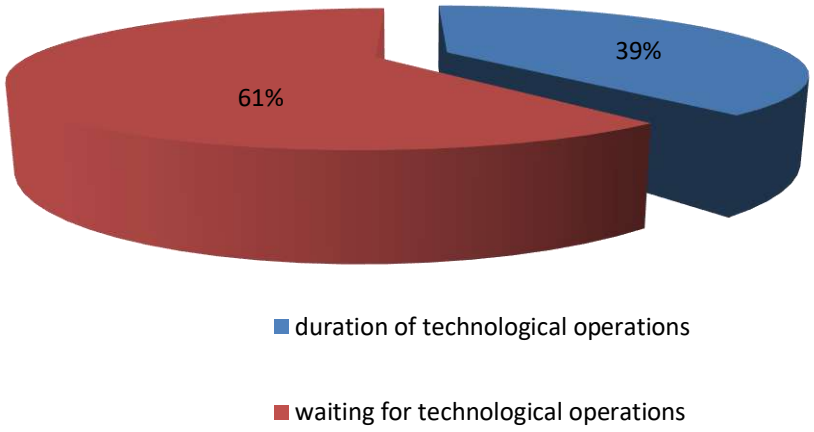

Figure 3. Diagram of the distribution of local wagons idle time during operations and in anticipation

Source: authors

Thus, to reduce inter-operational idle time of wagons, in order to improve the performance and improve the processing of wagon traffic in the interaction of the station and the railway connecting lines of industrial enterprises, it is necessary to develop a rational technology for service the cargo points at railway connecting lines of industrial enterprises.

Transport service of production units must fully meet the needs of production, which provides flexible management of the transportation process, adaptation of industrial railway transport to changes in operational volumes, determining the required size of the working fleet of wagons taking into account factors affecting the operation of industrial enterprises. In this regard, it is advisable to formalize the rational technology for service at railway connecting lines of industrial enterprises in the form of a mathematical model. This model is based on the reduction of operating expenses and the amount of possible penalties while minimizing of rolling stock idle time in anticipation of technological operations. The main penalties for the carrier are the payment of penalties for late delivery of goods. The amount of penalties for non-compliance with the contractual terms for service at railway connecting lines of industrial enterprises depends on the duration of the service delay and the number of detained wagons.

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The target function of the model a rational technology for service cargo points at railway connecting lines of industrial enterprises into account the penalty for violation of term to delivery freight will take the form:

$$C(N) = C_a + C_d^{ex} + C_{cl}^{ex} + C_{sh} + C_f + C_{fo}^{ex} + C_{tc} + C_f^g \to \min \qquad (1)$$

when implementing a system of restrictions:

$$\begin{cases} Z_{i-cl} > 0 \\ N \le l_{cp} \\ t_{tc} \le t_{st} \\ t_{ac} \le t_d \end{cases}, \qquad (2)$$

where N is the number of wagons delivered to the cargo point; C_a are the expenses of accumulation of a group of wagons for dispatching to the railway connecting lines of industrial enterprises; C_d^{ex} are the expenses associated with the wagons idle time in anticipation for delivery to the cargo point; C_{cl}^{ex} are the expenses associated with the wagons idle time in anticipation for removal from the cargo point after performing cargo operations with them; C_{sh} are the expenses of shunting work for the dispatching and packing wagons; C_f are the expenses associated with the time of finding wagons in the process of spotting / packing wagons; C_{fo}^{ex} are the expenses associated with the anticipation of wagons the cargo operations; C_{tc} are the expenses of technical and commercial inspections of wagons; C_f^g is a fine for late delivery of goods, if the delay is the fault of the adjacent station; Z_{i-cl} is the number of spotting / picking wagons; l_{cp} is the length of the cargo point in the wagons; t_{tc} is duration of technical and commercial inspections of wagons; t_{st} is standard time of technical and commercial inspections of wagons; t_{ac} is actual time of delivery; t_d is freight delivery time.

The second restriction prevents the dispatching of wagons to the cargo point in quantities exceeding the capacity of this cargo point. The third restriction stipulates that the duration of technical and commercial inspections of wagons must not exceed the standard

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time. The fourth condition reflects the fulfillment of restrictions on the delivery freight in the established terms.

The expenses of accumulation for a group of wagons for dispatching to the railway connecting lines of industrial enterprises:

$$C_a = \frac{C_{st} \sum_{i=1}^{k} N_i t_i}{\lambda} \quad (3)$$

where C_{st} are the expenses of storing the wagon under the accumulation for dispatching to the railway connecting lines of industrial enterprises; $\sum_{i=1}^{k} N_i t_i$ – wagon-hours idle time under accumulation; λ – traffic intensity of wagons dispatching to the railway connecting lines of industrial enterprises.

The expenses associated with the wagon idle time for waiting to be dispatching to the to the cargo point calculated by the formula:

$$C_d^{ex} = N\, t_{ex.d} C_{wh}, \quad (4)$$

where C_{wh} is the cost of one wagon-hour idle time; $t_{ex.d}$ is duration of wagons waiting for dispatching to the cargo point.

Studies have shown that the waiting time for dispatching of wagons to the cargo point is a random variable. Based on the analysis, it is established that this time is subject to the Erlang distribution of the 2nd order with density:

$$f\left(t_{ex.d}\right) = \left(2\mu\right)^2 t_{ex.d}^2 \cdot e^{-2\mu t_{ex.d}}, \quad (5)$$

where μ is intensity of service.

$$t_{ex.d} = \left(2\mu\right)^2 \int_0^{24} t_{ex.d}^2 \cdot e^{-2\mu t_{ex.d}}\, dt_{ex.d}. \quad (6)$$

Therefore, taking into account the research, the expenses associated with the wagons idle time for waiting to be dispatching to the cargo point, will take the form:

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$$C_d^{ex} = NC_{wh}(2\mu)^2 \int_0^{24} t_{ex.d}^2 \cdot e^{-2\mu t_{ex.d}} dt_{ex.d} \ . \quad (7)$$

The expenses associated with the wagons idle time for waiting to be picking wagons from the cargo point after performing cargo operations with them:

$$C_{cl}^{ex} = N t_{cl}^{ex} C_{wh}, \quad (8)$$

where t_{cl}^{ex} is duration for waiting to be picking wagons from the cargo point.

The expenses to shunting work of the spotting / picking wagons calculated by the formula:

$$C_{sh} = NC_{lh} \sum_{j=1}^{r} m_j t_j \ , \quad (9)$$

where C_{lh} is the cost of locomotive-hours of shunting locomotive operation; $\sum_{j=1}^{r} m_j t_j$ – locomotive-hours of shunting work.

The expenses associated with the time of finding wagons in the process of spotting / picking wagons

$$C_f = N t_f C_f, \quad (10)$$

where t_f is the time of finding wagons in the process for spotting / picking; C_f is the cost of one wagon -hour in freight traffic.

The expenses associated with the expectation of wagons to perform freight operations:

$$C_{fo}^{ex} = N t_{fo}^{ex} C_{wh}, \quad (11)$$

where t_{fo}^{ex} is the waiting wagons time to perform freight operations.

The expenses to technical and commercial inspections of wagons

$$C_{tc} = \frac{C_{ins}}{N}, \quad (12)$$

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where C_{ins} is the cost of inspection the wagons by employees of technical and commercial inspection points.

Fine for late delivery of goods, if the delay is the fault of the adjacent station:

$$C_f^g = f\left(t_{aa}, t_d, t_{doc}\right), \tag{13}$$

where t_{aa} – the actual time of arrival of the consignment at the station; t_{doc} is the time for crediting the transport documents.

Finally, the model to determine the optimal number of local wagons, which are fed to the cargo point at railway connecting lines of industrial enterprises with performing the system of restrictions (2) is as follows:

$$C(N) = \frac{C_{st}\sum_{i=1}^{k} N_i t_i}{\lambda} + NC_{wh}(2\mu)^2 \int_0^{24} t_{ex.d}^2 \cdot e^{-2\mu t_{ex.d}}\, dt_{ex.d} + N\, t_{cl}^{ex} C_{wh} + \\ + NC_{lh}\sum_{j=1}^{r} m_j t_j + N\, t_f C_f + N\, t_{fo}^{ex} C_{wh} + \frac{C_{ins}}{N} + C_f^g \to \min \tag{14}$$

The proposed model makes it possible to determine the rational technology for service cargo points at railway connecting lines of industrial enterprises, which will reduce the amount of payments under penalties. Taking into account the relevant system of restrictions (2), it is possible to determine the rational number of wagons in the dispatching to the railway connecting lines of an industrial enterprise. The application of the model will reduce unproductive wagons idle time at the station while reducing penalties for non-compliance with contractual terms. At the same time, this technology will allow operational staff to rationally organize the work of spotting / picking wagons from the cargo point with minimal expenses.

The implementation of the model has shown that it is possible to determine a rational technology with constantly changing volumes of work. The simulation was performed in the MATLAB environment (Figure 4).

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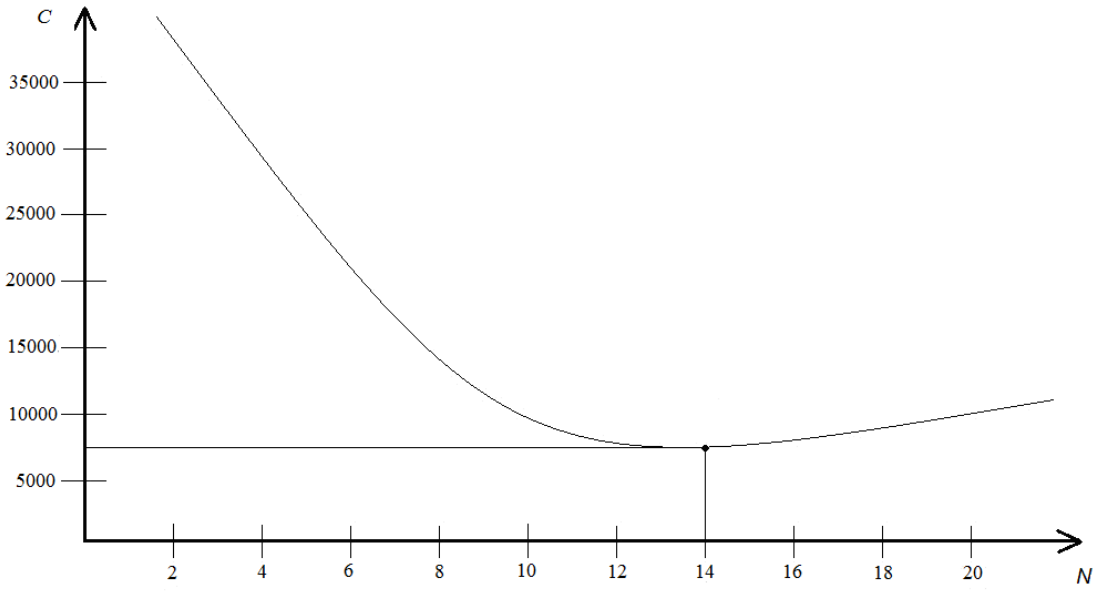

Figure 4. Dependence of operating costs on the number of wagon for dispatching to the railway connecting line of an
Source: authors

A significant achievement of this study is the creation of a model of rational technology for servicing cargo points of railway connecting lines of industrial enterprises. The developed model takes into account the probabilistic nature of the waiting time for dispatching of wagons to the cargo points, in contrast to the studies (Zapara and Garbuzov, 2015; Yelovoy and Potylkin, 2016; Prodashchuk et al., 2017; Shumik et al., 2016). An exceptional feature of the proposed model, in contrast to the works analyzed in the first section of this article, is the consideration of penalties for violation of the delivery time. Failure to comply with the terms of the contract may result in the payment by the railway of fines on claims and lawsuits of cargo owners. Taking into account the considered parameters of the mathematical model makes it possible to reduce the idle time of the local wagon at the station and reduce penalties for non-compliance with contractual obligations.

Conclusions

The detailed analysis of comparison of planned and actual values of local wagons idle time for 2016 - 2020 is carried out. The authors found that there are significant deviations from targets. The longest downtime of the local wagon at the station can be observed in 2020, it amounted to 82.76 hours - this is 38% more than planned. The reasons for this are

significant wagons idle time waiting for various technological operations, namely: waiting for dispatching of wagons to the railway connecting lines of industrial enterprises, waiting for unloading and loading operations, waiting for picking wagons from the railway connecting lines of industrial enterprises to the station.

In the paper forms a model of rational technology for service cargo points of railway connecting lines of industrial enterprises, taking into account possible penalties related to non-compliance with the deadline for delivery of goods to the destination. The proposed model in the implementation of the relevant system of restrictions will determine the rational number of wagons in the dispatching to the cargo point of enterprises and reduce the amount of payments for penalties.

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The experience of EU countries towards the development of infrastructure and logistics hubs

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ABSTRACT

The objective of the study is to assess the development of infrastructure and logistics hubs using the example of the EU countries, namely: Germany, Spain and Poland. The methodology is based on a comparative analysis of infrastructure hubs development indicators in Germany, Spain and Poland according to InfraCompass. Results. The general policy and strategy of the EU as a supranational institution determines the strategic goals and policies of Germany, Spain, and Poland in the field of infrastructure and logistics development. The EU provides financial incentives, political and administrative support for infrastructure hubs and logistics. Based on the research results, Germany, Spain, and Poland have common strengths contributing to infrastructure development: fair and transparent public procurement, a good insolvency protection system (Germany and Poland), a high credit rating (Germany), and financial stability (Poland). The general factors of the infrastructure facilities development are: in Germany – the development of infrastructure hubs is ensured by an effective regulatory framework and established rules for permitting, a quality legal system, a stable financial sector; in Spain – effective regulatory framework, effective tools of public administration; in Poland – the regulatory framework and infrastructure management systems.

KEY WORDS: Transport infrastructure; public transport; Transport Economics; transport planning.

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La experiencia de los países de la UE en el desarrollo de infraestructura y centros logísticos

RESUMEN

El objetivo del estudio es evaluar el desarrollo de la infraestructura y los centros logísticos utilizando el ejemplo de los países de la UE, a saber: Alemania, España y Polonia. La metodología se basa en un análisis comparativo de los indicadores de desarrollo de los hubs de infraestructura en Alemania, España y Polonia según InfraCompass. Resultados. La política y estrategia general de la UE como institución supranacional determina los objetivos estratégicos y las políticas de Alemania, España y Polonia en el ámbito del desarrollo de infraestructuras y logística. La UE ofrece incentivos financieros, apoyo político y administrativo para centros de infraestructura y logística. Según los resultados de la investigación, Alemania, España y Polonia tienen puntos fuertes comunes que contribuyen al desarrollo de la infraestructura: contratación pública justa y transparente, un buen sistema de protección frente a la insolvencia (Alemania y Polonia), una alta calificación crediticia (Alemania) y estabilidad financiera (Polonia). Los factores generales del desarrollo de las instalaciones de infraestructura son: en Alemania - el desarrollo de los centros de infraestructura está asegurado por un marco regulatorio efectivo y reglas establecidas para la concesión de permisos, un sistema legal de calidad, un sector financiero estable; en España - marco regulatorio eficaz, herramientas eficaces de administración pública; en Polonia: el marco regulatorio y los sistemas de gestión de la infraestructura.

PALABRAS CLAVE: Infraestructura de transporte; transporte público; Economía del transporte; planificación del transporte.

Introduction

The transfer of freight flows from road to more sustainable modes of transport, such as rail, inland waterway and maritime transport has been recognized by the European Commission (EC) as an important strategy towards "creating a sustainable transport system that meets economic, social and environmental needs" (CEC, 2006; 2009). For decades, constant activities have been taken in order to promote and implement such a modal shift (CEC, 2006). However, the available statistics indicate to the fact that the volumes transferred from road transport to other above-mentioned modes of transport were limited by the expectation of stabilization of the modal division in the long run; that is, the transport system required an efficient distribution of traffic flows between all modes of transport (CEC, 2006). Under the circumstances outlined, the EC Freight Transport and Logistics Action Plan (CEC, 2007) emphasizes that additional efforts and measures are needed to

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achieve a more significant modal shift. The latest policy strategy, set out in the White Paper on Transport of the European Commission (EC, 2011), includes infrastructure development, improving the quality of transport services and regulatory measures.

The strategic goals and policies of the EU countries in the field of infrastructure and logistics development provide for the need for financing, in particular, through investment mechanisms and various forms of public-private partnerships. Along with this, the policy involves not just the development of infrastructure, but the formation of nodes (hubs) in order to optimize transport and logistics flows. Investment needs for the development of infrastructure hubs on an international scale will grow steadily until 2040: according to estimation, current investment needs are 78, 782 billion USD, needs amount 93,653 billion USD, and projected needs are 97,195 billion USD until 2040 (Outlook, 2017). Investments are directed to the development of the transport sector (roads, railways), airports, ports, energy, telecommunications, etc.

Transport sphere experts with a strategic vision (mainly in Germany, France, the Netherlands and Sweden) in the 1980s and 1990s predicted that the regulation of transport would be insufficient. Since the late 1990s, an innovative concept has begun to develop integrating networks, vehicles, terminals and cargo, forming nodes (hubs) as infrastructure centres, optimizing logistics transportation and solving the problem of loads due to the growth of traffic flows. For instance, in 1995, a memorandum was adopted for the development of a platform by German railway and logistics experts (Kreutzberger, 2010) and an initiative of Deutsche Bahn concerning development of the Megahub in Lehrte (near Hanover). This new generation terminal has been designed for the large-scale exchange of continental load units between trains that concurrently visit a node (hub). In France, the new generation Commutor terminals were integrated into the railway network, which was an extremely innovative solution. Two hub terminals began servicing intermodal rail hub and HS networks, providing transport services to large areas of France and northern Germany (Kreutzberger, 2016). The development of infrastructure hubs provided for the automation and robotization of work, business processes; in particular, the terminals were equipped with a terminal internal transport and sorting system (TITSS).

The above mentioned tendencies in the development of infrastructure and logistics hubs indicate the relevance of studying this issue. The purpose of the academic paper lies in

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assessing the development of infrastructure and logistics hubs using the example of the leading EU countries, namely: Germany, Spain and Poland, forasmuch as the policy of these countries in the direction outlined is an example for other member states to follow.

1. Literature Review

The creation of hubs is driven by the need to ensure economic growth (Crescenzi & Rodríguez-Pose, 2008; Rodríguez-Pose, Crescenzi & Di Cataldo, 2015; Perez-Montiel & Manera, 2021), productivity and the formation of infrastructure networks (Zhang, Janic & Tavasszy, 2015; Romero & Van Waeyenberge, 2020). Infrastructure and logistics hubs are crucial in the location of companies, especially when making decisions concerning foreign investment. Their role is growing due to the spread of intermodal logistics networks providing transportation of goods on a large scale (Mindur & Hajdul, 2011; Morin et al., 2015). The scientific literature considers the global importance of railway junctions as centres of the logistics network (Schmidt, 2013; Kreutzberger & Konings, 2016), energy transport hubs (Çeviköz, 2016), transport corridors, expanding the economic potential of regions within the country (Zakrzewski & Nowacki, 2016), transport networks within cities as a way to expand telecommunications infrastructure (Rutherford, 2005), hub airports functioning as international and supra-regional infrastructure. All the outlined has a decisive impact on the competitiveness of firms and stimulates urban development (Romberg, 1996; Thierstein & Conventz, 2014).

Overall, the literature review has revealed limited quantitative studies of infrastructure hub development indicators in Germany, Spain and Poland. It should be noted that high-quality models of infrastructure and logistics hubs dominate in the publications including, for instance, railway junctions, energy transport centres and / or corridors, hub airports. This proves the relevance of studying the features of the development of infrastructure and logistics centres in the leading EU countries, strengths and development potential of infrastructure facilities through the strategy and policy of regulatory countries.

2. Methodology

The development indicators of infrastructure hubs in Germany, Spain and Poland have been used in the research, according to InfraCompass (2021), which assesses the development of infrastructure networks in the country by the factors as follows: Activity,

Financial markets, Funding capacity, Governance, Permits, Planning, Procurement, Regulatory frameworks. The factors specified are drivers of infrastructure development and logistics in countries. Due to the fact that Germany and Spain are the most efficient states in the development of infrastructure and logistics, these countries have been chosen for analysis and the possibility of forming the main favourable growth factors.

3. Results

The development of infrastructure and logistics hubs in Germany, Spain and Poland is determined by factors, which are different in each country, contributing to investment and innovation growth. The countries have high efficiency of air services, seaport and train services (especially in Spain), low level of electricity losses and high quality of electricity supply. The high level of welfare (GDP per capita, especially in Germany) contributes to the development of infrastructure (Table 1).

Table 1. Infrastructure hub development indicators, 2019.

Indicator	Germany	Spain	Poland
Efficiency of air transport services (1-7 best)	5,47	5,61	4,84
Efficiency of seaport services (1-7 best)	5,24	5,38	4,53
Efficiency of train services (1-7 best)	4,92	5,37	3,90
Electricity access, % of population	100,00	100,00	100,00
Electricity supply quality, % of output lost	4,30	9,46	5,63
GDP per capita, USD	46564,00	29961,00	14902,00
Infrastructure gap, % of GDP	0,00	0,12	0,49
Infrastructure investment[1], % of GDP	1,54	2,96	3,55
Infrastructure quality, (0-100 best)	90,21	90,31	81,15
Private infrastructure investment[2], 5-year average, USD millions	3378,29	684,23	249,36
Quality of road infrastructure, (1-7 best)	5,30	5,70	4,31
Reliability of water supply (1-7 best)	6,10	6,61	5,92
Road connectivity (0-100 best)	95,07	100,00	88,01

Source: InfraCompass (2021).

[1] Total economic infrastructure expenditure, based on government and multi-lateral development agency estimates.

[2] Financial close value of privately financed economic infrastructure.

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The total infrastructure development expenditures are the largest in Poland – 3,55% of GDP (with a GDP of 565,9 billion US dollars, 20,09 billion dollars of investments in 2019); in Spain, the indicator is 2,96% (with a GDP of 139,79 billion USD, 41,38 billion investment in 2019); in Germany, the indicator is 1,54% (with a GDP of 3 864,3 billion US dollars, in fact, 59,51 billion US dollars of investment in 2019). The high level of investments in the infrastructure of Germany and Spain ensures its high quality (quality ratings of 90,21 and 90,31, respectively), while the indicator in Poland is slightly lower (81,15). Private infrastructure investments amount to 3 378,29 million USD in Germany, 684,23 million USD in Spain and 249,36 million USD in Poland for the last five years (2015-2020).

In Germany, the development of infrastructure hubs is ensured by an effective regulatory framework and established rules for granting permits, providing support in the creation of enterprises and maintaining reliable protection of creditors from insolvency (Table 2). The second factor of infrastructural development is a high-quality legal system, a stable financial sector, which contribute to attracting investment and competition between suppliers. Herewith, the duration of the procurement procedures is a negative factor, which increases the costs of contractors, although the procurement procedures themselves are extremely transparent.

Table 2. Infrastructure Driver Comparison, 2020.

2020	Germany		Spain		Poland	
Driver	Rank	Driver_score	Rank	Driver_score	Rank	Driver_score
Activity	76,00	10,03	52,00	26,21	66,00	18,16
Financial markets	17,00	55,84	20,00	52,54	41,00	32,30
Funding capacity	9,00	76,36	25,00	51,15	29,00	46,93
Governance	12,00	78,53	17,00	74,90	21,00	67,58
Permits	32,00	75,46	23,00	80,37	64,00	46,61
Planning	33,00	76,65	38,00	74,33	40,00	73,44
Procurement	63,00	54,00	21,00	84,51	39,00	74,74
Regulatory frameworks	2,00	80,37	21,00	70,44	22,00	69,60

Source: InfraCompass (2021).

The principal strong points of Germany in the development of infrastructure hubs are as follows: 1) transparency of public procurement; 2) high credit rating of the country; 3) high-quality insolvency protection system. Transparency of procurement is ensured by the

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digitalization of procedures; it is possible to acquire an object in the country via the Internet, where tender documentation and procedures, selection criteria are presented in detail. Transparency of procurement processes stimulates competition, participation of contractors and optimizes the price / quality ratio. GDP per capita helps maintain the AAA rating provided by the country's major rating agencies. In turn, Germany's high credit rating allows the government borrowing at a lower cost. Enhanced protection of enterprises from bankruptcy and insolvency ensures the attraction of investment in infrastructure.

In Spain, the major factors in the development of infrastructure hubs and logistics are as follows: an effective regulatory framework, effective tools of public administration, providing support in the creation of enterprises. These crucial factors are complemented by fair and transparent public procurement processes fostering competition between suppliers and optimizing price / quality, performance through infrastructure investment. However, the principal problems of Spain include a high level of public debt and the spread of the COVID-19 pandemic, which causes problems in investing in new infrastructure projects.

The major strong points of Spain in the development of infrastructure projects are as follows: 1) low cost of business setting up; 2) fast registration of companies; 3) honesty and transparency of the procurement process. According to the data of the World Bank, the cost of business setting up in Spain is 3,9% of per capita income (below the average of high-income countries by 4,7%), which simplifies and facilitates the entry of new companies into the market (World Bank, 2021a). Registration of real estate in the country takes only 13 days, the efficiency of the process of which reduces the cost of the project and risks, stimulating investments, and facilitating business processes. Public procurement processes are simple, transparent and fair, which encourages the participation of contractors and competition, increasing the price / quality ratio.

In Poland, regulatory frameworks and infrastructure management systems foremost promote the development of infrastructure hubs encouraging private investment and developing industrial competition. However, the level of activity in infrastructure development and investment in private facilities remains low, despite the country's advantages. In order to encourage funding and promote competition, the government should provide more support in setting up new businesses. Such support can be implemented by

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reducing start-up costs, the time required to start a business, or by improving the efficiency of property registration processes.

Table 3. Infrastructure Driver Comparison, 2017-2020

Driver / Country	2017	2020	Growth, +/-
DEU	**60,543**	**61,620**	**1,078**
Activity	9,146	10,026	0,880
Financial	58,392	62,247	3,855
Funding	53,451	56,567	3,116
Governance	70,382	68,956	-1,426
Permits	71,834	71,915	0,080
Planning	86,458	86,000	-0,458
Procurement	76,249	73,817	-2,432
Regulatory	72,573	75,517	2,944
ESP	**56,356**	**57,370**	**1,013**
Activity	21,041	26,205	5,164
Financial	57,444	56,922	-0,522
Funding	30,794	34,262	3,468
Governance	64,524	64,448	-0,076
Permits	75,888	76,269	0,382
Planning	61,458	61,000	-0,458
Procurement	73,499	71,067	-2,432
Regulatory	63,170	64,989	1,819
POL	**51,453**	**48,441**	**-3,012**
Activity	18,077	18,165	0,088
Financial	42,132	41,733	-0,399
Funding	44,352	46,383	2,031
Governance	57,945	57,135	-0,809
Permits	57,211	42,971	-14,240
Planning	64,583	65,000	0,417
Procurement	70,559	64,309	-6,250
Regulatory	64,295	63,526	-0,768
Total countries average	**56,117**	**55,810**	**-0,307**

Source: InfraCompass (2021).

The major strong points of Poland in the development of infrastructure projects are as follows: 1) financial stability of the country; 2) high-quality system of protection against insolvency; 3) transparency and honesty of public procurement. Consequently, the country is one of the most financially stable, which contributes to a constant flow of financial resources between investors and enterprises, providing an inflow of capital to projects.

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According to the data of the World Bank, Poland has a developed system of protection against insolvency (World Bank, 2021b), which helps attract investment in the infrastructure. The public procurement process is transparent and fair thanks to a well-developed regulatory framework, providing regulation of the selection method of private partners for various forms of PPP, encouraging competition, participation, optimal price / quality ratio.

In order to ensure the further development of the hubs, Germany, Spain and Poland should use the existing potential in different dimensions. For example, in Germany, it is advisable to develop instructions for defining procurement processes in the infrastructure sphere. Currently, the country does not publish procurement guidelines for infrastructure projects. The publication of the guidelines will provide contractors with information on government processes, requirements, expectations, increase transparency and ensure achievement of better quality-to-price ratio by the government.

In addition, Germany requires the development and publication of an infrastructure development plan forasmuch as nowadays there is no cross-sectoral national or subnational plan in the country. As a complement to the current transport development plan, the infrastructure and logistics plan should highlight the basic challenges, investment opportunities and government-planned responses to challenges. The principal challenges of Germany include as follows: the problems of GDP growth due to the constant decline in the automotive industry, international trade tensions, leading together to a reduction in the projected values of GDP.

Spain has the potential to develop infrastructure projects, which has been significantly reduced due to the 2008 crisis. In order to do this, the country should assess the tendencies and challenges of all infrastructure sectors and markets that are of great importance for its development. Currently, the corresponding assessment exists only in the field of road infrastructure. Conducting such an assessment is of great importance in finding interested investors, lenders for potential project financing. Similar to Germany, Spain is also challenged by the long-term GDP growth trend at the level of 0,45%, while high-income countries average 1,8% GDP growth trend. This limits the long-term funding potential of infrastructure hubs. Another challenge for the country is the low cost of concluded agreements in the sphere of PPP infrastructure, compared to the average for high-income

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countries. Low cost may reflect the government's choice concerning publicly fund infrastructure.

The major opportunities towards ensuring the development of infrastructure hubs in Poland include the development of a national or subnational infrastructure plan. It is advisable to highlight information about the challenges and potential for investment in the plan, as well as detail the government's actions in the future. The duration of registration of property, real estate, which amounts 135 days, is among the main problems for the country, forasmuch as it significantly exceeds the average 25-day indicator for countries with a high level of income. The time-consuming registration process increases the level of risk and cost of the project, in particular, with the full transfer of ownership of the infrastructure. Poland, like Spain, has a low value of PPP infrastructure agreements, which amounts 0,005% of GDP.

4. Discussion

The scientific literature discusses the democratic regime of participation of the German government in the development of large infrastructure projects for sustainable development (Zhou, Tan & Sedlin, 2018). According to the Federal Route Plan until 2030 (Deutscher Bundestag, 2016), from 2016 to 2030, the federal government will invest 226,7 billion EUR in maintaining existing infrastructure, as well as in new projects for the construction and expansion of federal projects for roads, railways and waterways in Germany. In accordance with the requirements of BVWP 2030, the principal objectives of MTIP planning in Germany are as follows: 1) achieving mutual harmony between land use and the natural environment; 2) mitigating negative consequences of interested parties involved in land use; 3) guaranteeing social and economic benefits from investments in infrastructure projects; achieving maintenance, upgrading and transformation of infrastructure and improving the efficiency of the transport network through scientific planning and decision-making. The study conducted by Funke, Plötz & Wietschel (2019) also highlights the importance of reducing the negative environmental impact of the transport sector in Germany through innovative technologies. In order achieve the objectives outlined, the German government uses a planning regime with democratic participation features, and the planning process itself involves broad public participation. In the context of development of infrastructure hubs, Germany prefers social justice and strives to achieve the goals of revitalization and social harmony. Therefore, the German government adopts

development strategies involving broad public participation, the formulation of plans and projects with an emphasis on environmental mitigation, decentralized planning, coordination and balancing of interests by independent courts, which have become key elements of their democratic participation planning. In this planning mode, ex post planning costs for infrastructure (for instance, land compensation) are reduced (Zhou, Tan & Sedlin, 2018). The democratic regime of participation of the German government in infrastructure development is connected with the "Europeanization", a Common Transport Policy, which has led to the advancement at the supranational level of "transportation infrastructure projects through the Trans-European Transport Networks (TEN-T) concept" (Schenk, 2019). It is the EU that provides financial incentives, political and administrative support for infrastructure hubs and logistics. As it has been revealed in the present research, Germany, Spain and Poland have common strengths contributing to infrastructure development, namely: first and foremost, fair and transparent public procurement, high-quality insolvency protection system (Germany and Poland), high credit rating (Germany) or financial stability of the country (Poland).

The formation of the EU has contributed to the development of Spain's infrastructure. Since joining the European Union in 1986, the country has experienced stable economic growth, which has allowed it growing faster than other European countries. During this period, the Spanish government made large investments in the public infrastructure, using several types of approaches proposed by the EU. Most of the contractual PPPs concluded in Spain were concessions for the development of toll highways. However, over the past few years, there has been a significant increase in the number of other types of approaches, such as "shadow toll or availability of payment contracts". Contractual PPPs have also been used to build and operate other types of infrastructure such as urban rail systems, hospitals, prisons, etc. The recession of 2008 is known to have had very negative consequences for the Spanish economy. Gross domestic product (GDP) per capita fell sharply, and the unemployment rate rose from 9% to 26% of the working population in just four years. The crisis has also had serious consequences for the economic performance of concessions and infrastructure development. Traffic level was declining much faster than GDP. In addition, due to the liquidity crisis, the conditions imposed on borrowers by financial markets have become much tougher. Along with this, the government has experienced severe budgetary

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constraints on fulfilling its obligations under customs duty contracts and the availability of payments (Ortega, de los Angeles Baeza & Vassallo, 2015).

It was Spain's accession to the EU that ensured not only economic growth, but also financing of the infrastructure for convergence with other member states, the use of various types of PPPs in order to attract the private sector. Political support also contributes to the infrastructure development (Ortega, de los Angeles Baeza & Vassallo, 2015). In Spain, like in Germany, both central and regional governments are actively involved in building hubs, which has contributed to the development of all forms of PPPs and the active involvement of various interested parties (infrastructure developers, construction companies and banks). The present research has revealed that Spain's infrastructure is being developed through transparent procurement, low opening costs and easy company registration.

Conclusion

In the course of the research it has been found that the common policy and strategy of the EU as a supranational institution, determines the strategic goals and policies of Germany, Spain, Poland in the field of infrastructure development and logistics. The countries are characterized by similar features in financing and mechanisms for the development of infrastructure and logistics hubs (investment mechanisms and various forms of public-private partnerships). The policy of the countries provides not just the development of infrastructure, but the formation of nodes (hubs) in order to optimize transport and logistics flows. It is the EU that provides financial incentives, political and administrative support for infrastructure hubs and logistics. As it has been revealed in the present research, Germany, Spain and Poland have common strong points contributing to the infrastructure development, namely: first and foremost, fair and transparent public procurement, a good insolvency protection system (Germany and Poland), high credit rating (Germany) or financial stability of the country (Poland). In the countries under consideration, the common factors for the development of infrastructure facilities and nodes are as follows: 1) in Germany, the development of infrastructure hubs is ensured by an effective regulatory framework and established rules for granting permits, a high-quality legal system, and a stable financial sector; 2) in Spain, the crucial factors in the development of infrastructure hubs and logistics are an effective regulatory framework, effective tools of public

administration; 3) in Poland, the regulatory framework and infrastructure management systems foremost promote the development of infrastructure hubs.

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Satisfacción laboral en colaboradores de entidades públicas y financieras del Perú

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RESUMEN

La presente investigación tiene como objetivo comparar la satisfacción laboral de los colaboradores de la entidad pública Municipalidad provincial de Sullana y de la entidad financiera Caja Sullana. La metodología se centra en el enfoque cuantitativo, diseño descriptivo comparativo. La muestra estuvo constituida por 150 colaboradores, 73 del área de Desarrollo Social de la Municipalidad provincial de Sullana y 77 pertenecientes al área de talento humano de la Caja Municipal de Sullana. Para la recolección de datos se aplicó la evaluación psicométrica en ambas poblaciones, basada en el cuestionario de satisfacción laboral SL-ARG de Alex Ruiz Gómez. Entre los resultados encontrados se halló que existen diferencias significativas entre ambas entidades. Se concluye que existe un marco de diferencia entre los niveles de satisfacción de los colaboradores de la administración privada y los colaboradores que están sometidos a la administración pública.

PALABRAS CLAVE: Trabajo; gestión de personal; organización y gestión; Perú.

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Job satisfaction in collaborators of public and financial entities in Peru

ABSTRACT

The present research aims to compare the job satisfaction of employees of the public entity Sullana Provincial Municipality and the financial entity Caja Sullana. The methodology focuses on the quantitative approach, comparative descriptive design. The sample consisted of 150 collaborators, 73 from the Social Development area of the Sullana Provincial Municipality and 77 from the Human Talent area of the Sullana Municipal Fund. For data collection, the psychometric evaluation was applied in both populations, based on the SL-ARG job satisfaction questionnaire by Alex Ruiz Gómez. Among the results found, it was discovered that there are significant differences between both entities. It is concluded that there is a framework of difference between the levels of satisfaction of the collaborators of the private administration and the collaborators who are submitted to the public administration.

KEY WORDS: Labour; Personnel management; Organization and management; Peru.

Introducción

La Organización Internacional del Trabajo (2020) sostiene que el mundo laboral actual se caracteriza por sus profundos déficits de trabajo decente; que se define como la suma de los deseos que las personas proyectan en su vida laboral y abarcan desde las oportunidades presentadas en el campo laboral con el otorgamiento de ingresos acordes a la preparación del empleado, las condiciones adecuadas respecto a infraestructura, como la igualdad de trato y la libertad de opinar y expresar sus ideales y emociones.

Desde que se inició el confinamiento debido a la pandemia por la COVID 19 las entidades públicas y las entidades financieras privadas asumieron el reto de continuar con las acciones laborales; pero esta vez a través de un nuevo estilo, como es el teletrabajo. Los países que aún no habían experimentado este sistema tuvieron que implementarlo por la misma necesidad de las empresas en continuar ofreciendo productos y servicios a sus clientes y mantener así, el dinamismo de su economía. Es entonces que, en el Perú, el sector privado se adaptó a este estilo de trabajo de manera inmediata; en paralelo el sector público siguió los mismos pasos, pero con significativas deficiencias.

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Cabe precisar que el teletrabajo se conceptualiza como la forma de ejercer las funciones laborales fuera de las instalaciones de la empresa o el empleador, haciendo utilidad de las herramientas tecnológicas como: tabletas, móviles, computadores, laptops, teléfono, plataformas virtuales e incluso redes sociales. Y este estilo de trabajo se da en el marco de acuerdos en común entre el empleado y el empleador mediante un contrato, con fines específicos de continuar con los objetivos trazados por la organización.

En el Perú se ha percibido información estadística correspondiente a la expectativa en el trabajo: aproximadamente el 50% de los trabajadores no se encuentra contento dentro de su ambiente laboral, afectando con esto su capacidad de responsabilidad y compromiso con las funciones y trabajos estipulados. Asimismo, el 45% de la población de trabajadores que participaron en una investigación realizada, manifestó que no se siente feliz con su trabajo actual, siendo el principal motivo de dicha situación, los problemas relacionados con un inadecuado clima laboral (Lira, 2014).

En nuestra localidad (Sullana) se puede apreciar que existen instituciones públicas que no cuentan con instalaciones adecuadas y acordes a la necesidad de los trabajadores, ya que carecen de las condiciones para que se pueda realizar el cumplimiento de una jornada laboral completa. Más aún, con el sistema virtual, la documentación del usuario queda transitando en la nube a la espera de una atención inmediata, caracterizando de deficiente el desempeño del sistema; a diferencia de lo propuesto por las entidades privadas que cuentan con todo tipo de recursos para el desarrollo laboral, y que han implementado sistemas virtuales de atención inmediata con la visión de mantenerse en el mercado y salvaguardar su clientela.

En base a los expuesto, la investigación tuvo como objetivo primordial comparar la satisfacción laboral de los colaboradores de la entidad pública Municipalidad provincial de Sullana y de la entidad financiera Caja Sullana.

1. Satisfacción laboral

Los investigadores Yáñez et al. (2010) sostienen que la satisfacción laboral es el estado emocional positivo que emerge del resultado de la experiencia en el campo laboral de un empleado. Es así que, Robbins (2004) define la satisfacción laboral como la actitud global del individuo respecto a su espacio laboral, lo que implica que un colaborador con elevado

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nivel de satisfacción tiende a tener actitudes positivas que lo llevarán a tener mayor productividad, mientras aquella que se sienta insatisfecha acogerá actitudes negativas.

Para Coronel et al. (2020) la satisfacción de los integrantes de un grupo demanda trabajo colaborativo y comunicación, con metas en común por cumplir. Así mismo, Bernal y Flores (2020) afirman que la satisfacción del personal en base a su espacio laboral se vuelve un aspecto central para las organizaciones, ya que se ha reflejado que la satisfacción en el trabajo es una condicionante en el desenvolvimiento del colaborador que posteriormente se evidenciara en la satisfacción del usuario y la calidad de los servicios ofertados.

Pizarro et al. (2019) afirman que la motivación es un elemento indispensable que todas las personas deben poseer para la lograr objetivos en diferentes campos de la vida. Para García et al. (2020) la motivación laboral en las instituciones académicas es un factor determinante en la satisfacción laboral, convirtiéndose en esencial a la hora de ejecutar actividades encargadas dentro de la organización, para mantener un ambiente cálido e interactivo. Es así, que el colaborador necesita herramientas e instrumentos que lo motiven y le generen placer en el desarrollo de su trabajo para que pueda alcanzar el éxito en la organización donde se desempeña.

Es preciso resaltar que Muñoz (1990), expone que la satisfacción laboral y personal es de suma relevancia en la constitución del clima organizacional como parte integral del comportamiento de la misma, reflejados en la mejora continua de los procesos productivos. Los investigadores Alva y Juárez (2014) refieren que la actividad de un empleado va más allá de ordenar files o estar a la expectativa de los usuarios, considerando la necesidad de interacción que debe existir con los jefes inmediatos, quienes serán los evaluadores del ejercicio laboral realizado en un área específica.

Moreno et al. (2018) plantean ciertos factores para alcanzar la satisfacción laboral como: la libertad en el desempeño del trabajo, la variedad de diversificación, el pago, el reconocimiento al desempeño, la flexibilidad, las capacitaciones y especializaciones; así mismo, la comunicación con los directivos como factor primordial de las buenas relaciones, todos estos componentes forman y sostienen la satisfacción en el colaborador.

Por otro lado, la teoría de factores planteada por Ruiz y Zavaleta (2017) considera que la satisfacción laboral es la actitud demostrada por el trabajador ante su puesto de trabajo.

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En consecuencia, para que pueda ser medible se deben evaluar diversos factores, los mismos que se detallan a continuación.

1.1. Condiciones de trabajo

Las condiciones de trabajo están enmarcadas como el conjunto de acciones y características materiales que engloban el sistema político, social, cultural, económico, ambiental y organizacional, donde sucede la interacción laboral. Investigaciones han sostenido que la estructura de estas condiciones incide en la calidad laboral de cada colaborador e incluso en su misma vida personal, donde hasta cierto punto puede comprometer la salud física y mental (Martínez, Oviedo y Luna, 2016).

Para Quezada et al. (2021) las condiciones laborales se relacionan con los recursos financieros que posee la entidad, otorgando la seguridad y el respaldo al empleado de ser remunerado en el tiempo que estipula su contrato, así mismo, la adquisición de equipos que permitirá el ahorro de tiempo y la entrega de actividades en el lapso indicado. En tal sentido, Cacua, Carvajal y Hernández (2017) sostienen que las condiciones laborales son relevantes para el avance económico de una organización e institución, y tan solo el hecho de pensar en su abandono genera poblaciones vulnerables a la transformación económica donde los estilos de calidad de vida podrían verse comprometidos.

1.2. Remuneración y beneficios

1.2.1. Remuneración

La remuneración es el pago efectivo que se realiza a un colaborador por ejercer acciones enmarcadas en un conjunto de normas establecidas por una institución o entidad, que conlleva al funcionamiento de los procesos y al cumplimiento de objetivos de la organización. El Decreto Legislativo N° 728, Ley de Productividad y Competitividad Laboral en el Perú, constituye que la "remuneración es todo lo que el trabajador recibe por sus servicios, en dinero o en especie, cualquiera sea la forma o denominación que se le dé, siempre que sea de su libre disposición". En tal sentido, es lo que por derecho le corresponde a un empleado por el servicio ofrecido.

1.2.2. Beneficios

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Manzo y Moncallo (2004) sostienen que "los beneficios son aquellas facilidades, comodidades, ventajas y servicios que las empresas ofrecen para ahorrarles esfuerzos y preocupaciones, que pueden ser financiadas parcial o totalmente. Estos beneficios constituyen medios indispensables para el mantenimiento de la fuerza laboral dentro de un nivel satisfactorio de moral y productividad".

1.3. Relaciones humanas

Caicedo et al. (2018) sostienen que el ser humano, desde su existencia, siempre ha tenido la necesidad de relacionarse con su entorno, generar grupos amicales como laborales que le han permitido dinamizar su rendimiento y habilidad en las actividades encomendadas, aprovechando eficientemente los recursos otorgados en el campo laboral. Así mismo, Ismail, Karkoulian y Kertechian (2019) argumentan que los estrategas, al considerar las relaciones humanas, deben entender cómo conseguir que los colaboradores estén contentos e incentivados en el espacio laboral, considerando que, a mayor satisfacción, se obtendrá resultados eficaces en las tareas asignadas.

2. Metodología

La investigación responde a las características del diseño no experimental de tipo transaccional, denominado diseño descriptivo comparativo; este diseño según Hernández, Fernández, & Baptista (2014) se describe como la consolidación de dos o más investigaciones de tipo descriptivas simples, ya que consiste en recolectar los datos relevantes referentes a un mismo fenómeno de más de una muestra poblacional, para posteriormente realizar la comparación respectiva de los datos hallados.

El diseño para la ejecución del presente estudio es el siguiente:

-M1: Colaboradores del área de recursos humanos de la Caja Sullana.

-M2: Colaboradores del área de desarrollo social de la Municipalidad Provincial de Sullana.

-O1 y O2: Medición de los niveles de satisfacción laboral.

La muestra de estudio estuvo constituida por 150 colaboradores de dos subgerencias de la Caja Sullana y por 6 subgerencias del área de Desarrollo Social de la Municipalidad Provincial de Sullana, como se muestra a continuación:

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Tabla 1. Muestra de estudio.

Sub gerencias área de Gestión del Talento Humano	Cantidad	Subgerencias área de Desarrollo Social	Cantidad
Gestión de desarrollo Humano	44	Educación y Cultura	15
Capacitación	33	Responsabilidad Social	09
		Registro Civil	16
		Programas Alimentarios	17
		OMAPED	13
TOTAL	77	TOTAL	73

Fuente: Elaboración Propia.

3. Resultados y Discusión

Tabla 2. Diferencias de satisfacción laboral entre ambas entidades.

Muestras independientes

Satisfacción Laboral	Prueba de Levene de igualdad de varianzas		Prueba t para la igualdad de medias						
	F	Sig.	t	gl	Sig. (bilateral)	Diferencia de medias	Diferencia de error estándar	95% de intervalo de confianza de la diferencia	
								Inferior	Superior
Se asumen varianzas iguales	410,916	,000	14,057	148	,000	58,571	4,167	50,337	66,805
No se asumen varianzas iguales			13,698	74,622	,000	58,571	4,276	50,052	67,089

Fuente: Elaboración Propia

En la tabla 2 se evidencia que ante la prueba T y de Levene para la igualdad de medias y varianzas respectivamente; se aprecia que las medias de ambos grupos son distintas ya que la diferencia de las mismas asume un valor de 58,57. Así mismo, se aprecia que, al ser el valor de significancia, en ambas pruebas, menor a 0.05 indica que si existe diferencia entre las varianzas.

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Tabla 3. Condiciones de trabajo.

Factor I: Condiciones de Trabajo	Prueba de Levene de igualdad de varianzas		Prueba t para la igualdad de medias						
	F	Sig.	t	gl	Sig. (bilateral)	Diferencia de medias	Diferencia de error estándar	95% de intervalo de confianza de la diferencia	
								Inferior	Superior
Se asumen varianzas iguales	272,917	,000	14,417	148	,000	15,244	1,057	13,154	17,333
No se asumen varianzas iguales			14,049	74,511	,000	15,244	1,085	13,082	17,405

Fuente: Elaboración Propia

En la tabla 3 se evidencia que ante la prueba T y de Levene para la igualdad de medias y varianzas respectivamente; las medias de ambos grupos son distintas ya que la diferencia de las mismas asume un valor de 15,244. Se apreciar que, al ser el valor de significancia, en ambas pruebas, menor a 0.05 indica que si existe diferencia entre las varianzas. Estadísticamente también se evidencia una desigualdad significativa entre la media y la varianza de esta dimensión, dándonos como resultado que existen diferencias importantes entre los grupos. Esto permite argumentar que las condiciones de trabajo percibidas por los colaboradores de una entidad privada son diferentes a las de los colaboradores de una entidad pública, en la medida que los trabajadores de la entidad privada se sienten más retribuidos con los materiales necesarios para el buen desempeño laboral. Esto es ratificado por Robbins (2004) quien indica que uno de los aspectos importantes que alimentan la satisfacción laboral es la recompensa equitativa y las condiciones de trabajo que se convierten en un respaldo para que este pueda responder de manera apropiada a su desempeño laboral, llevándolo esto a un buen nivel de productividad.

Tabla 4. Remuneración y beneficios.

Prueba de muestras independientes

Factor II: Remuneración y Beneficios Laborales	Prueba de Levene de igualdad de varianzas		Prueba t para la igualdad de medias						
	F	Sig.	t	gl	Sig. (bilateral)	Diferencia de medias	Diferencia de error estándar	95% de intervalo de confianza de la diferencia	
								Inferior	Superior
Se asumen varianzas iguales	326,184	,000	13,051	148	,000	12,172	,933	10,329	14,015
No se asumen varianzas iguales			12,731	77,310	,000	12,172	,956	10,268	14,076

Fuente: Elaboración Propia

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En la tabla 4 se evidencia que ante la prueba T y de Levene para la igualdad de medias y varianzas respectivamente; las medias de ambos grupos son distintas ya que la diferencia de las mismas asume un valor de 12,172. Así mismo, se observa que, al ser el valor de significancia, en ambas pruebas, menor a 0.05 indica que si existe diferencia entre las varianzas. Esto permite argumentar que beneficios y bonificaciones de trabajo percibidas por los colaboradores de una entidad privada son diferentes a las de los colaboradores de una entidad pública. Esto es validado con los hallazgos realizados por Alva y Juárez (2014), quienes al desarrollar una investigación en una empresa privada de Trujillo llegaron a la conclusión que uno de los factores importantes en toda entidad es la retribución económica, ya que, pese a que varios de sus colaboradores eran compensados con días libres al ser convocados a trabajar un día feriado, no se mostraban conformes debido a que esperaban una retribución económica acorde a su esfuerzo y compromiso.

Tabla 5. Relaciones humanas.

Prueba de muestras independientes

Factor IV: Recursos Humanos	Prueba de Levene de igualdad de varianzas		Prueba t para la igualdad de medias						
	F	Sig.	t	gl	Sig. (bilateral)	Diferencia de medias	Diferencia de error estándar	95% de intervalo de confianza de la diferencia	
								Inferior	Superior
Se asumen varianzas iguales	11,331	,001	9,258	148	,000	3,446	,372	2,710	4,182
No se asumen varianzas iguales			9,151	120,122	,000	3,446	,377	2,700	4,192

Fuente: Elaboración Propia

En la tabla 5 se muestra que ante la prueba T y de Levene para la igualdad de medias y varianzas respectivamente, las medias de ambos grupos son diferentes ya que la diferencia de las mismas asume un valor de 3,446. Se aprecia que, al ser el valor de significancia, en ambas pruebas, menor a 0.05 indica que si existe diferencia entre las varianzas. En esta dimensión se refleja que existe un 49% de parcial satisfacción por parte de los colaboradores de la Caja Sullana en contraparte a los colaboradores de la Municipalidad Provincial de Sullana, en donde se encuentra un 36 y 34% de regular y parcial insatisfacción. De igual forma, se evidencia una desigualdad significativa entre la media y la varianza de esta dimensión, dándonos como resultado que existen diferencias importantes entre ambos grupos. Ante lo

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hallado podemos determinar que para los colaboradores de la Caja Sullana existe cierto nivel de agrado en el establecimiento de las relaciones fraternales, confianza y empatía dentro de su línea laboral; mientras que para los colaboradores de la Municipalidad provincial existe cierto rechazo en base a los bajos niveles de satisfacción presentados. Esto es complementado con lo planteado por Mc Clelland (1973), en su teoría denominada teoría de las necesidades, quien sostiene que existen tres necesidades básicas que tiene el ser humano y se desarrollan en base al aprendizaje y el contacto con la experiencia que determinan la satisfacción e insatisfacción laboral, entre ellas tenemos: la necesidad de afiliación que se basa en la capacidad del ser humano de brindar afecto, amor y una buena interacción con la sociedad, prefiriendo satisfacer las necesidades sociales, familiares y afectivas.

Tabla 6. Desarrollo percibido por los colaboradores de ambas entidades.

Prueba de muestras independientes

Factor V: Desarrollo	Prueba de Levene de igualdad de varianzas		Prueba t para la igualdad de medias						
	F	Sig.	t	gl	Sig. (bilateral)	Diferencia de medias	Diferencia de error estándar	95% de intervalo de confianza de la diferencia	
								Inferior	Superior
Se asumen varianzas iguales	177,454	,000	12,749	148	,000	8,976	,704	7,585	10,367
No se asumen varianzas iguales			12,443	78,985	,000	8,976	,721	7,540	10,412

Fuente: Elaboración Propia

En la tabla 6 se observa que ante la prueba T y de Levene para la igualdad de medias y varianzas respectivamente; las medias de ambos grupos son distintos ya que la diferencia de las mismas asume un valor de 8,976. Se puede evidenciar que, al ser el valor de significancia, en ambas pruebas, menor a 0.05 indica que si existe diferencia entre las varianzas. En esta dimensión se refleja una desigualdad significativa entre la media y la varianza de esta dimensión, dándonos como resultado que existen diferencias importantes entre ambos grupos. Esto nos lleva a inferir que la mayoría de los colaboradores de la Caja Sullana se muestran con expectativas de crecimiento y desarrollo profesional dentro de su campo laboral a diferencia de los colaboradores de la Municipalidad provincial de Sullana que no perciben muestras de ascenso ni de perfeccionamiento profesional por parte de su institución. Este hallazgo está relacionado con lo mencionado por Mc Clelland (1973) en su

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teoría anteriormente descrita, en donde una de las necesidades presentadas por el ser humano para lograr la satisfacción laboral es la necesidad de logro que se refleja en el afán por alcanzar los objetivos y demostrar su competencia que lo llevará a su reconocimiento.

Conclusiones

Existe un marco de diferencia entre los niveles de satisfacción de los colaboradores de las instituciones de administración privada y los colaboradores que están sometidos a la administración pública, en la medida que esto genera buena disposición de compromiso ante el ejercicio laboral, y con ello, buena disposición para la atención al público y ofrecimiento del servicio.

Es indispensable que las entidades públicas y privadas generen climas organizacionales adecuados y óptimos que permitan el desarrollo de los colaboradores; así mismo implementar oportunidades de crecimiento profesional que promuevan remuneraciones adecuadas a las especializaciones de cada colaborador, en el marco de la normatividad de la instituciones donde aplican sus funciones laborales; esto con el fin de generar satisfacción laboral en ellos, lo que conducirá a obtener mayor productividad en las actividades que ejercen, y cuya réplica se verá reflejada en clientes satisfechos con los servicios que las entidades brindan.

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