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The Circular Economy of PET bottles in Colombia

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ABSTRACT

Our objective is to analyze the characteristics underlying the implementation of the Circular Economy strategy for Polyethylene Terephthalate (PET) bottles and its influence on the management of such a container in Colombia for deployment and operation. According to Greenpeace International (2018), the packaging "use-and-throw-away" lifestyle has unleashed an emergency that has struck the health of ecosystems and living beings due to the use of plastic. Industries need to speed up their migration from a "linear economy" model, which implies producing, using, and disposing of goods, towards a "circular economy" that maximizes the use of resources and converts their waste into new materials (WEF, Ellen MacArthur Foundation, and McKinsey and Company, 2016). A descriptive methodology coupled with content analysis and in-depth interview was applied to characterize the use of PET bottles in the beverage industry in Colombia. The research identified the logistics chain (recycling - warehousing - transformer-producer - distributor - customer - consumption) and found problems in the recycling stage. PET producers have new responsibilities, namely Postobón, Coca-Cola, and Bavaria, with the first two leading the application of the circular economy on PETs for a decade.

Keywords: Circular economy; Strategies; PET; Implementation; Colombia.

1. Introduction

According to Greenpeace International (2018), "every minute, one garbage truck of plastic is dumped into our oceans." This, as a consequence of humanity's modern "use-and-dispose" lifestyle, has unleashed an emergency that impacts the health of ecosystems and the living beings that depend on them.

The above explains why environmental sustainability has gone from being the pur pose of activist groups to becoming a con cernof ordinary citizens,society and its orga nizations, and industries and governments w orldwide with the U.N.'s promulgation of t he SDGs (2015). For the Global Data agen cy (2018), sustainability ranks second amon g the eight “megatrends” for industrial processes using plastic materials.Given such a scenario, industries worldwide need to speed up their migration from a “linear economy” model, which implies producing, using, and disposing of goods, towards a “circular economy” that maximizes the use of resources and converts their waste into new raw materials (World Economic Forum, Ellen MacArthur Foundation, and McKinsey and Company, 2016).

The Colombian plastics industry is in the spotlight concerning the circular economy because it has failed to invest in science, technology, and innovation to reduce its ecological impact (CONPES, 2016). Colombia produces 12 million tons of garbage per year, and plastic comprises 10.78% of these (Graph 1), making it the second-leading group of solid waste and the first of interest in the circular economy.

The reason for developing this research is that Colombia consumes about 1.2 million tons of plastic a year, of which 56% are PET containers (Procuraduría General de la Nación, 2019 - Attorney General of the Nation’s Office), more than 4,000 million PET bottles a year, and the country only 31% of those (the worldwide average is 78%) (Diario La República, 2019; Ecoembes, 2019).

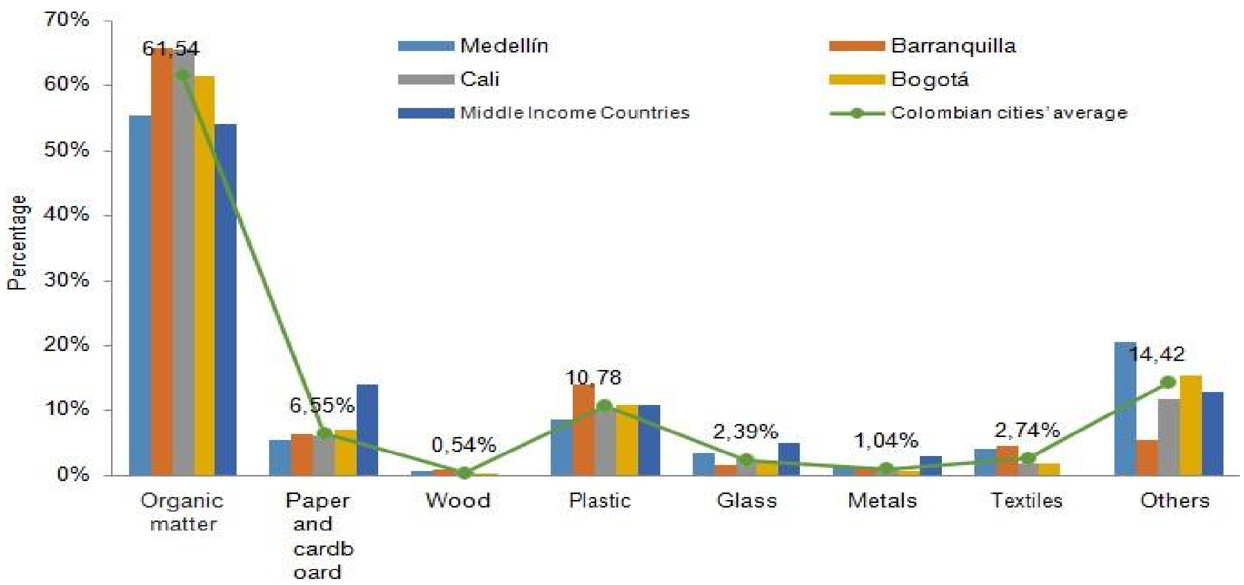
Such a PET recycling problem in Colombia has led to identifying the logistics chain behind it to specifically analyze where each echelon stands within the Circular Economy, determining that the recycling problem is due to the lack of a PET “culture for recycling” by the three leading companies in the beverage sector (Postobón SA, Coca Cola FEMSA, and Bavaria S.A.). In awareness of their responsibility with sustainable development, they have entered into sustainability commitments, as is the case of Coca-Cola FEMSA’s Environmental Declaration (2018), the new Postobón Sustainability Model (2018), and the 2025 Sustainability Goals of Bavaria S.A. (2018).

Therefore, this paper aims to describe the characteristics behind implementing the Circular Economy strategy concerning Polyethylene Terephthalate (PET) and its influence on the Colombian beverage sector’s development for deployment and operation. According to DANE (2020), the beverage sector consists of Division 11, according to the International Standard Industrial Classification (ISIC), as characterized by the production of beverages packaged into PET plastics.

Among the research contributions, the PET recycling problem is analyzed, and the logistics chain is analyzed in a broader Circular Economy-based management context. The consulting firm Acceleratio, focused on transition processes towards the Circular Economy, has identified the most recurring obstacles to rapidly adopting the model, i.e., the lack of support and incentives from governments, consumers’ psychological barriers, markets’ low capacity for recycling, and costly innovation processes or new technologies (Van Eijk, 2015).

The paper is structured theoretically: state of the art, a literature review and theoretical and conceptual framework, the methodology, findings and discussion, and conclusions.

Graph 1. Characterization of solid waste in some Colombian cities



2.Theoretical Structure

2.1.State of the art

The circular economy seeks to keep materials in circular processes, preventing their discarding while promoting their reintegration into the value chain once their useful life is over so as to be converted into new raw materials (Ellen MacArthur Foundation, 2014).

Research such as that by Marcet (2018) and Greenpeace (2018) concluded that waste recycling plays a crucial role in the circular economy, not only because of its impact on the environment but rather because of the way that waste is collected and handled and the promptness and the ability to do so en masse, can lead to higher recycling rates and materials coming back into use.

The Cradle to Cradle theory sustains that the recycling process is insufficient to bring economies closer to an effective circular economy model (Braungart and McDonough, 2002). The solution is not to do the impossible to reduce, reuse and recycle waste, but to effortlessly design the products to be reused from the start, offering circular products thought of as such from the origin (Braungart and McDonough, 2002).

2.1.1.State of the art on the impact of PET plastic.

The study by Gómez (2016) entitled "Diagnosis of the impact of plastic bottles on the environment: A state of the art" identified 60 research articles published between 1993 and 2016. It is highlighted that Colombia is the second country in PET impact studies. The search was 10-year scoped due to the lack of available information about the impact of PET (Tables 1, 2).

Of the 60 baseline papers reviewed, 63% (38) came in Spanish and 37% (22) in English. According to the range of years, the production of the papers is distributed, as shown Table 3.

The importance gained by the publishing articles on the impact of plastic on the environment during the 21st century is palpable (92% of last decade papers were published between 2000 and 2015).

Regarding the studies' country origin (Table 4), its distribution indicates that the American continent (the United States, Colombia, and Mexico) leads the publication of papers in indexed journals: Journal Arbor, Pro Quest-ebrary, Environmental, Water, Air, and Soil Magazine, and Industrial Engineering Magazine.

Gómez's study accounts for the importance of PET studies in Colombia, as it is the second- leading country on studies about the impact of PET plastics. The author maintains that, given the increase in the use of PET plastic, it is necessary to take appropriate measures to mitigate the environmental impact in the industries that package their products using plastic. A strategy to mitigate the environmental impact of plastic is shifting to the circular economy, which companies have undertaken under the SDGs.

Table 1. Information Collection Distribution in Database

Database	Descriptor	Years	N° papers found	N° relevant papers	Language
ProQuest Ebrary	Polyethylene terephthalate its impact on the environment	2004 2008	20	3	Spanish
	Packaging and environment	2006 2009	25	3	Spanish
	Waste and PET plastics	2009 2011	12	3	Spanish
	PET containers	2013 2015	16	1	English
Scielo	Biodegradtion of PET	2005 2007	20	3	Spanish English
Google Scholar	Plastics in Spain	2001 2003	10	1	Spanish
	Plastics	2007 2010	9	2	Spanish
	Problems with PET	2010 2012	13	3	Spanish
	PET plastics	2009 2013	26	3	Spanish

Source: Gómez (2016).

Table 2. Information Collection Distribution in EBSCO HOST

Database	Descriptor	Years	N° papers found	N° relevant papers	Language
EBSCO HOST	Environmental pollution	1993 1999	20	4	English
	Impact of PET	2003 2005	15	5	Spanish English
	Environment impact and PET	2004 2007	6	1	English
	Ecological Plastic	2005 2008	15	2	Spanish
	Studies on PET	2005 2007	20	1	Spanish
	Use bottle	2007 2009	5	1	English
	Packaging Plastics	2007 2011	10	1	Spanish
	PET bottle Chain	2008 2010	7	1	English
	Bottles	2009 2011	14	4	Spanish
	Contaminants from PET bottle	2009 2013	27	3	English
	Increase of PET	2009 2013	20	4	English
	Stress-cracking of PET bottle	2010 2014	13	1	English
	Environment and PET	2011 2014	15	6	Spanish English
	PET plastic	2012 2014	18	2	Spanish
	Bottles of PET	2013 2015	11	1	English
	PET bottles a case Study of Beijing	2013 2015	4	1	English
Source: Gómez (2016).					

Table 3. Distribution of the number of paper by year range

Year range	Number of papers	(%)
1993-1999	4	7
2000-2009	25	42
2010-2015	31	52
Total	60	100
Source Gómez (2016).		

2.1.1.State of the art of the Circular Economy.

Geisendorf and Pietrulla (2017) ascertain that the roots of the notion about the circular flow of material go back decades. Boulding (1966) stated that circular systems framed in the global economy are inevitable to guarantee human life in the long term. Pearce and Turner (1989) relied on Boulding's ideas that the traditional linear economy is unsustainable if not for recycling and, consequently, must be replaced by a circular economic system. Their reasoning is grounded in the second law of thermodynamics (Georgescu-Roegen, 1986) inasmuch as the entropy of an isolated system will increase over time and will devalue the energy or higher-order material. The Circular Economy's waste management policies' roots go back to Germany in 1972, where a waste disposal law was enacted, and the notion of extended producer responsibility developed (Geisendorf and Pietrulla, 2017).

These policies are considered the earliest steps to promote the implementation of the Circular Economy (Andersen, 2007). Another inspiration for the Circular Economy is research on industrial ecology (Preston, 2012) and general systems theory (Von Bertanlaffy, 1968) under the notion that an economy can be analyzed through a holistic and complex systemic thinking approach. Industrial ecology is a root for investigating the Circular Economy through industrial systems and operational optimization analysis.

Park, Sarkis, and Wu (2010) and Stahel (2016) assert that the Circular Economy was born in Europe with the definition of sustainability that has transcended to date, which originated in the analyzes derived from environmental summits and the very statement of growing environmental deterioration problems, such as the Brundtland report (1987) and the concept of sustainable development: "meeting the needs of the present generation without compromising the ability of future generations to meet their own needs."

By defining the circular economy, the author is referring to a "closed cycle economy" that "does not produce waste in excess and whereby any waste becomes a resource"

(Wysoki ń ska, 2016, p. 1). The closed-loop means that the materials remain in the cycle and can be continuously reused. In the Circular Economy, materials remain in the system, and “ waste ” can only exist by being reused (Wysokińska, 2016).

The Circular Economy is interpreted as a new business model (Ghisellini, Cialini, and Ulgiati, 2016) for a sustainable and healthy economy. It tries to incorporate several relevant aspects of sustainable development: social, environmental, economic, and technological (Ghisellini et al., 2016). The Circular Economy concept is an opportunity to transition the economy and develop new and different business models.

The Circular Economy addresses micro-processes in companies, as well as macro- level processes in the economy (Birat, 2015). Through its principles, the Circular Economy encourages an economy ’ s agents to foster a more respectful use of environmental resources (Planing, 2015). Innovators and explicit decision-making tools for the Circular Economy are considered of the essence to facilitate its implementation (Golinska, Kosacka, Mierzwiak, and Werner-Lewandowska, 2015). Lastly, measuring circularity is considered a crucial task, but there is no prevailing opinion on which operation to use. Many different approaches are discussed, most of which refer to the classic eco-efficiency indicators (Shou-feng, 2006) or alternatives such as the “ reuse potential ” indicator of Park and Behera (20 14).

According to Ghisellini et al. (2016), the Circular Economy is misinterpreted as just “an approach to more adequate waste management” (p. 2). Such a perception is enhanced through prevailing principles such as the 3Rs (Reduce, Reuse and Recycle), cited to summarize the core of the Circular Economy. However, this waste-oriented view of the 3Rs is too narrow. The actual notion of the 3Rs within the Circular Economy encompasses a much broader perspective of the economic system, and they can play a more prominent role in its design and implementation in many other areas.

The Circular Economy is broader and can include a detailed regenerative aspect, which refers to recovering materials, as well as using renewable energy solutions (Ghisellini et al., 2016; Ellen MacArthur Foundation, 2014; European Union, 2015). For recovering materials, these are reclassified into technical materials and nutrients. These are two flows of materials: biological nutrients that can be reintroduced into the natural system and artificial, technical ingredients that should be recoverable through industrial recycling mechanisms. The Circular Economy notion comprises Cradle to Cradle, Closed Supply Chain, Industrial Ecology, Reverse Logistics, Blue Economy, Regenerative Design, Performance Economy, Natural Capitalism, and Biomimicry.

Table 4. Distribution of the number of articles by country of origin

Country of origin	Number of papers	Country of origin	Number of papers
USA	13	Australia	1
Colombia	9	Bolivia	1
Mexico	8	Chile	1
Spain	5	China	1
Brazil	4	Costa Rica	1
Cuba	2	Croatia	1
Italy	2	Ecuador	1
Peru	2	India	1
Panama	1	Kenya	1
Venezuela	1	Poland	1
Salvador	1	Uganda	1
England	1	Total	60

Source: Gómez (2016).

Figure 1. The linear economy process

3.Theoretical Framework

The linear economy model is based on the ‘extract-use-discard’ pattern. The Ellen MacArthur Foundation (2014) sums it up like this: companies extract raw materials, manufacture products that they then sell to the consumer, and, at the end of the chain, consumers discard the product that no longer serves them. A representation of the linear economy model is given in Figure 1.

Organización de Naciones Unidas (2015) and Greenpeace (2018), as well as the theories by Braungart, McDonough, and Ellen MacArthur Foundation (2014), indicate that this model is coming to an end. The U.N. has warned about the scarcity of natural resources, and the planet will not have the capacity to supply its needs if the same rates of consumption have kept up by 2050.

In this regard, Greenpeace (2018) points out that the linear economy is accountable for the so-called ‘comfort crisis,’ as it promotes branded products in single-use containers and packaging1, encourages mass production and hyper-consumption, significantly prompting the waste crisis accounting for over 2.1 billion tons of solid waste a year.

The circular economy model is studied through two theoretical perspectives: that of the Ellen MacArthur Foundation (2014),which published the study ‘Towards a Circular Economy: Business Rationale for an Accelerated Transition’; and the ‘From cradle to cradle’ theory, posted by McDonough and Braungart (2002). Per the Ellen MacArthur Foundation, the circular economy “is a restorative or regenerative industrial system by intention and design. It replaces the concept of “expiration” with that of “restoration” (…) and seeks to eliminate waste through optimized materials, products, and systems design and, within these, business models” (2014, p. 4).

It is based on three principles: 1) the circular economy as a systematic process to ‘end waste’: Products are designed and processes optimized to achieve a reuse cycle.

2)Items are designed for reuse. The circular pattern differentiates the consumable and durable components of a product. 3) The invested energy is renewable to reduce the need for new resources and increase the ability for recovery.

The circular economy process is subjected to biological and durable components (Figure 2). The above-described model is effective provided that the concepts developed in the 'Cradle to Cradle' theory are integrated from the birth of the products. Products are conceived in closed production circles under sustainability strategies, thereby mitigating the environmental impact (Braungart and McDonough, 2002).

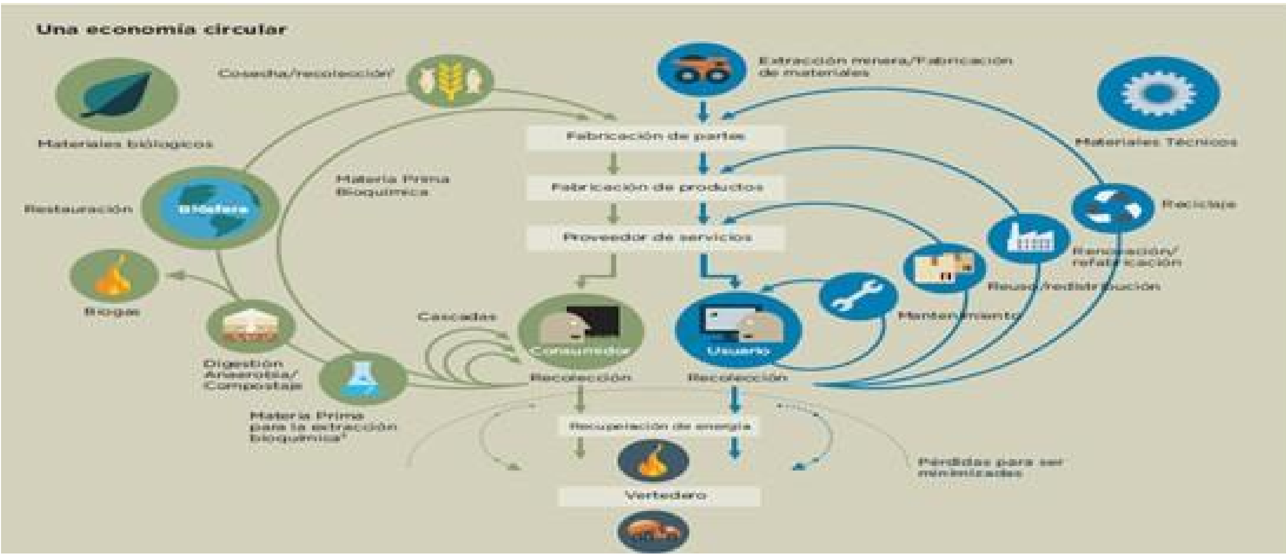


Figure 2. The circular economy process

3.1.International and Domestic Contextual Framework

By 2019, globally speaking, the Circular Economy leading country with the most public policies, most research, and patents was China, which has developed Circular Economy policies for about 20 years, perhaps under other names. However, nowadays they are number one, followed by the union of the Nordic countries and the Netherlands (the third-leading country on the issue); lastly come the countries of Latin America, which very soon will begin to stand out (Diario La República, 2019).

In Latin America, the circular economy is a hybrid issue that is just beginning to gain strength; there has been a boom since 2018. The Diario La República (November 22, 2019) interviewed Petar Ostojic, the first Circular Economy promoter in Latin America, according to the World Economic Forum (WEF). He asserts that Chile has adopted public circular economy policies through Corpo with programs that have already identified ventures and the creation of a Circular Economy Center worth USD

22 million. In Colombia, strategies driving several entrepreneurs and initiatives, such as Dow, have been recorded. Uruguay and

Mexico are developing an economy on this issue.

According to Ostojic, the circular economy promotes development because it entails a three-fold benefit: economic, social, and environmental development. The waste produced in Latin America is far from what developed countries in Europe produce; however, when it comes to recycling, Europe's rates are around 40% or 45%, whereas no Latin American country surpasses the 10% mark (Diario La República, 2019). There is still 30% or 35% to go to create more recycling-related jobs and entrepreneurship, which entails economic development. If taken the leap from the linear to the circular economy, entities such as the International Labor Organization have recorded that circular economy models can create up to six million in Latin America alone (Diario La República, 2019).

Regarding implementing the Circular Economy in Colombia, Ostojic sustains that it has been quite fast since it began in 2018 as Journals publications have it. Currently, it is part of the government strategy, which will be a before and after for Colombia, thus becoming a circular economy example due to the volume it represents and the importance of its market and industries (Diario La República, 2019). Of the 78 million tons of plastic produced per year, only 2% is reused, while developed countries' average is 40% and Latin America's 10%.

One of the factors holding the Circular Economy back in Colombia is the culture: people have begun to understand the difference between circular economy and recycling, and the importance of maintaining materials' worth for the longest time, rather than living a linear economy that thrives in planned obsolescence; the industry: this sector is regarded as an opportunity that allows developing environmentally-friendly industries (Diario La República, 2019).

4.Methodology

A qualitative study with descriptive features was conducted. The Qualitative Study methodology makes an intensive and holistic description and analysis of a phenomenon given by an organization, group of people, or a process (Merriam, 1988; Yin, 1994). Based on research-research theoretical foundations, the methodology included structured interviews and document analysis as a secondary source of information to characterize the implementation of the Circular Economy on PET containers.

Structured interviews were administered to nine executives from companies in the PET circular economy logistics chain in Colombia: a general manager of a PET recycling warehouse; a vice-president and a country manager for the two most crucial recycled- PET transformer plants in Colombia; a PET and recycled PET raw materials supplier's general manager; and five executives from PET-demanding companies: three sustainability managers, a sustainability director, and a Marketing director.

Each interview lasted one hour on average to describe the comments of each manager and then move on to characterize the circular economy on PET.

Below is the structured interview administered to all managers:

1.What does Circular Economy mean to you?

2. State your point of view on Resolution 1407 of July 26, 2018 (Extended Producer Responsibility - REP)

3.State your point of view on the ANDI's efforts to comply with the REP.

4.What do you consider to be the main obstacles to adopting the circular economy model in Colombia?

5.What is the status of companies such as Bavaria SA, Postobón SA, and Coca-Cola FEMSA?

6.What is your point of view on the production of PET containers in Colombia regarding quantity, quality, price, and the number of suppliers?

7.What do you know about PET-containers recycling in Colombia regarding the number of companies, capacity, quality, pricing, and challenges?

8.What circular economy ecosystem variables and stakeholders can be applied in Colombia concerning PET containers?

9.What are the PET-containers circular economy ecosystem variables restricting its implementation in Colombia?

Five documents were consulted, the analysis of which allowed characterizing the Colombian legislation on the Circular Economy concerning PET (CONPES and MADS), identifying the REP whereby producers are more strongly responsible for the implementation of the circular economy on PET by undertaking new functions. Furthermore, 26 documents about sustainability and circular economy issues and eight documents concerned with the circular economy in Colombia and PET in Colombia were reviewed. In this sense, the documents were described and analyzed for characterizing the circular economy on PET.

5.Results and discussions

In Colombia, public policy guidelines led by the Ministry of Environment and Sustainable Development (MADS per its acronym in Spanish), such as CONPES Document 3874 of 2016 and MADS Resolution 1407 of 2018, have been issued regarding the integral management of solid waste and the circular economy.

5.1.CONPES Document 3874 of 2016

Document CONPES 3874 outlines the national policy for the integral management of solid waste. Solid waste management articulates an environmental outlook with the public service component, a priority in national public policy. From solid waste as an integral process, progress is made towards the circular economy, "… which seeks to maintain the value of products and materials for as long as possible in the production cycle" (CONPES, 2016, p. 3). Products and materials tend to maximize use over time, reducing their impact on the environment and mitigating climate change.

The Strategic Axes of the national policy for the integral management of solid waste as an economic and environmental purpose (CONPES, 2016, p. 4) are: 1) adopting measures on (i) prevention regarding the waste generation; (ii) the minimization of those wastes that go to final disposal sites;

(iii) promoting solid waste reuse, use, and processing; and (iv) avoiding the generation of greenhouse gases; 2) improving citizen culture, education and innovation in comprehensive solid waste management to increase rates of separation at the source, use, and processing. The two additional axes account for the creation of an institutional environment for stakeholder coordination.

3)assigning specific, clear roles to all participating entities to have them lead organic waste processing activities and urban inclusive recycling systems strengthening, among other things; 4) implementing actions to improve monitoring, verification, and dissemination.

5.2.MADS Resolution 1407 of 2018

In Colombia, the Circular Economy model is still incipient. The National Circular Economy Strategy was only approved in 2018, wherein the Government encourages producers, suppliers, and consumers to develop and implement new business models that incorporate waste management and efficient material handling (MADS, 2018). The structure of the National Circular Economy Strategy is based on the SDGs to achieve efficiency through systems optimization, added value, and seizing opportunities (Figure 3).

The objective of the National Circular Economy Strategy is to maximize the added value in production and consumption systems in economic (profitability), environmental (climate change), and social (employment) terms, with circularity in the flow of materials, energy, and water; fixing action fronts (Figure 4).

The MADS designed mechanisms such as regulatory adjustment, development and innovation, knowledge and research, cooperation scenarios, financial instruments management, and the incentives for transitioning to the circular economy. The National Circular Economy Strategy developed lines of action regarding industrial materials and products, container and packaging materials, biomass optimization and use, water circulation, energy sources and use, and consumption of materials in cities.

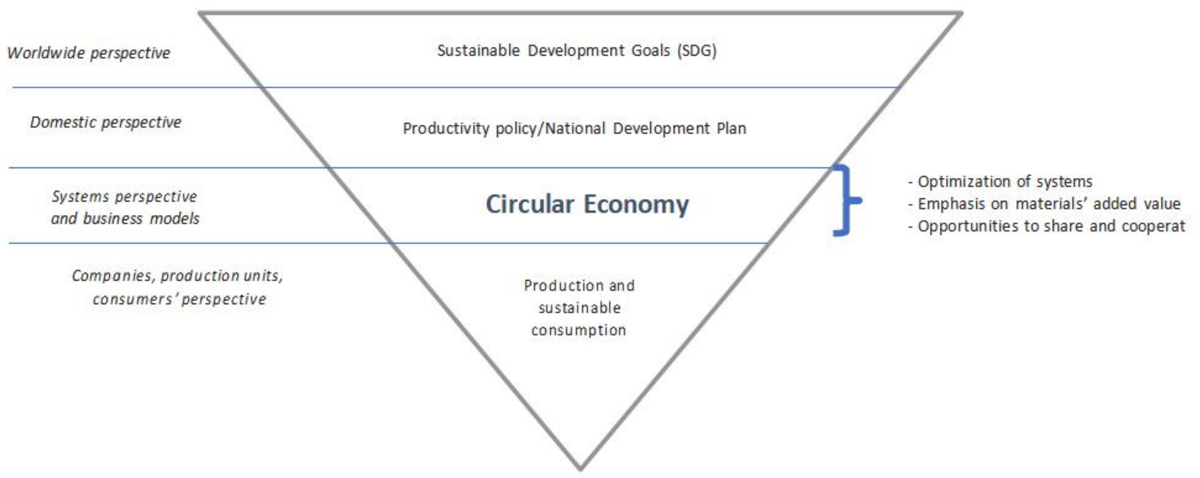


Figure 3. National Circular Economy Strategy
Source: MADS (2018)

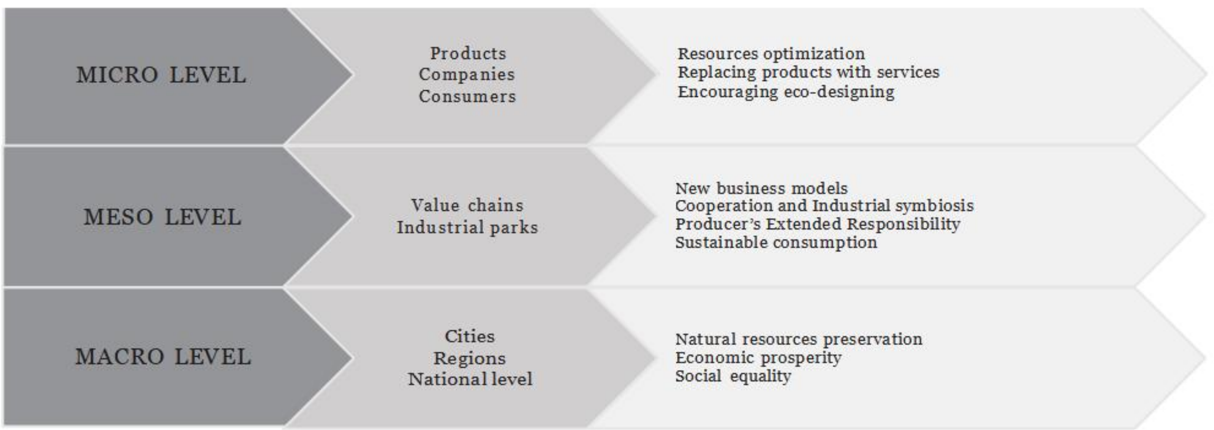


Figure 4. National Circular Economy Strategy Action fronts
Source: MADS (2018).

MADS and the Ministry of Commerce, Industry, and Tourism structured the National Circular Economy Strategy, which will transform the country's production and consumption chains through efficient materials, water, and energy management.

The strategy encourages producers, suppliers, consumers, and other stakeholders to the production and consumption systems to implement new business models that incorporate waste management, efficient material handling, and a change in lifestyles (MADS, 2018).

By mid-2019, MADS worked on disseminating the Circular Economy Strategy, holding regional workshops throughout

Colombia. The workshops' objectives were to disseminate the National Strategy, commit the regions to its implementation, identify regional initiatives for inclusion in a national portfolio, make them visible, and identify the barriers hindering the shift to business sustainability (MADS, 2019).

Furthermore, some Circular Economy Strategy goals have been set for 2022, which aim to increase recycling and waste use rates, which today stand at 8.7%, to 17.9% by 2022. The solid waste rate made the most out of is expected to climb from 17% to 30% by 2030. An increase in hazardous and special waste tons subject to post-consumption management is estimated to jump from 218,427 to 565,995 tons made the most out of by 2022 (MADS, 2019).

MADS (2018) Resolution 1407 provides that the business sector must make the most of use out of 30% of the material used for containers and packaging by 2030, in abidance by the sustainability strategies for the business sector and citizens' expectations. To take on the challenge, the ANDI Magazine (November 2019) prepared an issue entitled "Circular Economy: ANDI's Grand Bet." According to Ibarra (2019), deploying the circular economy on containers and packaging attests to Colombia's transition towards it.

5.3.Entrepreneurs' perspective on the Circular Economy Strategy

Developing the National Circular Economy Strategy entailed consultation among several stakeholders from the public and private sectors, academia, and civil society, regarding the transformation of production systems. Regional workshops and sectoral consultation sessions were held in different cities to publicize the strategy. Thus, productive guilds such as ANDI were in charge of leading the articulation of the strategy.

The 30/30 vision proposed by ANDI will develop in stages: Firstly, creating a democratic multisectoral organization, with market representation and a collective outlook to lead start-up actions; secondly, regional at-source separation, collection, and use models will be identified and implemented to enable the future scaling up of harvest rates as required under Resolution 1407 of 2018; thirdly, progress will be made in strengthening the value chains of packaging materials and in promoting new solutions; fourthly, eco-design practices will be encouraged, facilitating decisions that increase investments and alternatives to close the materials cycle, generating knowledge (ANDI, 2019).

5.4.Field research results

The description and comments from managers of companies in the recycler, deposit, transformer, and producer echelons of the Colombian PET circular economy chain yielded that:

ANDI's business sector-oriented efforts to abide by the Extended Producer Responsibility are positively viewed since it is a collective, guild, sectoral, integrating effort, which facilitates the MADS ' s work towards Colombian industry sustainability in the short, medium, and long term through the return of packaging materials. On the other hand, some producers believe that neither the government nor the ANDI are clear on circular economy affairs.

The leading PET producers in Colombia are Coca-Cola, Postobón, and Bavaria. The latter has played as a plastic containers producer for 15 years, and some of its specific characteristics are that it currently produces about 14,000 tons worth of amber PET a year for Pony Malta, which is much more complex to produce and recycle than other types of PET due to its manufacturing and processing requirements.

Colombian PET materials suppliers and demanders (transformers and producers) have shown their gradual adaptation and adherence to their new sustainable development-imposed responsibilities; however, they are aware that there is still much to be done. Some market players, such as San Miguel and Enka, were observed to perform as offerors in volume and technology, thereby serving a non-neglectable market share.

Virgin PET is not produced in Colombia; however, there is an adequate imported supply in terms of quantity, quality, price, and the number of suppliers, meaning that there are no supply problems. Nevertheless, the price depends on macroeconomic factors such as oil and a 10% tariff with which this product is taxed.

5.4.1.Main obstacles to the Circular Economy on PET in Colombia.

The main obstacles were accounted for by describing the logistics, recycling, deposit, transformer, producer, distribution, consumption, reuse chain. Concerning recycling, Colombia lacks a home-instilled culture of at-source separation, wherefore it is up to the recycler to fulfill that function; furthermore, some packaging companies fail to incentivize the recycler.

The producers regarded different political actors ' competencies as disarticulated and mixed-up, be it municipalities, governorates, or superintendencies, which go beyond the Producer's Extended Responsibility.

Per the transformers, there are three obstacles: public policies that fail to encourage the implementation of recycling initiatives; an incipient civic culture on the issue of recycling and sustainability (because there is no awareness on separation at the source); and the economic and technological barriers, which go hand in hand, for such initiatives demand substantial investments and they lack such financial leverage.

Moreover, some other obstacles were listed, such as recyclers not being welcomed everywhere, inadequate supply of good- quality recyclable materials, and end consumer awareness that they need to do things correctly right at the separation at the source.

5.4.2.Market formation and advancements.

The companies involved in the Colombian PET plastic production chain sustain that they are working faster than the Government. Companies such as Postobón SA and Coca Cola assure that they already implemented circular economy models, wherein 46% and 36% of their materials and packaging come from recycled material (Postobón, 2018; Coca Cola, 2018).

Bavaria is working together with the industry to move forward on implementing the standard on return above seizing issues, working closely with Postobón and Coca-Cola-Femsa. Bavaria is especially concerned with amber PET because Malt is sensitive to light due to its components. Moreover, amber PET undergoes a complex transformation process, a disadvantage for reuse.

Transformers partly drive sustainability through initiatives that help secure Circular Economy processes and favor the articulation of all actors into the chain.

Those most favored by the PET issue are Coca-Cola and Postobón. San Miguel, the owner of Apropet, is serving Bavaria; it is the one that delivers the recycled material for Pony Malta preforms, those are Amber PET.

For its part, Postobón is using Iberplast material and making its own preforms using ENKA material.

5.5.Colombian PET Circular Economy Ecosystem Description

The actors to the PET packaging circular economy ecosystem in Colombia base their Cradle to Cradle design on the application of eco-design and industrial production (Figure 5). Describing the logistics recycling, deposit, transformer, producer, distribution, consumption, collection, reuse chain.

A PET Circular Economy Ecosystem for Colombia was built as a result of the research description and induction (Figure 6). The formation of the Colombian ecosystem for the circular economy strategy is grounded, in the first instance, in the Paris Agreement and the Sustainable Development goals, which some countries committed to support and further with a view towards 2030 when global warming would reach a 2ºC maximum (United Nations, 2015).

In the second instance lie sustainability components: the social component consisting of the community, the family, collectors and/ or recyclers, NGOs, and national bodies such as the social fabric; the economic component, made up of producers, suppliers, distributors, clients, consumers and production guilds, characterized by exchange relations within the economy; and the ecological component that consists of collectors/recyclers,warehouses, and transformers, characterized by interactions for a circular flow (EMF, 2014).

In the third instance, the State and its many executive and control agencies take charge of formulating regulations on ecological and/or environmental matters to achieve sustainability for social, economic, and environmental activities in the short, medium, and long term.

Finally, environmental conditions shaped by government policies, the economy and the markets, culture and social fabric, and geography and infrastructure constitute the environment for sustainability (EMF, 2014).

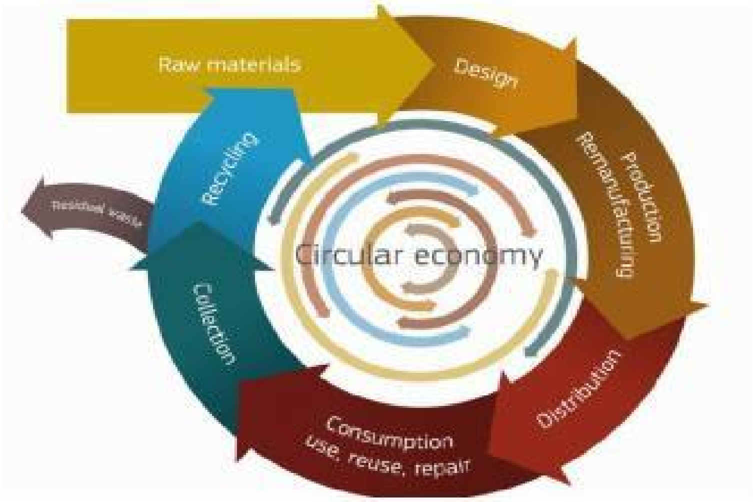


Figure 5. Circular Economy Model Diagram

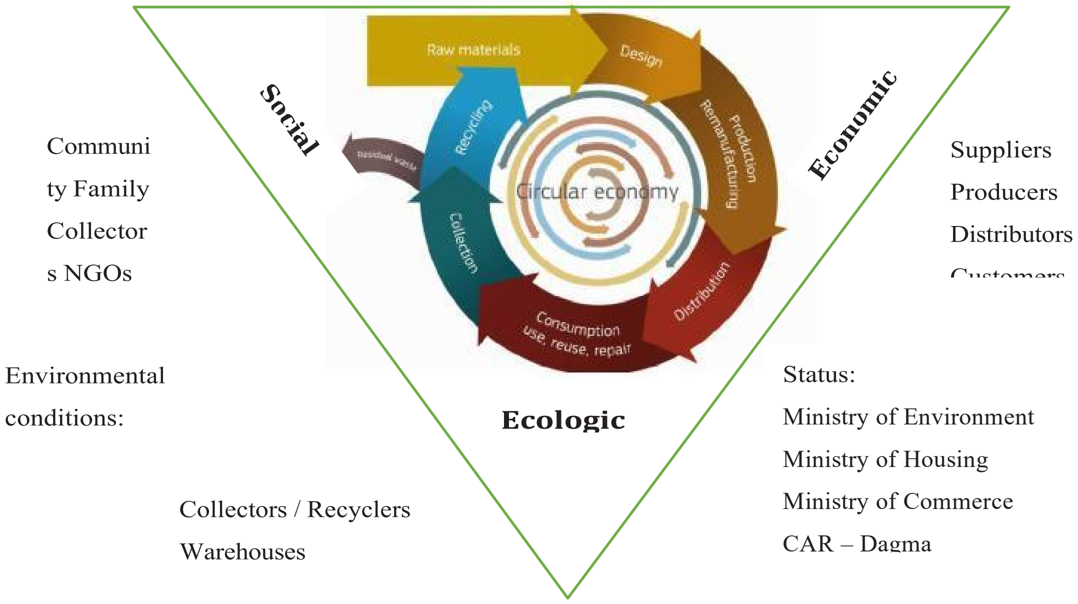


Figure 6. Colombian Ecosystem for the PET Circular Economy Strategy
Paris Agreement: Sustainable Development Goals

6.Conclusions

As seen from Colombian producers', processors', and recyclers' perspectives, the current state of the PET circular economy possesses particular characteristics, not because of the number of competitors, but because of the complexity inherent to the various exchanges within a PET packaging logistics chain. This chain becomes more complex under the Producers' Extended Responsibility since the government is no longer tasked with collecting packaging waste but rather the PET packaging producers themselves.

The various exchanges within the Colombian PET packaging logistics chain account for a series of actors such as recyclers, recycling depots, processors, producers, distributors, clients, consumers, and households, who must coordinate and align themselves so that PET material undergoes the proper, desired return. The problem is that there is no such coordination that enables the expected return and efficient recycling because the logistics chain lacks the culture and social fabric that foster return.

There are approximately 60,000 recyclers in Colombia and 4,400 recycling warehouses, making the supply of recycled PET dynamic. The EKORED recycling plant suggests the need to integrate the recyclers and to have the producers incentivize them so that the recycler-deposit logistics chain will effectively transform the PET in the bottles. Since recyclers are paid per kilogram for of material collected, they seek out the heaviest PET containers they can collect en masse in order to increase their income, preferring virgin PET over Bavaria's Pony Malta bottles amber PET (the company only recycles a small amount of it in just one of its plants).

Transformers demand recycled PET for transformation; however, not all PET material or waste is capable of transformation due to the risks it entails for the machinery. At present, there are PET transformers in Colombia (ENKA and Apropet), which produce about 100,000 tons of virgin PET per year as an additional offer to bottle-to- bottle recycling. Regarding amber PET, its conditions deteriorate due to collection/ recycling times, wherefore some favorable conditions are needed for its recycling and transformation.

The Colombian PET container market is complemented by PET-requiring beverage producers' demand for containers, including FEMSA, Postobón, and Bavaria. The first two have been producing beverages in the Colombian market for 25 years and are the ones that demand the most PET containers. As for Bavaria, it entered the amber PET container market ten years ago, and its production is limited compared to its competitors.

The lack of articulation between the circular economy logistics chain echelons, before and after MADS Resolution 1407 of 2018, whereby the circular economy strategy is implemented, is at present one of its development problems due to interpretation. Due to it being enacted until recently (in 2018) and limited dissemination, a waiting period is suggested for effective implementation; ANDI has taken up a relevant yet lacking leadership, as it waits for other institutions to show up and complement it and undertake the commitment. For adherence to Resolution 1407 on PET Producers' Extended Responsibility, investment is needed to continue strengthening the logistics chain regarding waste management and innovation in identifying new materials.

Finally, it should be noted that the Colombian population lacks a culture for recycling as the starting point that allows the Circular Economy Strategy to be applied appropriately. In that regard, environmental population-aimed education campaigns on recycling are needed.

7.Conflict of interest

The authors declare no conflict of interest.

8.Source of Financing

The research is sponsored by authors own resources.

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Innovating Artificial Intelligence for Workforce Preparation and Knowledge Development

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Abstract

Artificial intelligence (AI) transforms workplaces by streamlining operations, automating tasks, and enhancing decision-making. To bridge the knowledge gap in AI best practices, a workshop was created for executives, integrating change management principles. The workshop aimed to help participants understand AI's role, use AI tools for predictive analytics, and develop strategies for leveraging AI in change initiatives. This paper outlines the workshop's impact on building confidence, knowledge, and positive attitudes towards AI in the workplace.

Keywords: Artificial Intelligence (AI); AI knowledge; Organizational change; Confidence

1.Introduction

Artificial intelligence (AI) is the process of programming machines to perform tasks that generally require human intelligence. AI is transforming the way we interact with each other, altering not only our daily lives but also reshaping our work environment. In the workplace, AI streamlines operations, automates repetitive tasks, and enhances decision-making processes. From analyzing massive datasets to predicting market trends, AI empowers businesses to make strategic decisions swiftly and accurately. Moreover, AI-driven technologies facilitate personalized experiences for customers, improving satisfaction and loyalty. As organizations strive to stay competitive in today › s AI driven market landscape, integrating AI into their operations becomes not just advantageous but essential for sustained growth and success. This necessitates the introduction of AI practices amongst executives.

In an effort to bridge the knowledge gap surrounding artificial intelligence (AI) dissemination, particularly concerning best practices, within the organizational workforce, an AI workshop was created that incorporated change management principles. Change management is the systematic approach and set of practices aimed at effectively planning, implementing, and monitoring organizational changes to ensure smooth transitions, minimize disruptions while maximizing de- sired outcomes. When considering the integration of

AI into an organization, this needs to be done carefully with CM at the forefront.

The goals of this workshop were to help workers understand the role of AI in the organization, under- stand how to use AI tools for prediction analytics, help to explore AI-driven tools and techniques for enhancing stakeholder engagement and communication, help in the development of strategies for leveraging AI to support the adoption of change initiatives, and to help workers gain insights into real-world applications and case studies where AI facilitated effective change management.

The aim of this paper is to outline how artificial intelligence (AI) a workshop designed for teaching AI to start-up executives, to help learning the process of integrating AI into the workplace, referred to as change management (CM). The 4-day workshop helped with creating confidence, knowledge, and changing attitudes surrounding AI and its importance in the workplace.

2.Methods

2.1Program description

This AI workshop was conducted in Beijing, China from July 1–14th 2023, where all participants were start-up executives. The AI workshop contained 8 modules, spread over 4 non-consecutive days. Participation in this workshop was completely voluntary. Participants were recruited through email. For all participants who volunteered to participate in the workshop, a survey was administered before the start and at the end of the workshop. All surveys were administered online, while all workshop events took place in-person.In order to participate in the workshop, participants were required to attend all 4 days of the workshop and complete both surveys. Since the workshop was administered in English, all participants were also required to speak English. Only participants who gave informed consent were able to participate in the workshop.

2.2Workshop details

The AI workshop spanned four days, focusing on integrating artificial intelligence (AI) into change management (CM). On Day 1, participants were introduced to AI and CM concepts, exploring the relevance of AI technologies in change management. They delved into theoretical frameworks for AI›s role in CM, identifying potential AI applications within their organizational strategies through an activity called “AI Change Agents”. Day 2 focused on AI tools and techniques, teaching participants how to use AI-driven analytical tools for predictive analytics to assess change impacts and plan integrations. They also learned to enhance stakeholder engagement using AI, culminating in an activity where they designed AI-enhanced communication plans. Day 3 involved implementing AI in change initiatives, with case studies showcasing successful AI-facilitated changes and discussions on overcoming common obstacles. Participants engaged in an “AI Change Management Simulation” to apply AI concepts in managing a change scenario. On the final day, the focus was on building AI-ready CM strategies and exploring future trends in AI and organizational change. Participants discussed emerging AI technologies and their potential impacts, sharing insights and predictions in an activity titled “AI in Change Management – Vision 2030”. The workshop concluded with a wrap-up session, where participants reflected on their learnings and developed action plans for applying AI in their change management efforts.

2.3Measures

Pre- and post- workshop surveys required participants to answer questions about their attitudes, knowledge, and their confidence towards interacting with AI in the workplace using a 5-point Likert scale (1strongly disagree, 5strongly agree). Each survey consisted of 27 questions where knowledge, attitudes towards AI, and confidence of participating in an integrated AI work environment were evaluated. Statistical analysis was done on all data collected at the beginning and end of the 4-day workshop.

2.4Statistical analysis

Statistical analysis of all 27 items was conducted on pre- and post- workshop surveys using a Cronbach’s alpha, to determine knowledge and attitudes towards AI before and after the workshop. Co- hen’s d was used as a measure for effect size. Next, Mann-Whitney U Tests were performed to determine if there were any significant differences between items between the pre- and post- workshop survey.

3.Results

3.1Participants

Of the thirty people who attended the AI workshop, all 30 participated in the 4-day workshop. All participants who attended also completed the pre- and post- survey, so all participants were included in the analysis.

3.2Reliability analysis

The Cronbach’s alpha coefficient for all items in the pre- and post- survey were = 0.98 and = 0.96, respectively, indicating high internal reliability be- tween each item in order to measure knowledge, attitudes, and confidence towards AI.

3.3Pre- and post-survey evaluation

There was a significant improvement on knowledge, attitudes, and confidence towards AI ($n = 30$, $p < 0.002$, $W = 0$) with large effect size ($d = 0.78$).

3.4Difference between pre- and post-workshop survey

Table 1 shows the results of paired Mann-Whit- ney tests for each item. There was a significant increase in participant understanding of AI based tools in their field ($p = 0.043$, $W = 40$). Participants believed they were more able to utilize AI tools in their field ($p = 0.045$, $W = 52.5$). There was also a significant increase on participant's ability to utilize AI tools for adaptive feedback (p = 0.024, W = 53), and for personalized learning (p = 0.028, W = 37).

Table 1. Difference between pre- and post-workshop survey

item	question	N	Pre-percent(4+ Likert) in %	Post-percent(4+ Likert) in %	P-value	Effect size
1	I know how to interact with AI-based tools in everyday life.	30	43	47	0.48	–0.13
2	I know how to perform certain tasks using AI-based tools.	30	43	60	0.11	–0.31
3	I know how to initiate tasks based on AI technology through text or voice.	30	37	50	0.13	0.15
4	I have enough knowledge to use AI-based tools.	30	27	33	0.17	0.32
5	I am familiar with AI-based tools and their technical capabilities.	30	17	30	0.12	0.25
6	I understand the impact of AI tools on my field of work.	30	50	60	0.06	0.29
7	I can assess the usefulness of feedback provided by AI tools for work.	30	43	60	0.11	0.36
8	I can choose AI-based tools for knowledge application.	30	47	53	0.19	0.24
9	I know how to use AI-based tools to enhance learning efficiency.	30	30	37	0.34	0.18
10	I can interpret messages from AI-based tools to provide real-time feedback.	30	37	50	0.21	0.32
11	I understand AI-based tools and their applications in the workplace.	30	43	53	0.14	0.28
12	I have sufficient knowledge to choose AI-based tools.	30	23	37	0.09	0.32
13	I can use AI-based tools to search for relevant information in my field of work.	30	53	53	0.54	0.11
14	I know that professionals in my field of work use various AI-based tools.	30	33	40	0.25	0.22
15	I can use AI-based tools to better understand the content of my field of work.	30	37	30	0.85	0.04

Table 1continued

item	question	N	Pre-percent(4+ Likert) in %	Post-percent(4+ Likert) in %	P-value	Effect size
16	I know how to utilize AI-based tools specific to my field.	30	23	27	0.40	0.18
17	In my field of work, I know how to use different AI-based tools for adaptive feedback.	30	23	43	0.03	0.42

18	In my field of work, I know how to use different AI-based tools for personalized learning.	30	30	53	0.03	0.41
19	In my field of work, I know how to use different AI-based tools for real-time feedback.	30	23	50	0.01	0.48
20	I can use various strategies to optimize work efficiency using AI-based tools.	30	23	47	0.02	0.45
21	I can appropriately integrate AI tools into content optimization for my work.	30	37	50	0.11	0.30
22	I can take a leadership role among colleagues in integrating AI-based tools into our field of work.	30	27	33	0.11	0.20
23	I can choose various AI-based tools to monitor my work performance.	30	27	20	0.52	0.12
24	I can evaluate the effectiveness of AI-based tools in my work.	30	37	43	0.17	0.25
25	I can assess whether AI-based tools can improve efficiency in my work.	30	37	40	0.36	0.17
26	I can understand the legitimacy of any decisions made by AI-based tools.	30	37	53	0.08	0.33
27	I can understand who is responsible for the development of AI tools in their design and decision-making.	30	33	37	0.31	0.19

3.5Overall attitudes

In the pre-workshop survey 43% of participants had the ability to utilize AI tools, while after the workshop 60% of participants felt more confident in their ability. There was also an increase in the percentage of people who have knowledge about AI with only 47% of participants having knowledge in the pre-workshop survey, to 67% now having knowledge upon completion of the workshop.

4.Discussion

There were significant changes in attitudes and knowledge towards AI from before the workshop to after the workshop. There was an increase in the number of participants who claimed to have gained knowledge and increase their ability to utilize AI in their organization. Attitudes towards AI increased across all items, however, there was significance observed across ability to use AI tools. These results suggest that administration of an AI workshop is useful for helping executives understand AI, integrate AI into their companies, and better prepare them for the changing AI climate.

Participant knowledge was calculated based on Lik-ert scale values of 4 or 5, 5 being the highest possible. There were a significant number of participants whose responses increased form a from 1 or 2 to 3, however, since a value of 4 was not recorded in the post survey, they were not considered as gaining knowledge, even though, based on their response, they did. If all increases were considered, then the total number of post-workshop participants who felt confident after the workshop from 60% to 97%. Equally, the number of post-work- shop participants who gained knowledge about AI goes from 67% to 93%.

The entire workshop was done over the course of 4 days over a 2-week span, which means that the course did not take place in 4 consecutive days. The choice of this style of administration was cater to the schedules of the participants in the program. It seemed advantageous to spread out the workshop which we believed would protect against attrition. Although this did protect against attrition as all participants participated in the entre workshop, it can be argued that a consecutive-day workshop protects against fragmentated learning and allows for a more cohesive and immersive experience. However, in this workshop, increased learning was still experienced. This could also be due to the small size of workshop. It is possible that with higher attendance comes an increase in attrition and a need for restructuring the way the workshop is administered. This will be considered in future implementations of this workshop.

Most of the participants found the workshop useful and were able to gain from it. A future survey should be conducted to track whether any of the principles learned have been implemented and to find the strategies most used.

The survey used was the 5-point Likert scale for accessing knowledge, confidence, and utilization of AI tools. It seems to be asking the correct questions to access the outcome of the workshop as a Cronbach's alpha coefficient of = 0.98 and = 0.96 for the pre- and post- survey, respectively, was received. Another component that should be added to this survey are comments about the workshop on the post-workshop survey, and what each participant is hoping to get out of the workshop, on the pre-workshop survey.

A limitation of the study is that the size of the group was low with 30 participants, although having a larger group may not be as advantageous for learning. This was not tested. Another limitation is that there is currently no follow up analysis to determine the effectiveness of the workshop in practice. Future work will follow up on participants to understand which learning objectives or modules were most effective and that they are currently using.

5.Conclusions

This paper evaluated the efficacy of an artificial intelligence (AI) workshop held for start-up executives to help with understanding AI tools and integrating them into their companies. Upon completion of the workshop, participants were able to gain a better understanding for AI, able to utilize different tools that allow for the success of their companies while considering a change management plan for integrating AI.

Conflict of Interest

The study has no conflict of the interest.

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TWO DECADES OF RESEARCH IN HUMAN MOVEMENT SCIENCE IN COSTA RICA: FUTURE GROWTH AND DEVELOPMENT

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ABSTRACT

Rojas-Valverde, D. (2023). Two decades of research in human movement science in Costa Rica: future growth and development. PENSAR EN MOVIMIENTO: Revista de Ciencias del Ejercicio y la Salud, 21(1), 1-20. This manuscript provides a thorough analysis of the two- decade study of human movement science in Costa Rica, emphasizing the noteworthy expansion and advancement of the field. To enhance athletic performance, avoid injuries, treat diseases, and encourage physical exercise, researchers in Costa Rica have developed in-depth analyses, from the basic mechanics of human movement to the development of novel methods and technologies to do so. This article also looks at the potential for Costa Rica to become a leader in the field of human movement science research in the region, as well as its future growth and development. To spur innovation and enhance the outcomes of this research, the author discusses the significance of collaboration with specialists from across the world as well as the requirement for ongoing investment in research and development. The future challenges section provides keys to maintaining the exponential growth of recent years to foster development in issues such as the participation of women in the area, the permanent renewal of study plans, and the incorporation of cross-cutting axes of systematization and research in academic and labour processes. Finally, this study offers a path for the development of human movement science research in Costa Rica, with the potential to significantly move forward in the worldwide endeavour to enhance human movement, performance, and health.

Keywords: sports medicine;physical activity; Costa Rica

Introduction

Human movement science (HMS) is an interdisciplinary field that aims to understand the mechanisms and processes involved in human movements. The broad spectrum of

HMS is interrelated with areas such as sport and exercise medicine, sport and exercise science, health promotion, sports and exercise pedagogy, among others. The HMS is a specialized area of study that focuses on the application of knowledge related to the mechanisms and techniques for restoring and optimizing human functional capacity and well-being throughout the lifespan (Elliott, 1999).

In addition, this area of study contributes significantly to optimal physical functioning in sports and health. The objective of this field is to improve our understanding of human movement, with the goal of supporting physical activity in all aspects of daily life, including occupational and recreational activities (Malm et al., 2019). The study of human movement offers valuable insights into the physiological, neural, and psychological adaptations that occur as a result of exercise. Additionally, it sheds light on the role of regular physical activity in preventing and managing chronic diseases (Matheson et al., 2011), and the mechanisms by which the brain controls and coordinates everyday movements (Sallis, 2009).

Human movement research has played a significant role in the development of Costa Rica's sports and health industries over the past two decades. Researchers in Costa Rica have explored various aspects of HMS, including biomechanics, motor control, and neuroscience of movement. This research has contributed to the development of cutting- edge technologies (Chavarría-Fernández et al., 2023) and techniques that improve movement performance (Arias-Oviedo et al., 2019), prevent injury (Rojas-Valverde et al., 2019), and promote physical activity in Costa Rica (Barrantes-Brais et al., 2015) and beyond.

In addition, Costa Rica has become a hub for HMS research in Central America, with its researchers collaborating with experts from around the world to advance the field. This collaboration has led to innovative approaches to the study of human movement, and the development of new treatments and interventions for movement disorders (Rodriguez- Hernandez et al., 2022; Villalobos Viquez et al., 2022). With the continued growth and development of HMS research in Costa Rica, the country is poised to become a leader in the region, making significant contributions to the global effort to improve human movement and health, especially in Latin America.

In recent years, there has been significant growth and development in the field of HMS, as researchers in the country continue to explore new ways to improve movement performance (Gamonales et al., 2022), prevent injury (Gamonales et al., 2022), and promote physical activity (Jiménez et al., 2022; Villalobos Viquez et al., 2022). For example, advancements in technology have led to the development of new tools and methods for analyzing human movement, such as wearable sensors and motion capture systems (Chavarría-Fernández et al., 2023). These tools have enabled researchers to better understand the mechanics of movement and to develop more effective training and rehabilitation programs.

Costa Rica is a country that has been at the forefront of this growth and development in HMS in Central America. Researchers in Costa Rica have been studying various aspects of human movement, from the biomechanics of sports performance to the neurological basis of movement disorders. Costa Rica has a strong research infrastructure and has invested in developing research institutions (e.g., University of Costa Rica and National University of Costa Rica), laboratories (e.g., Centre for Research in Human Movement Sciences [CIMOHU] and Health and Sport Research and Diagnostic Centre [CIDISAD]) and programs (e.g., undergraduate, graduate, masters and doctorate) to support the growth of the field.

As a result, Costa Rica's strong research infrastructure, and has become a hub for HMS research in Central America and beyond. The country's continued investment in research and development in this area has the potential to lead to significant advances in understanding human movement and improving human health and performance.

In collaboration with national federations, the Olympic committee, health centres and public and private educational centres, this research has helped to inform the development of training programs and equipment to improve performance, treat diseases and prevent injury.

Overall, this paper provides a comprehensive overview of the growth and development of human movement science in Costa Rica over the past two decades, and highlights opportunities for continued growth and development in the future. By examining the current state of the field, and by identifying potential areas for future research and collaboration, this paper will contribute to the ongoing advancement of HMS research in Costa Rica.

Data extraction method

All information search was conducted on April 18th, 2023, using the advanced search platform of Web of Science (Clarivate). The initial search was made for institutions in Costa Rica included in this digital platform (e.g., UCR, UNA, CATIE, ULACIT, UNED, UTN, TEC). Once the data was refined by institutions, it was filtered according to sport science category (Web of Science category). Due the Web of Science platform sometimes included collaborator authors as members of the universities the final filtering based on top 10 researchers in sport science was performed manually. Each of the entries found when performing the filtering process is presented in Figure 1. For the required analyses, bibliometric information was analysed using the Web of Science tool (e.g., analyze results). The Web of Science categories assign each published paper to a category based on the journal the manuscript was published. Each manuscript is assigned to only one category of the Web of Science Core Collection.

The citation analysis (Teixeira da Silva, 2021), H-index and 10i-index was performed by selecting the top five researchers according to Web of Science data and then extracting the information from Google Scholar. When necessary, all information related to authors who did not belong to Costa Rican higher education institutions was eliminated. All researchers' names were avoided, and initials were used to avoid any unnecessary ranking, as this is not the aim of the manuscript.

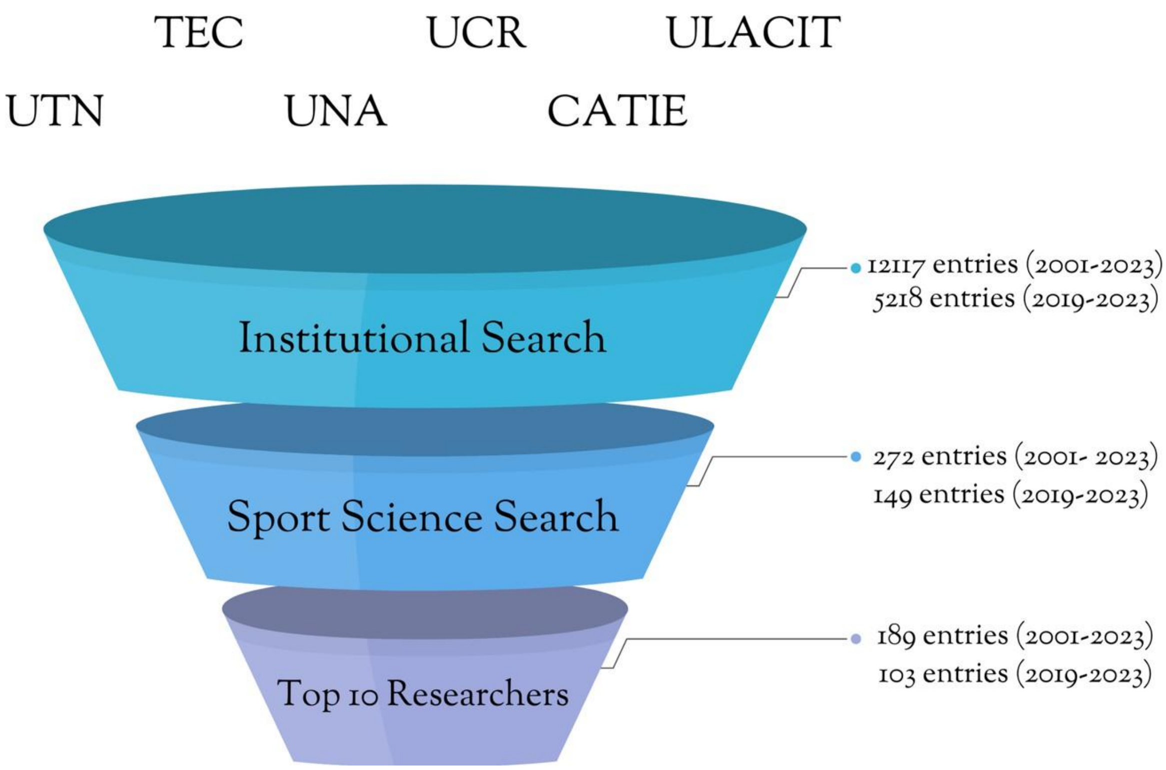

Figure 1. Data filtration process and entries found. Source: prepared by the author with data from Web of Science.

Research current state

Research areas

Nutrition, psychology, occupational health, and physical therapy are just a few of the areas where human movement scientists are crucial. Understanding and resolving a range of health concerns and enhancing people's quality of life depend on their experience and knowledge of human movement. Human movement scientists are important because they bring their knowledge of movement analysis, biomechanics, and exercise physiology to other fields. Their contributions enhance the health and wellbeing of people and communities, and their multidisciplinary approach may result in ground-breaking fixes for difficult medical problems.

In this sense, Costa Rican researchers have been involved in published material in such a variety of fields such as nutrition, public environmental and occupational health, social sciences, psychology, education, physiology and others (see Figure 2). This variety of areas in which Costa Rican scientists publish only shows that human movement sciences are a very broad discipline offering solutions to a wide range of problems posed from other research fields. This type of inter and multidisciplinary work is an indication that the quality of publications and impact has increased.

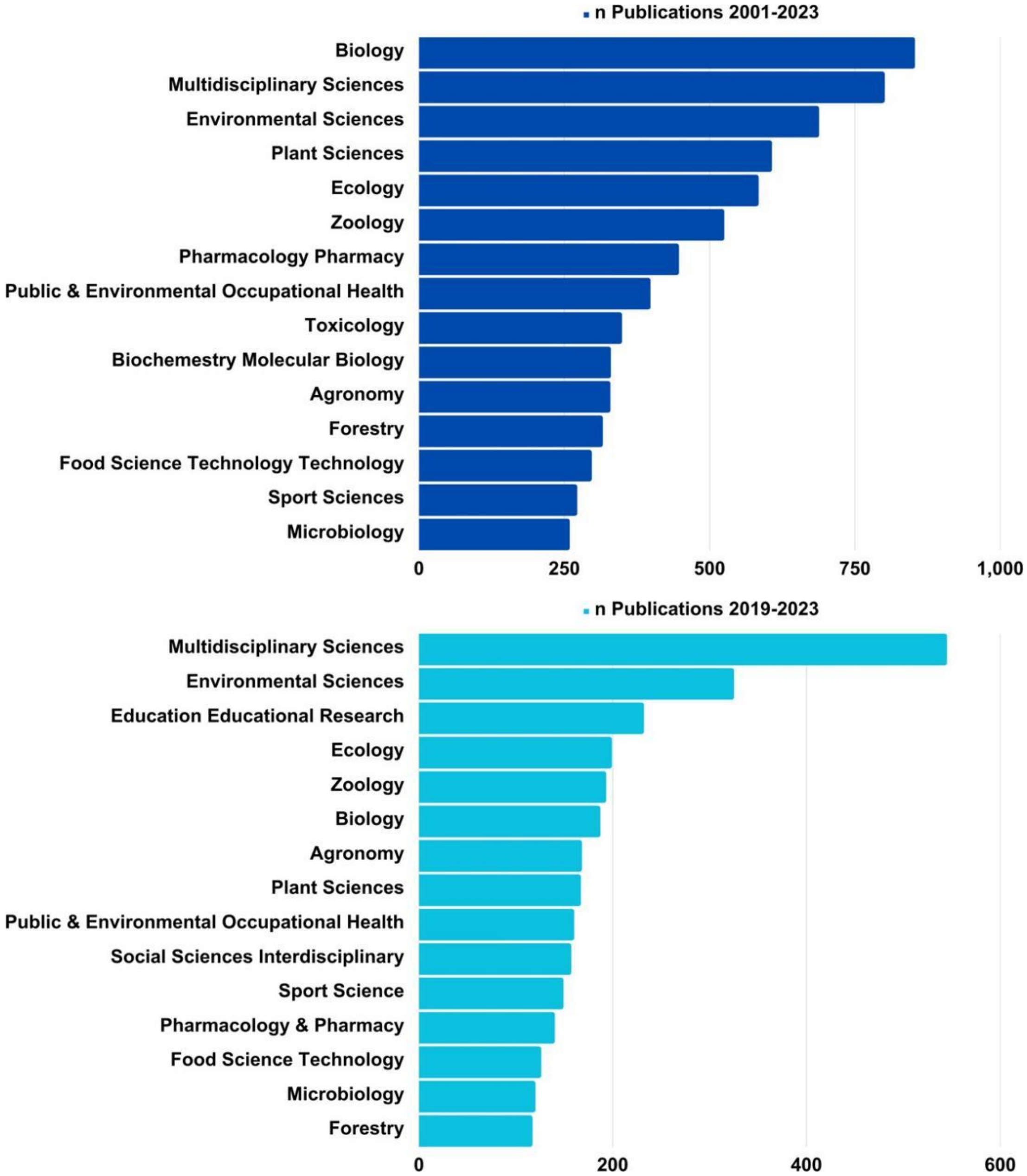

Figure 2. Research areas in which all Costa Rican researchers had published since 2001 to 2023 (total of 12117 and 5218 entries respectively). Source: prepared by the author with data from Web of Science.

Since 2001, human movement sciences have been ranked within the top 16 research areas according to statistics from the Web of Science platform. The exponential growth of publications in this field is evident in the increase of publications in the last five years and the rise to the top 11 areas with the most publications in Costa Rica. Only from 2019 to present, 54.78% of the total publications available since 2001 in the field of sports science have been published. Additionally, this area has moved up from the 14th position to the 11th position (see Figure 2).

Publications per year

In the last 5 years, scientific research has made significant progress in various fields. With the advent of new technologies and innovative approaches, researchers have been able to explore new areas of study and make groundbreaking discoveries. Over the last five years, HMS has experienced a significant boost in scientific production, especially in Costa Rica. According to statistics from the Web of Science platform, HMS has ranked among the top 11 research areas with the highest number of publications in the country (see Figure 2). This increase in publications is a witness to the exponential growth of the field, which has been expanding rapidly over the past few decades.

The growth of HMS research has been particularly pronounced over the last quinquennium, with more than half of the total publications available in the field since the year 2000 being published in the last five years alone (see Figure 3.). This remarkable increase in research output is evidence of the growing interest in the field, despite the fact that there is still a lack of resources and investment in HMS research.

As the field continues to evolve, researchers and practitioners alike are poised to make significant contributions to the understanding of human movement and its impact on health and performance. It was noticed that since 2001 a total of 272 entries in sports science was found. A total of 121 meeting abstracts, 120 articles, 18 review articles, 12 editorial materials, and one early access.

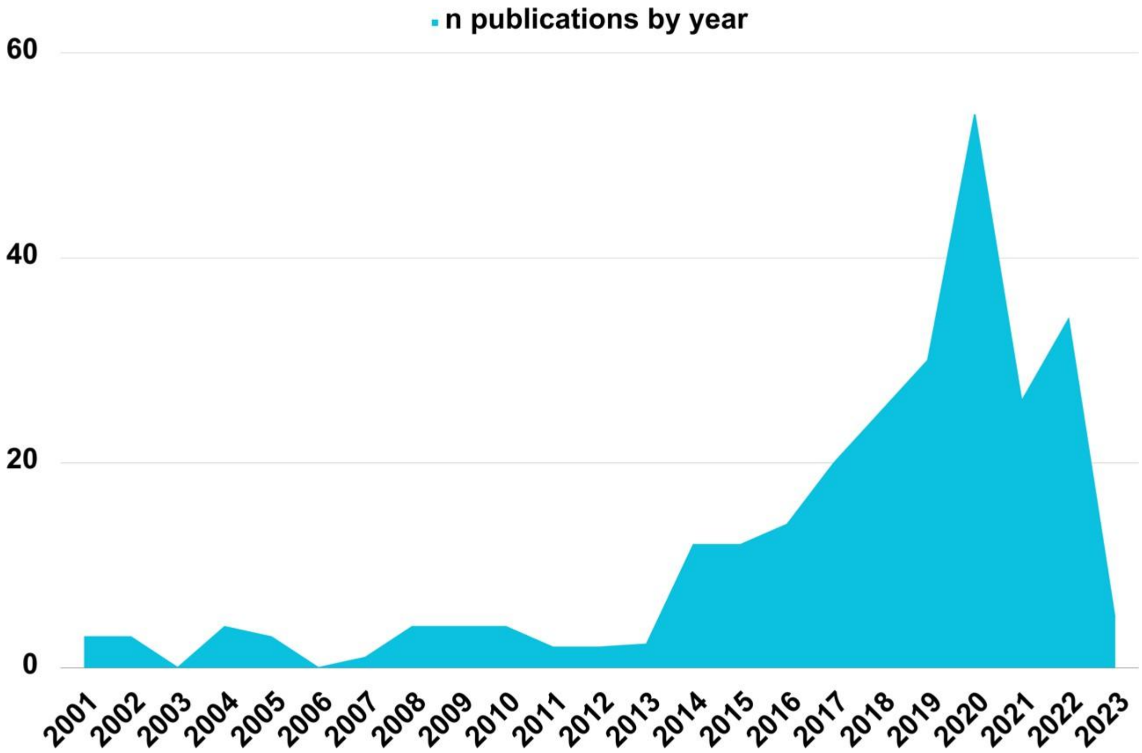

Figure 3. Number of studies published by year in HMS by Costa Rican researchers (total of 272 sport science entries). Source: prepared by the author with data from Web of Science.

This growth could be the outcome of the availability of new technologies and methodologies that have enabled researchers to study human movement in greater detail and with greater precision. In addition, it has allowed to broaden the range of study possibilities, not only by having better and more material, but also because there is a highly trained human resource that has been able to access doctoral studies due to the doctorate program developed by UCR and UNA. As a consequence of the development of this doctorate program, eight new doctors have graduated in the two promotions offered. This has contributed to an even substantial growth in the number of doctors in HMS. Currently, based on the graduate study program database, between the UNA and the UCR staff there are more than 25 researchers and lecturers with a doctoral degree related to the HMS. This has led to new insights into the mechanisms and adaptations of human movement. Finally, the investment in research and development in Costa Rica has increased in recent years, providing more resources for researchers to conduct studies in human movement science. This investment has led to the expansion of research programs and the recruitment of new researchers to the field, further fuelling the growth of published material in human movement science.

International and multidisciplinary collaboration

Furthermore, there has been a concerted

effort to promote interdisciplinary collaboration in research, bringing together experts from different fields to tackle complex problems related to human movement. This has led to innovative approaches and new discoveries that have contributed to the growth of the field. We need to move away from oversimplified views of issues in HMS. These issues often have complex causes and we must acknowledge that there are no ultimate solutions, only optimal ones. To find these solutions, we must focus on prevention within the context of the patient or athlete. To achieve this, we must break down research barriers and explore alternative methods to better understand the why and how, instead of just the what, where, when, or who. This requires prioritizing knowledge transfer through implementation research that uses mixed-method designs and participatory action approaches (Verhagen & Middelkoop, 2022).

From this point of view, it is critical for scientists in Costa Rica to broaden their areas of knowledge and interrelate with issues from other areas of study and research. It is from problem-solving with an interdisciplinary and multidisciplinary approach that we enrich our own area of knowledge. In this sense, from the HMS, there has been a great interrelation with diverse areas (see Figure 4). The interplay between HMS and other disciplines, such as medicine (Gamonales et al., 2023), nutrition (Capitan-Jimenez & Fernando Aragón- Vargas, 2022; Gamonales et al., 2022; Gomez-Miranda et al., 2022), psychology (Gutiérrez- Vargas et al., 2021; Hernández-Gamboa et al., 2022; Jiménez-Maldonado et al., 2018), occupational health (Crowe et al., 2022; Mora et al., 2022) in Costa Rica, has allow HMS professional to expand their knowledge and create new opportunities of research. This type of collaboration allows for providing solutions to a sector of the population from a broader paradigm.

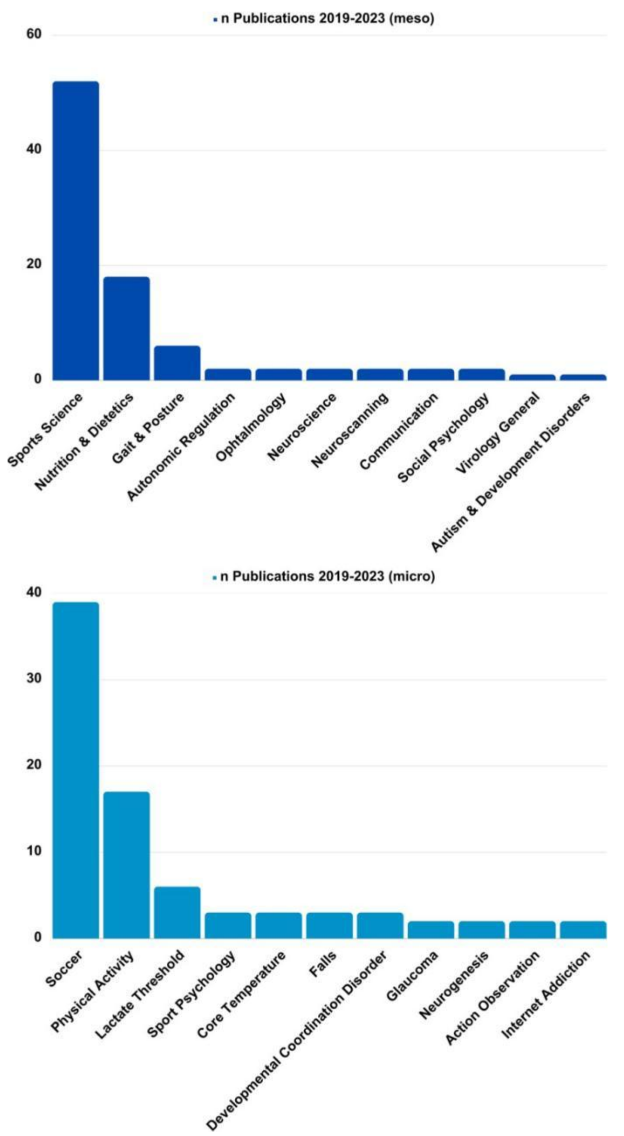

Figure 4. Areas of publications rather than sport science by HMS researchers in Costa Rica based on citation topic meso (a) and micro (b) of Web of Science (total of 149 sport science entries). Source: prepared by the author.

Collaboration at an international level is crucial for the development and growth of high-quality research in HMS in developing countries like Costa Rica. By collaborating with experts from different parts of the world, researchers in Costa Rica can access cutting-edge technology, methods, and expertise. This can help them overcome resource limitations and generate innovative research that can significantly advance the field. Additionally, international collaboration promotes the exchange of ideas and perspectives, which can lead to a more comprehensive understanding of the field and its applications (Dusdal & Powell, 2021; Green & Johnson, 2015). This, in turn, can lead to better solutions for addressing the health needs of the population. Human movement scientists in Costa Rica have a wide network of partners including University of Extremadura, University of Murcia, Autonomous University of Baja California among others (see figure 5.).

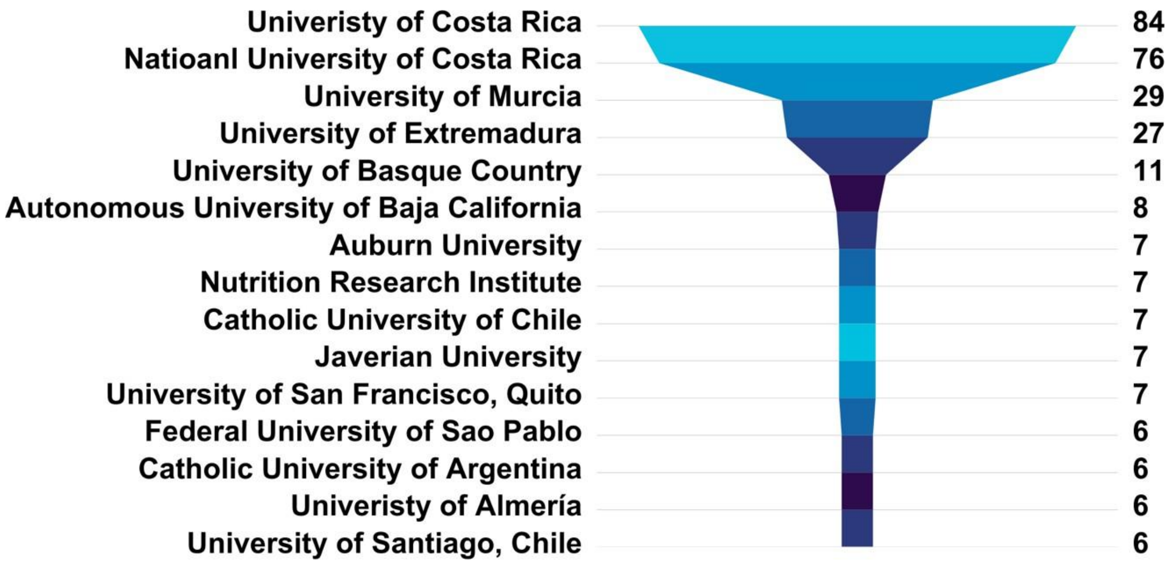

Figure 5. Number of published papers by institution with Costa Rican HMS researchers as collaborators (based on a total of 149 entries of sport science). Source: prepared by the author with data from Web of Science.

Authors on top rankings in the country

The number of publications can play a critical role in increasing the visibility of a researcher's work. Publishing multiple articles in reputable journals can help to establish a researcher's expertise and reputation in their field, making it more likely that their work will be recognized and cited by other researchers. Having a higher number of publications can also help to increase the visibility of a researcher's work through search engines and academic databases (Lackner et al., 2021). As more articles are published, the likelihood of the researcher's work appearing in search results increases, making it easier for other researchers to find and cite their work.

Furthermore, having a larger number of publications can help to demonstrate a consistent and sustained commitment to research, which can be viewed favourably by grant funders, promotion and tenure committees, and other stakeholders. This can increase opportunities for funding, collaborations, and other professional opportunities. The HMS researchers of the public institutions are positioned in the top rankings in the country. The Figure 5. Shows the number of scientific publications of each of the top HMS researchers.

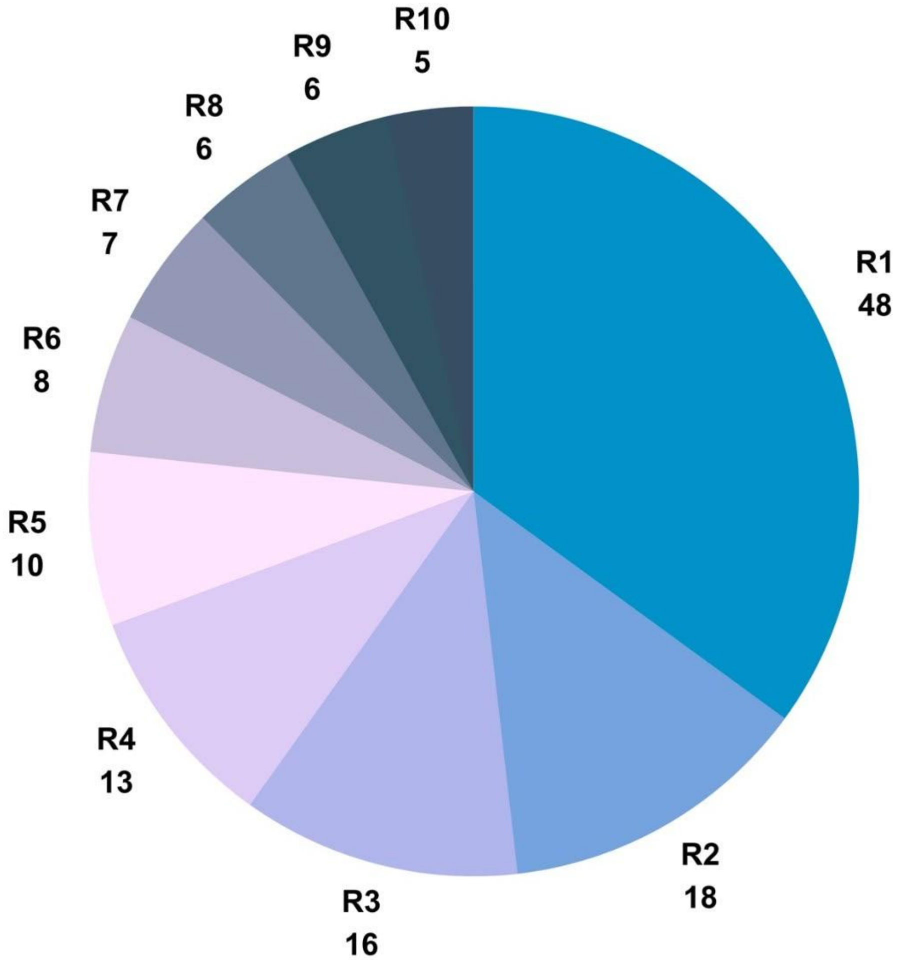

Figure 6. Number of manuscripts published by the top 10 HMS researchers in Costa Rica 2019-2023 (based on a total of 149 entries). Source: prepared by the author with data from Web of Science.

Article types

Exploring all the available options for publishing articles can be incredibly important in maximizing the visibility and impact of our research findings. Depending on the research question, methodology, and intended audience, different types of articles may be more appropriate for disseminating information effectively.

For example, editorials and opinion pieces can be particularly useful for highlighting controversial or timely topics and providing personal insights and perspectives on research findings. These types of articles can generate interest and discussion among researchers and the wider public, which can lead to increased visibility and impact.

Reviews, on the other hand, can provide a comprehensive analysis and summary of existing research in a particular field, helping to synthesize key findings and identify gaps in knowledge. This can help to advance the field by promoting new research questions and areas for investigation, as well as providing a valuable resource for researchers seeking to build on previous work.

Technical notes, case reports, and other types of articles can be particularly useful for highlighting innovative research methods or novel findings, which can attract attention and generate interest from researchers and practitioners in related fields.

By exploring all the available options for publishing articles, researchers can increase the likelihood of their research being read, cited, and recognized by the wider scientific community. Different types of articles can appeal to different audiences and can help to promote research findings in different ways, increasing the overall impact and visibility of the research. In Costa Rica, 57.1% of the manuscripts published are original articles, 30.6% meeting abstracts, 8.5% review articles, 3.2% editorials, 1.1% preprints, 0.4% letters or corrections.

Author citation and index

Citations based on Google Scholar data are frequently used as a benchmark for the calibre of research in human movement science. Citations show that other researchers valued the study and utilized it as a source of inspiration for their own work. A study's high citation count indicates that it has made a substantial contribution to the area and that other experts hold it in high esteem (Teixeira da Silva, 2021). The top five HMS researchers in Costa Rica are cited more and more frequently, as seen in Table 1. High citation index and worldwide research collaboration have a beneficial association. Collaboration among academics from various institutions and nations can result in more information sharing, fresh perspectives, and better research outputs.

Research of a better calibre may result from international collaborations that bring together academics with a variety of viewpoints, skills, and resources. Increased access to financing and research facilities, which can result in more significant research, is another benefit of collaborative research (Roldan-Valadez et al., 2019).

International cooperation can also make it easier for research findings to reach a wider audience, which can result in more citations. A higher citation index results from research that is published in high-impact journals since it is more likely to be cited by other academics. International cooperation can also improve the standing of the research institutes and the researchers themselves. Researchers are more likely to receive citations from other researchers and have higher rankings when they are linked to high-quality research that has a substantial influence on the field (Nieminen et al., 2006).

Table 1.Number of citations per year, H and i10 index of the top 5 Web of Science Costa Rican authors.

Author Initials	Total Citation	Citation last 5	H Index	H Index last 5 years	i10	i10 Index last 5 years	2016	2017	2018	2019	2020	2021	2022	2023
DRV	1426	1403	21	21	3	36	-	1	0	70	234	429	540	106
					7			1						
JMJ	2346	1423	23	18	5	32	1	2	17	221	251	244	317	100
					1		3	3	9					
							2	2						
LAV	2240	805	18	12	3	18	1	1	14	139	167	141	180	36
					2		6	6	2					
							4	0						
BSU	808	680	17	15	2	18	3	4	37	77	153	183	183	40
					2		2	7						
RGV	479	439	12	11	1	12	6	8	10	52	122	118	109	22
					5									
FAR	274	164	9	7	9	6	2	2	26	26	34	41	33	4
							3	4						

Source: prepared by the author with data from Google Scholar.

Publication Language

It is crucial that HMS professionals in Costa Rica continue to publish in English as they have done up to this point (80.2% in English, 19.4% in Spanish, and 0.5 in Portuguese), as English is the language in which most of the scientific evidence is published. The diffusion and effect of a research study's findings can be significantly impacted by the language of publishing. Publishing in a language that is widely used, like English, can boost visibility and make it easier for people all over the world to access the research. Research published in English-language journals is more likely to be accessible, read, and referenced by researchers worldwide since English is thought to be the language of scientific communication (Gotti, 2021).

Publishing in a language that is less common as Spanish, however, can restrict who can access the study. It could also be more challenging for scholars outside the linguistic group to find and reference the research. Additionally, publishing in a language other than English may reduce the possibility that the study will be indexed or included in international databases, which may further reduce the research's impact and visibility (Di Bitetti & Ferreras, 2017).

It is crucial to keep in mind that some research projects can have a more regional focus, in which case publishing in a language that is commonly used in the area might be preferable. Additionally, there is a rising understanding of how crucial it is to support research done in languages other than English, especially when it comes to studies that are centered on non-Western contexts (Aragón-Vargas, 2014).

High-quality scientific dissemination journals

As observed, a large portion of the scientific production published by Costa Rican scientist is carried out in the journals of both public universities that offer careers related HMS. These journals have a trajectory of more than ten years and have published several volumes. Additionally, both journals are indexed in the most recognized national and international repositories and search engines (e.g., SciELO, Scopus, Emerging Source Citation Index), as well as in catalogues such as Latindex, MIAR, Dialnet, and Redalyc, and directories such as the Directory of Open Access Journals.

Furthermore, these journals have innovated in publishing methods and processes, accepting a variety of article types, promoting different issues on social media, providing first-hand information to visually impaired people, among other strategies. Additionally, the members of the different editorial teams, scientific committees, and the most important journals in the field of HMS in Costa Rica include 79 (Pensar en Movimiento) and 32 (MHSalud) scientists from different institutions, disciplines, and countries such as Portugal, Spain, Germany, the United States, Brazil, Chile, Colombia, among other countries around the world. Of these individuals, 31 (39.24%) and 8 (25%) are women, respectively.

This scientific dissemination platform has promoted the publication of studies related to student processes of final graduation projects for undergraduate and graduate degrees. Currently, the quality leaps that both journals have made allow scientists from around the world to disseminate their results and make these studies available on the most recognized international platforms (Dwivedi et al., 2021; Klar et al., 2020).

Identifying future challenges

As leaders in the field of HMS in Costa Rica, universities are committed to pushing the boundaries of research to improve outcomes for the general population, including both ill individuals and athletes. This commitment is based on high standards of practical and clinical performance and professional preparation, combined with established community connections and a spirit of innovation, setting HMS professionals apart from other areas. The consolidation of HMS professionals as fundamental agents in the processes of disease and injury prevention and treatment, as well as those aimed at optimizing health and performance, is of paramount importance.

To achieve these objectives, it is crucial to recognize the key role of investigation and systematization of professional practices. From universities, the research related topic and content of the HMS degrees courses must be considered a critical element of study plans. Role models and mentors are needed to instill in students the values of curiosity, creativity, criticism, and analysis. This is crucial to rise the number of HMS professional involved in research, considering only four researchers published more than the 50% of total studies in Costa Rica. Finally, Costa Rican researchers should make a better effort on publishing more original articles, review, and meta-analysis, considering a great number of publications based on Web of Science are abstracts (e.g., meeting abstracts). Also, Breaking gender bias in science in Costa Rica is crucial to ensure equal opportunities and representation for all genders in the scientific community, leading to more diverse perspectives and innovative solutions to scientific challenges. Universities should consider common forms of gender bias in science as lack of representation, and lack of recognition. This requires actions to provide better opportunities and equity.

CONCLUSIONS

Evidence suggests that during the past five years, Costa Rica has seen an exponential increase in both the caliber and number of scientific publications in the field of HMS. Critical aspects that will enable the growth and sustainability of the number and caliber of scientific works in the field must be examined now, at the pinnacle of their importance. For the future, consideration should be given to how international collaboration networks will grow, how new young people, particularly women, will be empowered to hold scientific positions, how people will be trained in new technologies and methodologies, and how artificial intelligence tools will be used to gather, analyze, and organize data.

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THE PARADIGM OF CIRCULAR ECONOMY IN HERITAGE PRESERVATION OF SOUTHERN CHILE

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Abstract

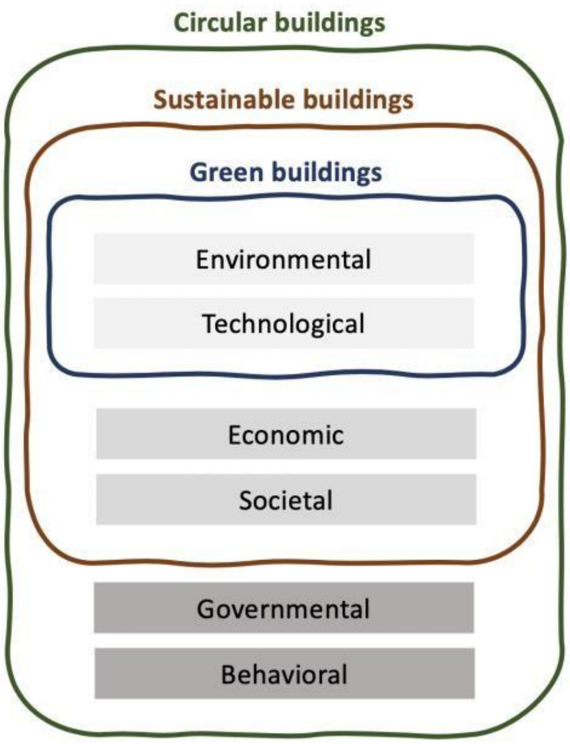
The change to a circular economy paradigm should be established by the implementation of different actions of knowledge, decision-making strategies, stakeholders' engagement, which are usually supported by the overlapping of the sustainable dynamics created through the encounter of the natural, economic, human, and cultural approaches. This new approach to the management of cultural heritage requires scientific knowledge and expertise from multiple disciplines in order to decide on a specific action. This study considers 26 variables relating to heritage, physical vulnerability of buildings, and external hazards, and develops a functional degradation index for the buildings studied.

This information helps to broaden existing knowledge on the preservation of buildings and to streamline the decision- making process in the management of set of heritage buildings in South America. A set of 20 timber buildings located in the city of Valdivia (southern Chile) through in-situ visual inspection were examined. The buildings are ranked in terms of priority based its intrinsic functionality. This kind of approaches are new contributions to the area of the sustainability in the management of cultural heritage, which includes a balanced integration of technological, environmental, economic,social, governmental and behavioural performance.

Keywords: Circular economy;management, functional degradation;heritage timber, Chile.

INTRODUCTION

The McKinsey Global Institute stated in 2011 that human population continues to use more and more material resources as the population increases around the World (1). In 90s construction sector was responsible for 40% of the use of raw material and a third of the energy consumed globally (2). Between 2010 to 2020, this sector is still the world's largest consumer of raw materials, and accounts between 25% to 40% of the global carbon dioxide (CO_2) emissions (3). In this sense, the built environment puts one of the highest pressures in relation to natural environment. This kind of roles is directly oriented to to a circular economy (CE) approach. Moving towards a circular economy system will provide a significant chance to address this through the reduction and protecting material resources and reducing the carbon dioxide emissions (4). As is stated by Eurostat in 2020 (5), “the built environment is an important sector economically, with the construction industry contributing, on average, 5-13% of the total gross added value”. In a European level, polices have been developed for improving significantly the sustainability of the area, but what is happening in other regions around the world such as South America? Concerning this question, this study contribution tried to analyze and to develop a new approach focused on the heritage timber buildings preventive maintenance methodology avoiding enormous budget and consumption on resources, with the idea of a sustainable approximation towards circular economy in the South of Chile.



The concept of circular economy in the heritage-built environment

The ‘circular economy’ term is becoming progressively commonplace (4). During the 2002 World Summit Conference, the circular economy was defined as the balanced integration of economic, environmental, and social performance (6). The idea of circular economy is focused on minimizing the use of natural resources and the production of waste. Chamberlin et al (7) remarked that some tendencies interpret circular economy as another initiative related to recycling or sustainability. In order to verify the specific dimensions, which involves the concept of circular economy (CE) some references have been particularly analyzed (8). Regarding the evolution of the dimensions of building research focused on circular economy is possible to identify some factors: (i) environmental, (ii) technological, (iii) economic, (iv) societal, (v) governmental and (vi) behavioral. This set of dimensions conform in different concepts that are related to green buildings, sustainable buildings and circular buildings (Figure 1).

Figure 1. Circular economy and built environment dimensions.

Circular economy and built environment dimensions

The technological dimension allows to connect the last innovations in the area of construction management (9) to the service of the heritage-built environment. This factor is significant due to new technological procedures will allow new application to the built environment of cities and neighborhoods. Concerning the environmental dimension, Pomponi and Moncaster in 2017

(3)commented about the environmental aspects stressed the lower environmental influences that reuse has over new products, new materials and new constructions, such as in the cases of wood (10).

The economic factor is focused in minimized the resources used in the management of set of architectural heritage. The paradigm is renewable the construction itself with the smallest affections over the environment. In 2015, Daly (11) commented that circular economy is usually stated to as ‘sharing economy’, emphasizing its strong social aspects. This normally includes collaboration and partnerships in building projects (new and existing) and a wider engagement with stakeholders involved.

The governmental actions are paramount in the importance of preserving and maintain cultural value linked with heritage buildings emplaced in a local context (12). National and regional government should have the integrity to develop standard focused on the preservation of the identity of a particular and specific building, neighborhood, city, place and context. The behavioral factor in circular economy literature, emerged as a breakthrough in built environment (3). “There is clearly a strong need to accelerate behavioral research in heritage-built environment sustainability; it is apparent that it is people, rather than technologies, who are the key to embracing circularity” (3, p. 715).

PUBLIC POLICIES IN THE PRESERVATION OF HERITAGE-BUILT ENVIRONMENT IN CHILE

The integral management of architectural heritage is one of the main challenges of the 21st century. In this sense, international organizations and national governments are recognizing the need to generate new tools to support an integral planning of the heritage-built environment (13) and incorporating the set of stakeholders involved in the process (users, owners, professional experts, public administrations and private sector) (14) thus promoting an integral approach (Figure 2).

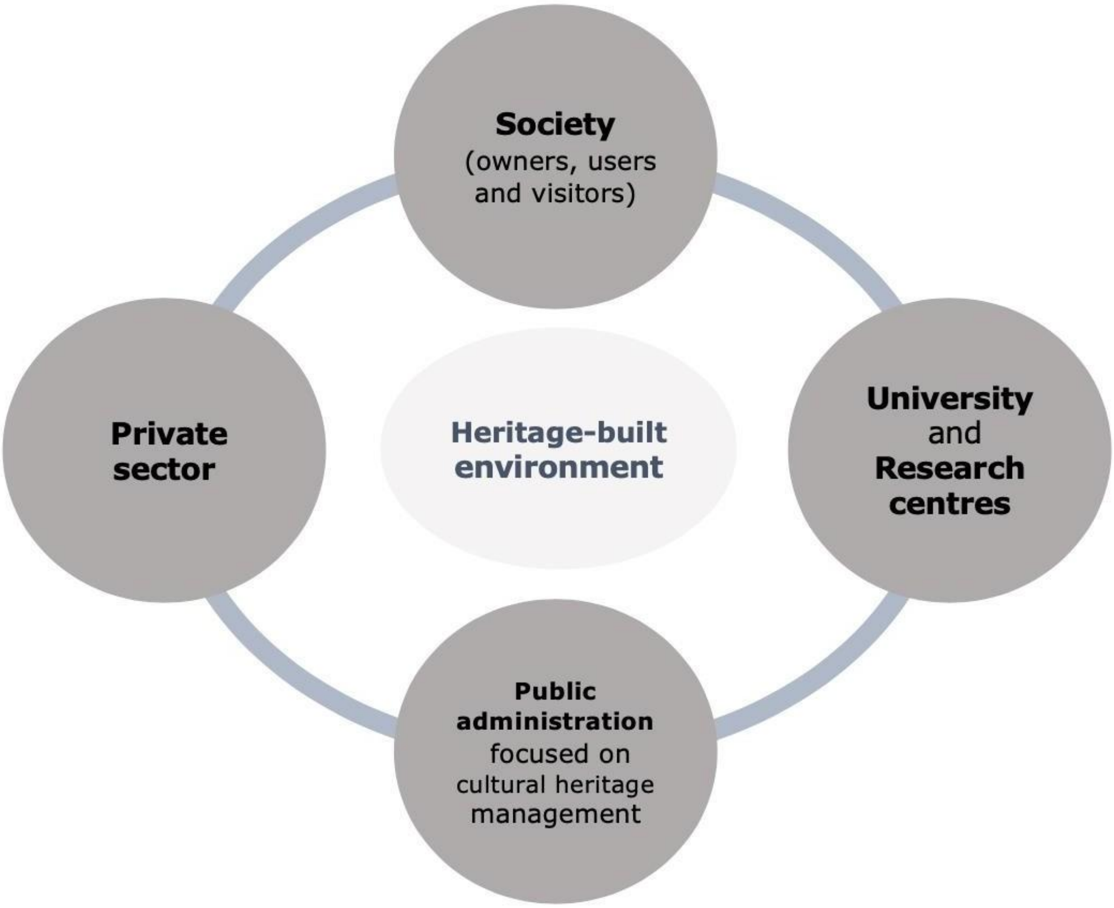


Figure 2. Stakeholders involved in the heritage-built environment management.

In the Chilean context, the Ministry of Housing and Urbanism (MINVU in Spanish) is the organism in charge of carrying out urban planning and regulatory actions. In addition, it considers the general dispositions contemplated in the Urban Planning and Construction Regulations (General Law of Urban Planning and Construction -LUPC- and its General Ordinance - GOPC-) which empowers the Communal Regulatory Plans (CRP) to designate Heritage Building Conservation (HBC) and Zones of Historical Conservation (ZHC), in relation to the conditions and characteristics established in the article 2.1.43 of the General Ordinance of Urban Planning and Construction. These heritage buildings are protected under the provisions of article 60 of the LGUC. Management at the national level is carried out through the Urban Development Division (UDD) of MINVU.

In this sense, within the framework of the Urban and Housing Policy, a special emphasis is being placed on the city and neighborhoods, as focal points of urban integration policies

(15). Concerning the dimensions covered, social integration, environmental balance, economic development and incorporating the protection and enhancement of heritage as the foundational axis of the identity of the communities and regions of Chile (15). Based on these principles, the Government of Chile assumes the responsibility of recovering and preserving what is known as urban heritage (15).

This Urban Heritage is framed by buildings (HBC) and public spaces (ZHC) whose constitutive form is an expression of collective memory, rooted and transmitted over time, which individually or together reveal cultural typologies, environmental and social that express and promote the culture and social roots of the city and the region in which the constructions are emplaced (15). Urban heritage recovery and protection policies aim to revalue the cities of Chile (15), creating vibrant cities and more attractive to citizens, through urban planning that safeguards the identity of neighborhoods (16), promoting the protection of quality urban heritage. This kind of policies are also framed within the objectives of the National Center for Conservation and Restoration of Chile (NCCR): (i) organize and execute policies on heritage conservation and restoration at the national level.

Potential impact and scientific novelty of the approach

The potential impact of this study is its contribution to the development of a public policy focused on a circular economy focus towards an integral management and protection of local cultural heritage (Historical Conservation Buildings - HCB) (15) defined through the General Law of Urbanism and Construction (LGUC in Spanish), the Communal Regulatory Plans (PRC in Spanish) and the Ministry of Housing and Urbanism (MINVU in Spanish) of Chile. The scientific novelty of this research is its multi-scale analysis, from the heritage building itself (HCB), to the scale of the neighborhood or commune in which the buildings are emplaced and to the socio-cultural context of southern Chile.

RESEARCH OBJECTIVES

This research proposes the preventive conservation of a set of 20 heritage timber buildings located in the city of Valdivia, capital of Los Ríos region, South of Chile. These constructions are under protection by the Ministry of Housing and Urbanism – Government of Chile, which seeks to preserve the environmental, cultural, architectural, economic and social value of heritage buildings, promoting the use of technology in the assessment of constructions. To address these concerns, this paper proposes a new approach to decision- making for the development of preventive maintenance strategies, taking into account vulnerability, external hazards, and architectural characteristics of timber heritage buildings with a focused on the particular context of the city of Valdivia. The purpose is to develop a diagnostic tool taking into account consideration concerns related to circular economy (environmental, technological, economic, social, governmental and behavioral features) and the real local conditions of heritage timber buildings in South America, ensuring that the preservation strategies that are chosen are appropriate for the specific buildings. This kind of approaches can help to policymakers in the use of technical criteria to establish a maintenance schedule in local contexts. This work is crucial for controlling the functional degradation of buildings, thus reducing damage from external hazards and overhead for owners and users.

MATERIALS AND METHOD

Case studies emplaced in southern Chile

Valdivia is situated in the south of Chile (Figure 3), the city presents a population around 160,000 inhabitants (last census conducted in 2017). During the 19th and 20th the Chilean government supported German immigration to Chile, so that German culture overlaps with prior Spanish colonization (17). The Valdivia Germans adopted architectural and stylistic characteristic, albeit with some modifications in the use of wood (18) (19). In 2009, Montenegro et al. (20) state that wood was established as the primary building material in southern Chile. The case studies (20 historical buildings) were selected randomly from the set of Historical Conservation Buildings (HCB) (15). Figure 4 shows the 20 heritage buildings analyzed. All the buildings have two stories and little ornamentation. The sample examined present the next constructive characteristics (19) (21) (Table 1).

Table 1. Buildings' constructive characteristics.

a. The foundations of the structures are formed by wooden beams supported by timber
b. The structure of the buildings analysed are built in wood, with a post-and-beam construction type
c. The constructions present a spacious hall, a central corridor, which provides access to the other spaces
d. Generally, the buildings have a maximum of two storeys; in many of them the first floor's height is greater than the ground floor
e. The external coatings usually were designed in wood
f. The use of the sample is normally housing

Figure 3. Location of the 20 case studies in Valdivia (Chile).

The heritage timber buildings considered in this study are mainly private buildings. The buildings' owners are directly responsible for their conservation, which normally requires a high budget that they cannot afford and cannot easily recuperate (22). The deterioration of this kind of structure is directly related to mechanical, chemical, or even biological causes (23), and of course environmental factors (temperature, wind and rain action) and external natural hazards (earthquakes, floods).

Figure 4. Set of case studies located in Valdivia city.

"Preserving historic ensemble constitutes an attractive case study in terms of both the methodological challenge it poses (due to the diverse nature of the assets examined) and the potential application when evaluating the viability of preventive conservation plans or assessing a cultural heritage-restoration policy" (24, p. 570). This is especially significant in developing countries, as conservation policies tend to have fewer tax benefits for owners of historic buildings (24, p. 570).

The city of Valdivia is emplaced in Los Ríos region in southern Chile is one of the most important biodiversity conservation areas in South America. The weather conditions in Valdivia are as follows: (i) the weather is normally warm, with significant average annual rainfall; (ii) the temperature is usually above 11-12°C; (iii) the average relative humidity is around 85% (relative humidity is always above 75%); (iv) the annual thermal amplitude is around 9° C; (v) rainfall is more than 2000 mm per year, reaching higher levels during the winter compared with lower rainfall during summer; in the driest months (January, February) rainfall still exceeds 60 mm (25). This information helps in the definition of the environmental exposure conditions in which the case studies are emplaced and therefore helps in understanding the affections of the weather conditions in the performance of the state of conservation of the heritage-built environment under study.

Functional degradation methodology

The analysis of functional degradation affections in terms of heritage buildings needs to consider the safety and conservation of cultural heritage assets. The functional degradation method, which is designed RIPAT1.0, was initially developed by Alvayai (26), Valdebenito et al. (27) and Pintor (28) at the Universidad Austral de Chile, and was then used on timber buildings in Nueva Imperial, in the Araucanía region in Chile, by Valdebenito et al. (27). The functionality method (RIPAT1.0) consists of the quantification of a total of 26 variables established by means of a professional expert survey on consultation with seven professional experts with skills in civil engineering, building management, and architecture (26, 27). This methodology can quickly and easily order, compile, and quantify the evaluation of architectural value (A) (equation 1), vulnerability (V) (equation 2) and hazards (H) (equation 3) (28, 29).

Heritage attributes (A) of buildings, as defined by Ibrahim et al. (12), correspond to the visible part of a country or region's history, concerning the complexity of cultural and stylistic development, conveyed over time. Vulnerability (V) of buildings is defined as the degree of loss of performance as a consequence of a natural phenomenon (30). Hazards (H) correspond to the influence of external affections that may impair a building ' s performance (31). Table 2 shows the description evaluations of the input variables (from 0 to 1). Table 3 outlines the input variables and the hierarchical structure of the system and the weighting of the input variables and intermediate variables involved.

Table 2. Valuation of variables of the set of parameters for defining functionality of buildings

Valued variables	Description	Points (0-1)
Heritage attributes (*A*)	Good condition	0
	Bad condition	1
Vulnerability (*V*)	Good condition	0
	Bad condition	1
Hazards (*H*)	Good condition	0
	Bad condition	1

Microsoft Excel was used to run the system. Excel is widely used for calculation by all stakeholders in the construction sector (engineers, architects, managers, and planners) and is currently available for use online, free of charge. Functional degradation model (RIPAT1.0) (equation 4) is calculated by multiplying the factors A, V, H.

$$A = (0.60A_1 + 0.30A_2 + 0.10A_3) \quad (1)$$

$$V = (0.35V_1 + 0.30V_2 + 0.10V_3 + 0.15V_4 + 0.10V_5) \quad (2)$$

$$H = (0.33H_1 + 0.34H_2 + 0.33H_3) \quad (3)$$

The output of the model (RIPAT1.0) varied between 0 and 1. Table 4 shows the qualitative and quantitative valuation of the output model (29) (32). Considering the classification of Table 4: (i) condition A (0.00 ≤ RIPAT1.0 < 0.25) is referred to buildings with a low functional degradation; (ii) condition B (0.25 ≤ RIPAT1.0 < 0.75) concerns buildings with a medium functional degradation; (iii) the worst possible scenario is condition C (0.75 ≥ RIPAT1.0< 1.00), corresponding to buildings with a high functional degradation.

$$RIPAT_{1.0} = (A * V * H) \quad (4)$$

Table 3. Hierarchical structure and weighted variables of the functional degradation method.

Input variables	Weighting	Intermediate variables	Weighting	Intermediate variables	Output variable
A11 - Territorial value	0.20	A1 - Heritage significance	0.60	A - Heritage attributes	Functional degradation index (RIPAT1.0)
A12 - Architectural value	0.20				
A13 - Preservation value	0.20				
A21 - Architectural style - historical sequence	0.15	A2 -Representativeness	0.30		
A22 - Representative elements	0.15				
A31 - Typological classification according to use	0.05	A3 - Exposition of the structure	0.10		
A32 - Occupancy	0.05				
V1 - Effects of deterioration			0.35	V - Vulnerability	
V21 - State of conservation	0.075	V2 - Structural problems	0.30		
V22 - Columns risk level	0.075				
V23 - Overloads	0.075				
V24 - Density of divisions	0.075				
V31 - Quality of divisions	0.002	V3 - Non structural problems	0.10		
V32 - Stairs	0.002				
V33 - Facades	0.002				
V34 - Cover	0.002				
V35 - Ceilings	0.002				
V41 - Asymmetry	0.005	V4 - Structural skills	0.15		
V42 - Corners	0.005				
V43 - Structures interventions	0.005				
V5 - Floor-Structure interaction			0.10		
H1 - Seismic zone			0.33	*H* - Hazards	
H21 - Seismic amplification	0.167	H2 - Local hazard (site effects)	0.34		
H22 - Dynamic expansion	0.167				
H31 - Geotechnical features	0.167	H3 - Geological location	0.33		
H32 - Construction skills	0.167				

Table 4. Functional degradation conditions for timber heritage structures (Pintor, 2014).

Conditions level	Range	Functional degradation condition
A	$0.00 \leq RIPAT_{1.0} < 0.25$	Building with a low functional degradation
B	$0.25 \leq RIPAT_{1.0} < 0.75$	Building with a medium functional degradation
C	$0.75 \geq RIPAT_{1.0} < 1.00$	Building with a high functional degradation

RESULTS AND DISCUSSIONS

This study develops an approach for estimating the functional degradation conditions of a total 20 case studies, emplaced in the South of Chile, city of Valdivia. Concerning the methodology application, Table 5 specifies the information related to the set of input variables and functional degradation condition (output model) of the 20 heritage timber buildings analyzed. The buildings examined in this study are defined as heritage building by the Communal Regulatory Plan, Ministry of Housing and Urbanism of Chile (33). Analyzing the case studies the next results are achieved: (i) 10% of the sample (2 buildings) have reached the lowest structural vulnerability affection, i.e.: Condition A ($0.00 \leq$ RIPAT1.0 < 0.25 - building with a low structural vulnerability affection); (ii) a total of 13 buildings (65% of the sample) are classified in condition B, buildings with a medium structural vulnerability affection ($0.25 \leq$ RIPAT1.0 < 0.75); (iii) the remaining 25% of the sample (5 buildings) present the highest structural vulnerability affection - Condition C ($0.75 \geq$ RIPAT1.0 < 1.00) (Table 5).

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Table 5. Inputs-output of the functional degradation model, for the 20 case studies analysed.

Inputs variables	ID - Case studies																			
	C-3	C-10	C-5	C-20	C-12	C-13	C-6	C-16	C-15	C-2	C-17	C-4	C-19	C-7	C-14	C-11	C-18	C-8	C-1	C-9
A11	1.0	0.0	1.0	1.0	1.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
A12	0.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
A13	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0
A1	0.7	0.3	1.0	1.0	1.0	0.3	0.7	1.0	1.0	1.0	1.0	1.0	1.0	0.7	1.0	1.0	1.0	1.0	1.0	1.0
A21	0.0	1.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
A22	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
A2	0.0	1.0	0.5	1.0	1.0	0.5	0.5	1.0	1.0	1.0	0.5	1.0	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0
A31	0.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0
A32	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
A3	0.5	1.0	1.0	0.0	1.0	1.0	0.5	0.5	0.5	1.0	1.0	0.5	1.0	1.0	0.5	1.0	1.0	1.0	1.0	1.0
A	**0.5**	**0.6**	**0.9**	**0.9**	**1.0**	**0.4**	**0.6**	**1.0**	**1.0**	**1.0**	**0.9**	**1.0**	**0.9**	**0.8**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
V1	1.0	1.0	0.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
V21	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0
V22	0.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
V23	0.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0
V24	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
V2	0.3	0.0	0.8	1.0	0.5	0.8	0.8	1.0	0.8	1.0	0.8	0.5	0.3	0.5	0.5	1.0	1.0	1.0	1.0	1.0
V31	1.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	1.0	1.0	0.0	0.0	1.0
V32	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0
V33	0.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0
V34	0.0	0.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0
V35	0.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
V3	0.2	0.2	0.6	0.0	0.8	1.0	0.6	0.8	1.0	0.8	0.6	0.8	0.6	0.4	0.6	0.6	1.0	0.6	0.8	1.0
V41	0.0	0.0	1.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0
V42	0.0	1.0	0.0	0.0	1.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0	1.0	1.0	0.0	0.0	1.0	1.0	1.0	1.0
V43	1.0	0.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0
V4	0.7	0.3	0.7	0.3	0.3	0.7	1.0	0.7	0.7	0.7	0.7	0.7	1.0	1.0	0.7	0.7	1.0	0.3	1.0	1.0
V5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
V	**0.6**	**0.5**	**0.5**	**0.8**	**0.4**	**0.9**	**0.9**	**0.6**	**0.5**	**0.6**	**0.8**	**0.8**	**0.7**	**0.8**	**0.8**	**0.9**	**1.0**	**0.9**	**1.0**	**1.0**
H1	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
H21	0.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0
H22	0.0	0.0	1.0	1.0	1.0	1.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0
H2	0.0	0.0	1.0	0.5	1.0	1.0	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.5	1.0	1.0	1.0
H31	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
H32	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
H3	0.0	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
H	**0.3**	**0.5**	**0.8**	**0.5**	**1.0**	**1.0**	**0.8**	**0.8**	**1.0**	**1.0**	**0.8**	**0.8**	**1.0**	**1.0**	**1.0**	**0.8**	**0.8**	**1.0**	**1.0**	**1.0**
$RIPAT_{1.0}$	**0.09**	**0.15**	**0.34**	**0.36**	**0.38**	**0.39**	**0.44**	**0.46**	**0.50**	**0.58**	**0.59**	**0.62**	**0.62**	**0.63**	**0.72**	**0.76**	**0.83**	**0.86**	**0.98**	**1.00**
Condition	**A**								**B**									**C**		

A descriptive functional degradation condition of three case studies is shown in Fig. 3. The case study (C-9) presents a high functional degradation condition - Condition C. The methodology proposed an intervention in a short period of time, before than 5 years from the in-situ visual inspection, in terms of guaranteeing the structural stability of the building. The functional degradation index was 0.98 points < 1.00 (maximum). It is due to the affection of next inputs variables: (i) (A) heritage attributes (A11 - territorial value, A12-architectural value, A13 - preservation value, A1 - heritage significance, A21-architectural style, A22 - representative elements, A2 - representativeness, A31 - typological classification, A32 - occupancy and A3 - exposition of the structure); (ii) (V) vulnerability (V1 - effects of deterioration, V21 - state of conservation, V22 - columns risk level, V23 - overloads, V24 - density of divisions, V2 - structural problems, V31 - quality of divisions, V32 - stairs, V33- facades, V34 - cover, V35 - ceilings, V3 - non-structural problems, V41 - asymmetry, V42 - corners, V43 - structures interventions, V4 - structural skills, V5 - floor-structure interaction) and (H) external hazards affections (H1 - seismic zone, H21 - seismic amplification, H22 - dynamic expansion, H2 - local hazard, H31 - geotechnical features, H32 - construction skills, H3 - geological location). These set of variables were evaluated in the worst possible situation (Table 6).

Table 6. Functional degradation conditions for the 20 timber heritage constructions.

Range of functional degradation (*RIPAT*1.0)	Functional condition	ID Case study	Functional degradation index (*RIPAT*1.0) applied	Constructive features	Variables related to functional degradation condition: Heritage attributes	Vulnerability	Hazards
$0.00 \leq RIPAT_{1.0} < 0.25$ Low functional degradation	A	C-3	0.16		A_{11} A_1 $A32$	V_1 V_{24} V_{31} V_{34} V_5	H_1
$0.25 \leq RIPAT_{1.0} < 0.75$ Medium functional degradation	B	C-5	0.44		A_{11} A_{12} A_{13} A_1 A_{21} A_{31} A_3	V_{23} V_{24} V_{31} V_{35} V_3 V_{41} V_{43} V_5	H_1 H_{22} H_2 H_{31}
$0.75 \geq RIPAT_{1.0} < 1.00$ High functional degradation	C	C-9	0.98		A_{11} A_{12} A_{13} A_1 A_{21} A_{22} A_2 A_{31} A_{32} A_3	V_1 V_{21} V_{22} V_{23} V_{24} V_2 V_{31} V_{32} V_{33} V_{34} V_{35} V_3 V_{41} V_{42} V_{43} V_4 V_5	H_1 H_{21} H_{22} H_2 H_{31} H_{32} H_3

The C-5 case is shown as an example of the condition B - medium functional degradation (0.62 points). The building presents affection mainly related to these inputs parameters: (i) (A) heritage attributes (A11 - territorial value, A12-architectural value, A13 -

preservation value, A1 - heritage significance, A21-architectural style, A31 - typological classification and A3 - exposition of the structure); (V) vulnerability variables (V23 - overloads, V24 - density of divisions, V31 - quality of divisions, V35 - ceilings, V41 - asymmetry, V43 - structures interventions, V5 - floor-structure interaction) and some (H) external hazards affection (H1 - seismic zone, H22 - seismic amplification, H22 - dynamic expansion, H2 - local hazard, H31 - geotechnical features, H32 - constructions skills, H3 - geological location) (Table 6).

The case study C-3 is classified in condition A (0.16 points), it is in a low functional degradation index. The timber structure presents the next affections related to: (i) (A) heritage attributes (A11 - territorial value, A1 - heritage significance, A32 - occupancy); (ii) (V) vulnerability (V1 - effect of deterioration, V24 - density of divisions, V31 - quality of divisions, V34 - cover, V5 - floor-structure interaction); (iii) (H) external hazards affection (H1 - seismic zone) (Table 6).

This kind of approaches goes from the construction itself, concerning the neighborhood and the extension of the city in which the set of constructions are emplaced in the regional context of South Chile. The model proposed and applied is able to rank heritage buildings based on their functional degradation condition. After the RIPAT1.0 methodology was used in the city of Valdivia, a priority of intervention map was generated (Figure 5).

The great advantage of this kind of technique is that it is a quick and simple way of systematizing and computerizing data, and it provides a knowledge framework for professionals and researchers for the sustainable assessment and conservation of heritage timber structures (34) in southern Chile.

Chile, like other South American countries, is located on the Ring of Fire, the Pacific Ocean coastline that is considered the greatest subduction zone, known for intense volcanic and seismic activity (35). However, the Latin American countries situated in this high-risk area (27) (36) do not usually use methodologies for assessing and managing the heritage functional degradation (37). In Chile, (15), there have been some efforts to incorporate sustainability criteria into policies and plans of institutions and to implement instruments of integral use planning, but these efforts are currently only performed at the sectorial level.

The use of new technologies for protecting cultural heritage from external hazard affections has prompted important sustainable methodological changes in the preservation of heritage structures (38). Despite a substantial amount of scientific studies and discussions on this topic, few policies are based on a holistic understanding and real application of a sustainable approach (39).

This study aims to provide recommendations for the definition of functional degradation in heritage timber houses in Valdivia (South Chile) (Figure 6), developing a sustainable and innovative tool for quickly and easily organizing, compiling, and quantifying the preventive evaluation of architectural heritage (40), in order to develop public policies in an urban scale of conservation strategies and preventive maintenance plans to minimize damage to cultural heritage and reduce the cost of expensive interventions. This set of variables are involved in the focus of circular economy (CE including factors related to:

(i) technology (ii) environment; (iii) economy; (iv) social; (v) government and

(vi) behavior.

These approaches help in the implementation of a more effective decision-making process, contributing to the sustainability of resources and minimizing waste generation and unnecessary overhead. This information is paramount for identifying efficient and sustainable future steps for preserving the heritage features of similar buildings in South America.

Figure 5. Map illustrating the functional degradation conditions, based on heritage attributes, vulnerability and external risks affection of the sample, Valdivia (Chile).

CONCLUSIONS

This study represents one of the first attempts to assess functional degradation, taking into account the inherent heritage attributes of heritage buildings, their intrinsic vulnerability, and the impact of external hazards. The methodology (RIPAT1.0) was applied in a total of 20 heritage timber houses in the city of Valdivia, Chile. Information on strategies for managing heritage buildings in South America is currently scarce; hence, this type of methodology is a significant contribution to the development of holistic preventive conservation strategies for timber structures in southern Chile. A functional degradation scale was established, ranging from Condition C (red color - high functional degradation) to Condition A (green color - low functional degradation). The heritage buildings analyzed are inside of a public policy focused on an integral management and protection of local cultural heritage (Historical Conservation Buildings - HCB) defined through the General Law of Urbanism and Construction and the Ministry of Housing and Urbanism of the Chilean government. In this sense, this approach is a new contribution to the current public policies in a circular economy paradigm focus on the preventive preservation of the heritage-built environment in South America (Chile). The approach tries to optimize the consumption of resources (economical and environmental dimension). It also concerns the cultural value of architectural heritage (social and behavioral value) emplaced in a particular context (South Chile). The Valdivia population adopted architectural and stylistic characteristic in the use of wood state that wood was established as the primary building material in southern Chile. This study marks a new step in the management and optimization of maintenance work in heritage buildings, enabling experts to select the best moment to intervene to prolong the functionality of buildings in the most cost-effective manner. In future, this model may be adapted to other contexts. The current model could be improved to make the system more versatile and applicable to other situations with other types of buildings and sets of buildings; for example, those located in different climatic, social, environmental, and economic contexts.

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TECHNOLOGICAL CHANGE AND ITS IMPACT ON ECUADORIAN BUSINESS DEVELOPMENT

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ABSTRACT

The advances that science and technology have had in recent years have been one of accelerated changes, leading to the urgent need to have professional training to face the challenges imposed by contemporary innovation from business practice. The objective of this article is to analyze the impact that technological change has had on business development, mainly as a result of the implementation and use of ICTs in companies. Methodologically, this work was developed based on documentary and field research. Starting with a bibliographic review of all the existing documentation on the problem, followed by field work through the application of surveys to the administrators of Ecuadorian companies, which allows obtaining information on the properties, characteristics and important aspects of the use of technology in companies and the change in their structure that it entails. It was possible to conclude that there is a high correlation between the variables of technological change and business development with a p "Spearman's Rho" of (0.967), likewise the specific hypotheses were validated showing that the access and use of information and communication technologies (0.942), process innovation (0.908), organizational innovation (0.883), and information systems (0.876) impact on Ecuadorian business development.

Keywords: Technology;Business Development;Tic's;Company; Structure; Change

INTRODUCTION

The globalization of markets, which characterizes the current economic model, has allowed the emergence of new technologies, which have given rise to a different productive structure, where innovation and technological development are promoted as a key element of business development.

Companies today have identified that both their future and their ability to compete and differentiate themselves are largely subject to the use and incorporation of new technologies in their organizational processes. However, for many Ecuadorian companies this is still a great challenge, especially because of the lack of knowledge of businessmen about the importance of these technologies, affecting their ability to develop new products and innovate production processes.

For (Mujica, 2000), technological change has integrated in companies a different approach to obtain knowledge, interactivity, speed, autonomy, communication and economic progress. Likewise, (Gates, 2000), mentions that it is an innovative model promoted by the technological platform, through the use of telephone, cable, computer and internet networks, which are nowadays the ones that make information and communication circulate, guaranteeing a sustainable future for organizations.

According to (Ochoa & Cordero, 2002), new technologies refer to the accumulation of processes and products that result from the current tools that support communication channels, which store, process and digitally transmit information.

On the other hand, (Thompson & Strickland, 2004) say that technological change occurs thanks to the support of devices, tools, equipment and electronic components, which manage information, currently allowing to have an effective development and business economic growth.

It is important that owners, managers, administrators of companies can glimpse the importance of technology to improve their productivity, however, its application must be done intelligently, understanding that it is not only about introducing technology in their processes, but also must meet some requirements such as: having a good knowledge of the processes of the company, clearly understand the technological needs to implement them gradually and that these can have a positive effect.

Finally, we must understand that technological change has transformed our way of working and managing resources, which is why today it is considered an important key to making our work more productive, supporting teamwork, streamlining communications, making financial analysis, and promoting products in the market, allowing companies to bring out more products, of better quality, and in less time.

Technological innovation in organizations.

Nowadays, in an aggressive and changing environment, in order to compete successfully, companies need to have greater accessibility to information, which in turn must be sufficient and sophisticated. Therefore, it is considered that technological changes have become a consistent competitive advantage that encompasses: machines, tools, equipment, facilities, etc. In addition, information has become a strategic resource of the first order that companies use to improve their productive and competitive capacity.

As a result of economic globalization, the importance given by companies to technological innovation activities in order to achieve a competitive positioning has increased. The accelerated development of new technologies has become the main motivation for organizations to transform their management models, with the purpose of evolving in time on the changes demanded by the modern market, and also represents a strategy to improve the competitive position of companies.

In view of the above, it is essential that companies, regardless of their size, develop resources and capabilities aligned to the new challenges, through the renewal or changes in the processes, products or services of the organization. In other words, technological innovation is a process that helps to improve the structure at all levels of organizations, in addition to promoting productivity, differentiation and cost reduction.

Business development

Business development links several elements such as: economic growth, business culture, leadership, knowledge management and innovation, which help entrepreneurs to put an organization on the road to achieving its objectives. Furthermore, through the recognition of the capabilities of human capital, this integration generates a positive effect on companies, which will allow an organization to take advantage of the opportunities presented in a globalized environment and therefore achieve business development.

According to (Varela, 2011), business development is the process through which an entrepreneur and his collaborators obtain or invigorate skills and abilities that contribute to the management of the company's resources and the innovation of products and processes, which help the company to grow.

Likewise, (Jabit, 2010), states that business development is a response to change, in terms of beliefs, attitudes, values and structure of organizations, so that they can better acclimatize to new technologies, new markets and new challenges; allowing the strengthening at all levels in organizations (p. 474).

For (Hernandez, 2011), it is a process that is responsible for creating an organizational culture in which various social technologies are used to change the behavior of individuals and groups in terms of decision making, communication and business planning (p. 322).

On the other hand, for (Guizar, 2013), it is about some theories, values, strategies, and techniques based on behavior and aimed at the planned transformation of the work environment of an organization, with the objective of increasing individual development and optimizing business performance (p. 147).

Finally, it can be said that business

development is the established and organized change of theories, values and strategies, in advance with the purpose of originating progress at a personal and group level of all the subjects that are part of an organization, that is to say, it is the process by which the manager and his collaborators acquire abilities and skills that help the efficient and effective management of the company.

Objectives of business development

The objectives of business development are aimed at achieving an improvement in the processes of the organizations and in the quality of life of the personnel working in them, always trying to achieve a balance between the results of the company and the satisfaction of the personnel. Among some of the objectives are the following:

- Establecer clear goals, achievable and shared by the members of the organization.
- Asumir collaboration and commitment of all members to achieve organizational goals.
- Generar identification of the members with the organization.
- Promover flexibility of the organization to accept changes and improvements.
- Aceptar change as an opportunity for a new culture.
- Integrar the potential of new technologies in an integrated and coordinated whole (Cummings, 2008, p. 264).

In short, the objectives of business development are aimed at improving business processes, thus being able to achieve individual and group transformation, so that the company can respond to the demands of change in the external environment, as well as internally (Audirac, 2010, p. 275).

Benefits of the use of technological means in companies.

Information and communication technology significantly helps the development and competitiveness of companies, supporting the following aspects: Automation of processes, constant monitoring of processes, optimization in the analysis of information, better decision making, adequate coordination of remote processes, improvement of internal operations through the use of internet, facilitates teamwork of multidisciplinary professionals geographically located in different places, allows a better transfer of knowledge, allows to respond to specific needs by solving problems in an interactive and cooperative way thanks to the quick access to information, among others.

Applied Methodology

In the present research the complete inductive method was applied, starting from the particular to the general. Karl Popper (1990) mentions that all scientific methodology must be mainly deductive, and that it is always intended to know more than what is known, finding new evidence about the investigated phenomenon (p. 62). Likewise, exploratory, descriptive, explanatory, documentary, quantitative, field and correlational research was used.

Research design

A Likert scale survey was developed, of a polychotomous-non-experimental type, which, according to Hernández, Fernández, and Batista , (2014), in this sense, information is received at a certain time, to obtain relevant data from the target group. (p.40).

Unit of Analysis (UA)

According to the illustration in table # 1, according to data from the Superintendence of Companies,

(2021), the total number of companies in Ecuador is 74,868.

Table1: Classification of companies in Ecuador. Year 2019

TAMAÑO	NÚMERO	%
Micro	43.732	58%
Pequeña	20.802	28%
Mediana	7.239	10%
Grande	3.096	4%
Total	**74.868**	**100%**

Information for 2019, as of January 12, 2021.

Prepared by: The authors

Sample chosen

Due to the characteristics of the study, it was necessary to apply a simple random probability sampling, estimating the margin of error and the confidence level. This technique is based on the theoretical bases of texts by Hernández, R., Fernández, C. and Batista, P. (2006). For this purpose, the following formula was applied to calculate the sample, where: N = Population or universe (74,868), n = Sample size (?), Z = Confidence level (1.96), P = Probability of acceptance (0.5), Q = Probability of rejection (0.5), e = Margin of sampling error (0.05).

$$\mathbf{n} = \frac{\mathbf{Z^2.P.Q.N}}{\mathbf{Z^2.P.Q + (N)(e)^2}}$$

$$n = \frac{1{,}96^2 * (0{,}5) * (0{,}5) * (74.868)}{1.96^2 * (0.5) * (0.5) + (74.868) * (0{,}05)^2}$$

$$n = \frac{3{,}8416 * 0{,}25 * 74.868}{3{,}8416 * 0{,}25 + 74.868 * 0.0025}$$

$$n = \frac{71{,}903.23}{188.13} = 382$$

Data collected

Through the 382 surveys, the necessary data were collected to fulfill the research objective. The instrument was validated by experts and underwent content, criterion and construct validity analysis using the SPSS 25 statistical program. The survey consisted of 30 questions, 15 per study variable, using the Likert scale, with a hierarchical rating of: never (1), rarely (2), occasionally (3), frequently (4), very frequently (5).

Results

Using the IBM-SPSS-25 statistical software, the measurement instrument used was validated using the "Cronbach's Alpha" coefficient, the result of which was 0.993, determining that there is a very high level of reliability and validity.

Table 2: Cronbach's alpha

Resource: Statistical software - IBM-SPSS-25

Estadísticas de fiabilidad	
Alfa de Cronbach	N de elementos
,993	30

Hypothesis testing

Using the IBM-SPSS-25 statistical software, the hypotheses were validated using Spearman's Rho p-correlation coefficient, the results of which are shown in Table # 3.

Table 3. Hypothesis Test Validations

Hipótesis	Variable Independiente	Variable Dependiente	Sig	Rho de Spearman	Resultado
H. General	X. Cambio tecnológico	Y. Desarrollo empresarial	,000	,967	Se rechaza Ho
H. Específica 1	X1. Acceso y uso de tecnologías de la información y comunicación		,000	,942	Se rechaza Ho
H. Específica 2	X2. Innovación de Procesos		,000	,908	Se rechaza Ho
H. Específica 3	X3. Innovación organizativa		,000	,883	Se rechaza Ho
H. Específica 4	X4. Sistemas de información		,000	,876	Se rechaza Ho
** La correlación es significativa en el nivel de 0,01 (bilateral)					

Resource: Statistical software SPSS-25

Interpretation of results

General Hypothesis (X)

H1:Technological change impacts Ecuadorian business development.

Test analysis

The general hypothesis, using the IBM-SPSS-25 statistical software, shows a bilateral significance of 0.000 and a Spearman's Rho correlation coefficient p of 0.967, thus demonstrating that there is a high correlation between the variables under study.

H. Specific (X1)

H1: Access to and use of information and communication technologies have an impact on Ecuadorian business development.

Test analysis

In the specific hypothesis 1, there is a bilateral significance of 0.000, and a Spearman p coefficient (Rho) of 0.942, discarding the null hypothesis (H0), accepting the alternative (H1), which establishes a significant positive correlation.

H. Specific (X2)

H1: Process innovation has an impact on Ecuadorian business development.

Test analysis

In the specific hypothesis 2, a bilateral significance of 0.000 is observed, with a Spearman p coefficient (Rho) of 0.908, determining a very high correlation, according to the measurement scale.

H. Specific (X3)

H1: Organizational innovation has an impact on Ecuadorian business development.

Test analysis

In the specific hypothesis 3, a bilateral significance of 0.000 is reached, with a Spearman p coefficient (Rho) of 0.883, suppressing the null hypothesis (H0), validating the alternative (H1), determining a very high correlation between positive and significant.

H. Specific (X4)

H1: Information systems have an impact on Ecuadorian business development.

Test analysis

Regarding the specific hypothesis 4, a bilateral significance of 0.000 and a Spearman p coefficient (Rho) of 0.876 are observed, eliminating the null hypothesis (H0), approving the alternative (H1), which shows a good correlation according to the measurement scale.

DISCUSSION

Nowadays everything is developed with the help of technology, which supports and facilitates the manufacturing processes, allowing the increase of productivity and competitiveness of the companies. Technological progress examined from an economic angle, represents today the greatest importance acquired by technology as a productive element, due to the changes that have been possible on the goods produced, markets, competition, advanced concepts of design and service, intelligent materials, process automation, software, among others.

Technological advances have a greater impact in developing countries, generating positive effects on business productivity levels, as well as on labor productivity. In addition, they clearly affect a country's economic growth, in terms of investment, trade, human and social capital, as well as innovation. It is therefore essential to analyze the factors involved in technological implementation, as this will help to identify the strategies to be followed by the organization.

Companies are facing a challenge that goes beyond technological renewal; it is a matter of a social, economic and cultural transformation planned in advance. Therefore, it can be stated that knowledge management is the resource capable of creating value for those companies that apply it in all areas.

CONCLUSIONS.

1. During the last decade it has been proven that the technological and

communication media have had a beneficial impact on us at a social and economic level, and that their use and diffusion explain the positive evolution of the vast majority of countries in the world.

According to the hypotheses:

1.Regarding the general hypothesis, the existence of a good correlation was observed, with a p "Spearman's Rho" of 0.967, demonstrating that technological change impacts the business development of Ecuadorian companies, which should be given greater importance to the use and application of technological tools in companies.

2. Specific hypothesis 1 proves that there is a good correlation with a p "Spearman's Rho" of 0.942, underlining that access to and use of information and communication technologies have an impact on Ecuadorian business development.

3.Regarding specific hypothesis 2, a good correlation is determined, with a p "Spearman's Rho" of 0.908, allowing the conclusion that process innovation has an impact on Ecuadorian business development.

4.It is observed in specific hypothesis 3 that there is a good correlation with a p "Spearman's Rho" of 0.883, emphasizing that organizational innovation has an impact on Ecuadorian business development.

5.Finally, in the specific hypothesis test 4, a good correlation was evidenced, with a p "Spearman's Rho" of 0.876, highlighting that information systems have an impact on Ecuadorian business development.

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Family farming: analysis of sustainability through social economic and environmental indicators

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Abstract

This research aims to discuss and analyze the importance of sustainability in family farming on a rural property. Thus, it is necessary to investigate the level of sustainability present in the agroecosystems located in the city of Fagundes, in Agreste da paraíba. For this purpose, the MESMIS method was used, which addresses a series of social, economic and environmental indicators to diagnose sustainability in ownership of family agricultural production systems. 73.70% of the ecosystem's indicators are in ideal situations, thus showing management close to adequate sustainability. In order to improve the productivity and sustainability of agricultural practices, recommendations were proposed to correct the weaknesses found, the measures aimed at elaborating the socioeconomic conditions of the family group and the place, in order to increase productivity in the agro-ecosystem.

Keywords: Sustainability; MESMIS method; Agroecosystems; Indicators.

Introduction

Nowadays, Brazil stands out as one of the countries that produces the most food in the world due to its large cultivated area and the diversity of food produced. Family farming is responsible for a large part of this production, accounting for more than 80% of the food produced in the country. The importance of strengthening family farming should be recognized, given that it is responsible for cultivation and management practices that have a lower environmental impact on the space where they are located. Therefore, the search for a sustainable system should be the focus of both a local and a broader vision (IBGE, 2006).

According to Altier (1989), the sustainability of small producers should be measured by an indicator that establishes at least four criteria, regardless of the method used to evaluate this sustainability.

These are: maintaining the productive capacity of the agro-ecosystem; conserving natural resources and biodiversity; strengthening social organization and, as a consequence, reducing poverty; strengthening local communities, preserving their traditions and knowledge and ensuring their participation in the development process.

Brazil stands out in the production of various crops, especially beans and cassava. Around 70% of beans and 87% of cassava come from this sector of Brazilian agriculture (Rodrigues, 2012). Most of these products are grown by family farmers. In order for these agro-ecosystems to perform well in terms of sustainability, environmental, economic and social factors need to be analyzed. In this way, we can leverage the critical points found in these indicators, thus making family farming sustainable and conducive to development.

Bossel (1999) states that in order to assess the levels of sustainability of different realities, appropriate indicators are needed, which can address social, economic and environmental dimensions. Thus, according to Abbot and Guijt (1999), an indicator is a quantitative and qualitative measure that helps to transmit and synthesize a set of information about complex processes, events or trends in a given reality.

Unlike modern commercial agriculture, which uses fixed or temporary workers on medium or large properties, family farming is the cultivation of land by small rural landowners, essentially using family labor. Recognizing family farming as one of the tools responsible for food production in Brazil means recognizing the importance of those who work in the countryside, live in the countryside and produce in the countryside. On 27/07/2011, Portal Brasil published a story entitled "Family farming produces 70% of the country's food, but still suffers in marketing". The text states that: Despite being responsible for producing 70% of the country's food, family farming faces challenges in marketing and organizing its production (IBGE, 2006).

It is important to emphasize the fundamental role that family farming plays, since most of the food consumed by society comes from its production. Therefore, their permanence and strengthening are of great importance, not only because of the respect they deserve as a social group, but also because they support food security, the production of raw materials, local and regional development and nature conservation.

In this respect, the sustainability of agroecosystems is understood to mean maintaining the ecosystem's capacity to support itself through cyclical practices, which imply the ecosystem's capacity to absorb and recompose itself in view of anthropic use, seeking to conserve natural resources so that they can meet present needs without compromising availability for future generations (Campos; Carvalho, 2017). In this way, this article presents a field research experience that aimed to use social, economic and environmental indicators to assess the sustainability of family-based rural properties called the Agreste community, located in the Agreste region of Paraíba.

Methodology

Reference was made to the MESMIS method of Campos and Carvalho (2017) and Astier et al., (2002) with sustainability in family-based agroecosystems in the state of Paraíba. It is a method that, in a cyclical, participatory and multi-scalar way, seeks to identify anthropogenic changes in a system based on sustainability standards. The method is applicable to agricultural, forestry and/or livestock production systems, and seeks to holistically point out the limits and possibilities of the system's sustainability from the economic, social (including cultural and political) and environmental perspectives (Maser, Astier; Lopez-Ridaura, 2000).

The method consists of a series of six-stage assessment cycles (Figure 1). First, the system under analysis is characterized, identifying the aspects of the management system and its socio-economic and environmental context. This is followed by an analysis of the agro-ecosystem's critical points in order to identify the limiting and favorable factors for sustainability. It is important to note that the method is flexible in terms of the possibility of making methodological adaptations, encouraging modifications based on the specificities of the study sites (Verona, 2008).

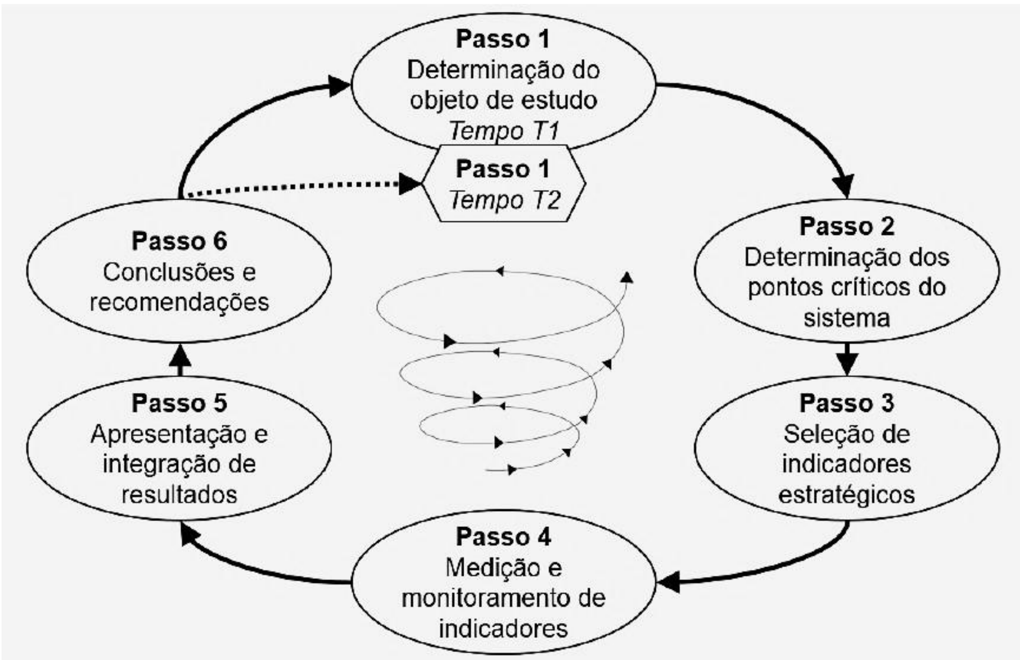

Figure 1- MESMIS evaluation cycle

Source: Adapted from Masera et al., (1999).

The research in question has an exploratory approach and descriptive analysis, based on theoretical research and field studies in the Agreste community, in Fagundes-PB. In order to assess the sustainability of the agro-ecosystem under study, the MESMIS method "Marco de Evolución de Sistemas de Manejo de Sustentabilidad" was used. This model was proposed in Mexico in 1999 by Masera, Astier and López-Ridaura. The method evaluates the agro-ecosystem based on the three main dimensions - social, economic and environmental. It is widely used around the world, especially when evaluating cases of family or peasant farming, with an emphasis on ecologically-based practices, and seeks to gain a comprehensive understanding of the limiting factors and possibilities for development in agro-ecosystems (Verona, 2008). In this evaluation system, indicators play a key role in obtaining data for the subsequent measurement of sustainability (Gallo et al., 2015).

In Brazil, MESMIS has been applied mainly in family-based production units as an academic exercise, in the form of dissertations, theses and other research and extension projects supported by funding agencies. According to the procedures established by the method, the steps were as follows:

During the months of November and December 2018 and January 2019, the characterization was carried out based on on-site observations and the application of questionnaires, making it possible to recognize the study area, as well as providing the researcher with knowledge of the characteristics and specificities of the property studied. The research was conducted in a family-based agro-ecosystem located in the Agreste community, in the rural area of the municipality of Fagundes - PB (Figure 2), at the following coordinates: latitude 7º21'18" S and longitude 35º46' 30" W. Located in the southern part of the municipality and to the east of the urban center.

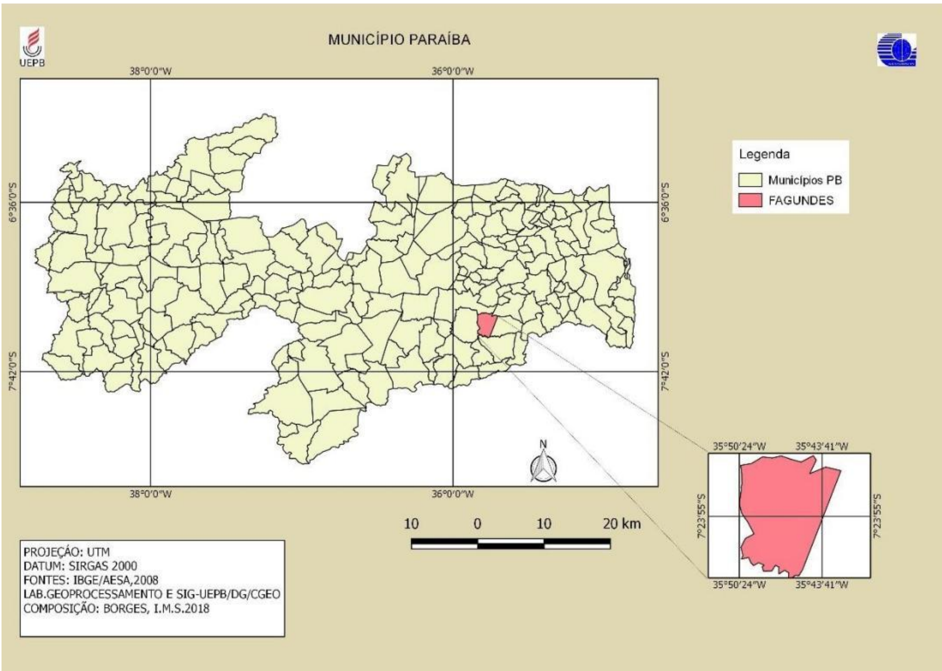

Figure 2- Location map of the municipality of Fagundes- PB

Source: Own (2019).

The relief of the area is quite steep, moderately dissected, with altitudes of approximately 505 meters, with poor and shallow soils, except in the areas of narrow and deep valley bottoms, and vegetation composed of deciduous forest, Cerrado and Caatinga (CPRM, 2005). The climate is characteristically very hot, with a rainy season in winter. The average annual temperature in this municipality hovers around 25°C.

The community in which the agro-ecosystem under study is located is rich in family farming units, where various crops are grown, as well as several species of animals. Since its foundation, the municipality has preserved its agrarian character, with agriculture being the most important sector of the economy. The family groups grow corn, fava beans, beans, potatoes, jerimum and organic vegetables. Their production is destined for self-consumption and some products are sold at the town's central market.

However, measuring and monitoring indicators This stage presents the quantitative performance of the level of sustainability of each indicator in the social, economic and environmental dimensions (Alves et al., 2016). The stage was carried out using the questionnaires and information obtained in qualitative on-site approaches, following the evaluation model proposed by Verona (2008) and used by Gallo et al. (2014), where the sum of the parameters verified in each indicator refers to the degree of sustainability of the area under study, to this end, values from 1 (one) to 3 (three) are assigned for each indicator evaluated. In this way, the indicators scored 1 (one) present a non-desirable condition, those scored 2 (two) represent a regular condition, and those evaluated 3 (three) correspond to a desirable condition for sustainability. The indicators and parameters are shown in Figure 3.

DIMENSÕES	Nº	INDICADORES	PARÂMETROS		
			1	2	3
Econômica	01	Renda Econômica	Salário mínimo	De 2 a 3 salários	Acima de 3 salários
	02	Produção Agrícola	Pouca	Razoável	Acima da média
	03	Implementos Agrícolas	Modo intensivo	Manual	Quando necessário
	04	Comercialização da produção	Com intermediário	Intermediário+ venda direta	Venda direta (feiras, local de produção, etc.)
Ambiental	05	Uso de recursos naturais	Não faz	Faz, sem manejo	Faz, com manejo
	06	Água para consumo humano	Não tratada	Filtrada	Tratada
	07	Água para agricultura	Não tratada	Filtrada	Tratada
	08	Esgoto	Ambiente	Fossa	Tratada
	09	Reciclagem do lixo	Não faz	Faz parcialmente	Faz 100%
	10	Cobertura do solo	Solo exposto	Com cultivos	Cobertura em todo o ano
	11	Adubação	50% orgânico	< 90> 50% orgânico	>90% orgânico
	12	Áreas degradadas	Várias	Poucas	Não há
	13	Desmatamento	Já realizou	Parcialmente	Nunca houve
	14	Queimadas	Já realizou	Parcialmente	Nunca houve
	15	Análise e correção do solo	Não faz	Faz esporadicamente	Sempre que necessário
Social	16	Atuação de cooperativas	Não tem	Existe parcialmente	Existe integralmente
	17	Mão de obra terceirizada	Para todas as atividades	Apenas algumas	Não há
	18	Ajuda de programas sociais	Não tem	Recebe pouco	Recebe significativamente
	19	Escolaridade	Não Alfabetizados	Alfabetizados	Alfabetizados com segundo grau completo

Figure 3- Indicators used to assess sustainability in the agro-ecosystem of the Agreste community in the municipality of Fagundes- PB

Results and discussion

The family production unit belongs to a family made up of a couple aged over 55 and three children aged between 23 and 30. In terms of schooling, the couple's education ranges from 4th to 7th grade, i.e. one of the two is not literate. As for the children, two of them have higher education, one being a teacher and the other an agricultural technician. They have lived on the property for more than 20 years, since it was inherited from the owner's father, and they dedicate themselves exclusively to farming and livestock rearing, except for the daughters who work on the side, but still contribute to the farm's activities. This is where much of the family's livelihood comes from. The land is 4.5 hectares in size and almost all of it is dedicated to farming, in which family labor is employed.

Table 1- Agricultural crops grown in the agro-ecosystem

Source: Own (2019)

Gêneros cultivados		**Produção estimada por colheita**		
Espécie	**Nome popular**	**Quantidade plantada**	**Quantidade lucrada**	**Valor estimado**
Phaseolus vulgares	Feijão	3 kg	160 kg	R$ 650
Zea mays	Milho	4 kg	300 kg	R$ 300
Phaseolus lunatus L.	Fava branca	2 kg	200 kg	R$ 800
Manihot esculenta	Mandioca	40 galos	200 kg	R$ 500

Beans and corn are grown in a consortium system. Growing in a family-based agroforestry system allows for greater use of the planting area and provides a greater continuous supply of organic matter to the soil due to the existence of various plant species. In addition, the practice allows for better conservation of the soil's chemical, physical and biological attributes, reducing production costs and avoiding the proliferation of pests and weeds in the crops. Part of the produce is destined for direct consumption by the group and another part is sold. The main critical points found in the agro-ecosystem were:

The critical points found in the unit

studied were as follows: water for agriculture; sewage agriculture; sewage; soil analysis and correction; and the work of cooperatives; aid from social programs programs (Figure 4). With the identification of the weak points in each indicator, we observed a greater fragility in the environmental dimension, where the greatest number of indicators are marked in the not desirable parameter, corresponding to a value of 1 (one). Some other points were at a value of 2, while other indicators remained at a value of 3, as shown in figure 3.

Figure 4- Representation of the values found for each indicator in Agro-ecosystem 01

Source: Own (2019)

The results obtained with the sum of the parameters of each indicator was equal to 41 points. These results indicate that the agro-ecosystem under study has most of the indicators in ideal situations, but also indicates the presence of alterations, requiring the implementation of mitigating measures to control the weak points, which are essential for adequate sustainability. The sum closest to ideal conditions was observed by Campos and Carvalho (2017) in a study carried out in Fagundes -PB Agreste Paraibano, where the value was 38 points. In this sense, the result found for this property is unsustainable, but very close to sustainable, since the property is sustainable when it reaches 40 points.

Considerations

The diagnosis and analysis of the social, economic and environmental dimensions of the area where this research took place demonstrate the importance of family production units in the municipality. In the evaluation of 5 indicators, around 26.30% were unsustainable, so the aim is to improve them so that they become sustainable according to the method.

In relation to the evaluation of the

sustainability index of the family production unit, it is in a regular situation, as most of the indicators have favorable values. In this context, in order to improve productivity and the sustainability of agricultural practices, recommendations were proposed to correct the weaknesses found. The measures were based on the socio-economic conditions of the family group and the area, with the aim of increasing productivity in the agro-ecosystem.

A thorough evaluation is fundamental to establishing what we mean by sustainability, thus analyzing, qualifying and diagnosing the situation of the agro-ecosystem, pointing out possible environmental problems and subsequently some solutions for improvement, thus seeking to preserve the environment.

Suggestions for future work include evaluating farms in two different areas and making a comparative analysis of social and environmental indicators. Analyze and correct the soil and compare the level of sustainability of family farming.

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GIS TECHNOLOGY ROLE AND PLACE IN RUSSIAN ECONOMY DIGITALIZATION

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ABSTRACT

The development and active use of information and communication technologies launched the digitalization process, which radically changes the ways of communication and communication technologies. Experts compare the depth and scale of the ongoing changes with the processes of the economy industrialization during the late 19th - early 20th centuries. The article presents the study results of geoformation technology development trends within the framework of the economy digitalization. The authors considered the stages of geographic information system development globally and in Russia. To meet the study's aim, they carried out the analysis of GIS technology implementation and use in various sectors of the Russian economy. Plus, the analysis and synthesis, monographic, comparative analysis are considered. Based on the results obtained, it can be inferred that for the most part international indicators and indices assess the technical aspect of the digital economy formation and development, which is not entirely correct, given the fact that we cope with a tough complex phenomenon. It is associated with the process of social-economic institutions of society informatization, and the process of globalization leads to their transformation at the macro level. The assessment of digital technology implementation level in the country economy at the international level is not made according to individual indicators considered in this study. Complex indicators are used for this, allowing, on the one hand, cover some indicators and give an overall assessment. However, on the other hand, they do not take into account and level out the peculiarities and specifics of individual countries and types of activity development.

Keywords: Digitalization; geoinformation technologies; geoinformation system;GIS

1.INTRODUCTION

Widespread digitalization as a process has brought the economy to a new level, which has also become digital now. Nowadays the digital economy is rapidly developing all over the world and covers more and more areas of activity. According to N.S. Rytova, the digital economy can cover everything that can be formalized, i.e., described by logical diagrams. Thus, our reality today is determined by scientific and technological progress and the introduction of new technologies (Rytova, 2018; Polozhikhina, 2020; Ruzikulova et al., 2021).

In a broad sense, the digital economy is the result of a new industrialization (due to the introduction of ICT - information and communication technologies, or the fourth industrial revolution) and the emergence of a new technological order – the Industry 4.0 (Polozhikhina, 2020).

The digital economy of the Russian Federation, like in other countries, is based on the use of modern information and communication technologies, including geoinformation technologies.

Geographic information system (GIS) as a concept and sphere of scientific and practical activity emerged less than a hundred years ago. GIS is a system for collecting, storing, analyzing and graphic visualizing of spatial (geographical) data and related information about the required objects. GIS is an information system that provides collection, storage, processing, access, display and dissemination of spatially coordinated data on terrestrial objects and processes (Anikeeva et al., 2018).

The geographic information system allows you to implement a number of functions, the main of which are determination of an object exact location in space; visualization of the information received for making management decisions; monitoring of natural resources.

2.METHODS

It is recognized at the international level that the spread of new ICTs and the formation of a digital economy on their basis opens up broad prospects for development. But at the same time, it creates new risks (Polozhikhina, 2018).

The World Bank report highlighted the following risks of digitalization:

cyber security;

the possibility of mass unemployment;

“digital division” increase (a gap in digital education, in terms of access to digital services and products, and, thus, a gap in well-being level) between citizens and businesses within countries, as well as between countries (Kukharev & Fudina, 2021).

The progressive development of digitalization and expansion of information technology use possibilities and, in particular, GIS in all areas of activity requires studying the dynamics and trends of this process, which is almost irreversible.

Research methods used in this work: analysis and synthesis, monographic, comparative analysis.

3.RESULTS AND DISCUSSION

The improvement of GIS is associated with its progressive development and is most often divided by experts into three stages: pioneer (late 1950s - 1960s), state initiatives (1970s and early 1980s), user period (mid 1980s to the present day). Each stage is characterized by the accumulation of theoretical knowledge and the development of tools for practical problem solution. So, already at the first stage of GIS development, the Canada Geographic Information System was developed, making it possible to automate the mapping of Canadian land resources and their classification (Naidu, 2015).

The second stage of GIS development showed that the process of further design of increasingly complex systems requires significant funding, which led to the participation of large state institutions. At this stage, several large-scale geoinformation projects were implemented, the most famous of which is the 1970 US census. For this, the US National Bureau of the Census used a special topological approach based on the presentation of cartographic data Dual Independent Map Encoding (Bernhardsen, 1999; Durugboa et al., 2013; Maguire et al., 1991). At present, almost all national GIS projects are based on the data from population censuses in individual territories, since a significant part of published census data contains information with a spatial component (Gregory & Southall, 2000).

The growing demand for the practical application of GIS tools contributed to the transition to the third stage, characterized by the need to create corporate and distributed geodatabases, which were formed based on geoinformation technology commercialization. Besides, this was facilitated by the integration of GIS and database management systems and the development of network applications.

The impetus for the activation of developments in the framework of geoinformation technologies was given by the appearance of free versions of software products, such as the Geographic Resources Analysis Support System (GRASS) (Nair, 2012), and ArcView 1 for Windows (Kukharev & Fudina, 2021).

During the mid-1980s, they began to develop their own geoinformation technologies in the USSR, but they were not introduced into practice. Although in the early 1990s the first Russian scientific and production center for geoinformation was opened in the Russian Federation, only the development of the Federal Target Program "Electronic Russia" contributed to the creation and implementation of large regional geoinformation systems.

Today, a number of authors note, that we are witnessing the stage of the world geoinformation infrastructure formation, when one of the vectors of modern civilization development was the rapid development of geoinformation systems (Klochkova et al., 2017; Anikeeva et al., 2018; Koshkarev, 2009).

So, A. V. Koshkarev characterizes the period that began in the mid-90s as the beginning of a new era of geoinformatics - the era of infrastructural spatial data (ISD), which replaced the era of GIS (Koshkarev, 2009). In accordance with the GOST R 52438-2005, spatial data infrastructure is “an information and telecommunication system that provides access for citizens, business entities, state and municipal authorities to distributed spatial data resources, as well as dissemination and exchange of data in a publicly available global information network to increase the efficiency of their production and use (Kukharev & Fudina, 2021).

The need to embed the Russian economy into the global geoinformation infrastructure is confirmed by the adoption of the Concept for the Creation and Development of the Spatial Data Infrastructure of the Russian Federation. As noted in the Concept, the creation and development of this infrastructure is conditioned by the objective needs of citizens, organizations, government bodies and local authorities in the effective use of reliable, operational and relevant spatial data (Ilyushina, Sizov & Belenko, 2021).

The analysis of the main parameters of digital technology penetration into all spheres of the Russian Federation economy makes it possible to assess the pace and dynamics of these processes. It is advisable, first of all, to consider the dynamics of the information and communication technologies (ICT) sector development, which is understood as a set of organizations engaged in economic activities related to the production, distribution and use of ICTs (Kukharev & Fudina, 2021). Figure 1 shows the dynamics of gross value growth in the organizations of ICT sector, given in billion rubles for the period 2005-2018.

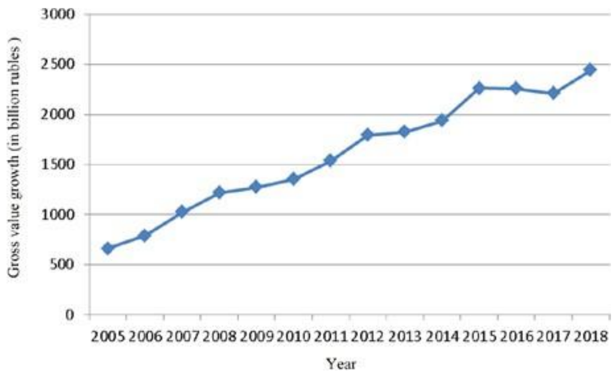

Figure 1: Dynamics of gross added value growth among the organizations of the ICT sector during 2005-2018, billion rubles[The graph was developed by the author based on the data of (Indicators of the information society: 2010; Indicators of the digital economy: 2019)].

The data analysis allows us to note that the volume of added value of the analyzed organizations increased by 3.7 times and showed a steady growth trend in 14 years, which indicates positive trends in the development of information and communication technologies. Nevertheless, the share of this indicator as a percentage of GDP has been fluctuating within 2.6-2.8% over the past ten ye[]ars, and its growth has not been observed (Indicators of the digital economy: 2020).

If you look at the volume of investments in fixed assets, which also clearly reflect the development trends of these organizations, it can be noted that they increased from 271.5 to

598.3 billion rubles over the same period, that is, 2.2 times, which shows the high investment efficiency in this area of activity. Fig. 2 shows the dynamics of changes concerning the investment volumes in the fixed assets of ICT organizations.

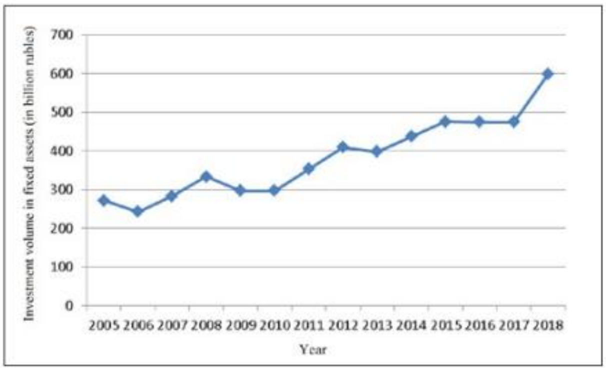

Figure 2: Dynamics of changes concerning investment volume in fixed assets of ICT organizations during 2005-2018, billion rubles[The graph was developed by the author based on the data of (Indicators of the information society: 2010; Indicators of the digital economy: 2019)].

However, it should be noted that the return on investment in fixed assets, if we estimate it as a share in added gross value, steadily decreased from 0.4 rub./rub. in the first analyzed year to 0.21 rub./rub. in 2017. This situation took place during the observation period and during the first 13 years. And only in 2018 this indicator increased again and amounted to 0.24 rubles of capital investments per ruble of added gross value. This suggests that a certain proportion of new products has not been introduced into production yet and is under development.

The basis for one of the most significant high-tech products in the development of spatial data infrastructure was laid by the research work "Development of a system project for the creation of a spatial data infrastructure in the Russian Federation" (Russian statistical yearbook. 2020), commissioned by Rosreestr. It reflects in detail the requirements for the constituent parts of the SDI, highlights the constituent parts of the geoportal and describes the requirements for their functionality.

It is legitimate to note that the level of the Russian economy digitalization is determined not only and even not so much by the indicators of ICT organizations, but by the use of these technologies via organizations in other spheres of the economy and the population. As for the population, during the first ten years (from 2005 to 2014), the level of growth in digital literacy was determined mainly by the growth of household number with personal computers.

This indicator increased from 25 to 71%, or 2.84 times.Further, since 2011, the proportion of the population with Internet access has been calculated. This indicator has grown 2.7 times over the past ten years, from 26% to 69%. A fairly obvious indicator of digital technology development by the population is the growth of Internet use proportion for state and municipal service receiving, which has also grown almost 2.5 times since 2013 (Indicators of the digital economy: 2020: statistical collection).

The assimilation of digital technologies by the population also makes it possible to use infrastructural spatial data (ISD), which have become available due to free access provision for geodata sets. The main point of entry and access to ISD resources is the geoportal (Antsiferova et al., 2021). The development of such a geoportal provided the population with open access, for example, to such an online service as the Public Cadastral Map.

If we talk about the trends and level of digital technology application in the organizations of various spheres of the Russian economy, it should be noted that technical support for their use has been applied in organizations over the past 10 years. Back in 2013, almost complete and widespread use of personal computers was recorded in the organizations of all types of economic activity. The maximum indicator is 98.8-98.9% in the institutions of higher education and communications, the minimum is 92.0-88.8% in the organizations for the production and distribution of electricity, gas and water, as well as in other types of organizations (Russian statistical yearbook. 2020: Statistical collection).

In subsequent years, to assess the level of digital technology mastery in production and social sphere, they also began to consider the level of the Internet and software product use, calculating the proportion of organizations using digital technologies. The use of GIS technologies in the organizations of various types of activity can be assessed by using the web-GIS trend. It is a geographic information system in the Internet/Intranet, the users of which can view, edit and analyze spatial data using web browsers. Web GIS applications allow a wide range of users to exchange any georeferenced data, thus ensuring a lower cost. Currently, the clouds contain a large number of geoinformation resources: data, maps, models, applications, sites and portals (Kukharev & Fudina, 2021).

The analysis of statistical data for 2017 showed that more than 60% of participants carry out banking and other financial transactions, except for the organizations conducting the transactions with real estate, and from 29.4% of water supply organizations to 49% of wholesale and retail trade organizations conduct professional training of personnel An

assessment of the Internet use for video conferencing showed that, in addition to the IT and respectively), a high share was noted in wholesale and retail trade (52.9%), as well as in extractive and manufacturing industries (46.3 and 46.7%, respectively). As for the recruitment of personnel, the leading positions are occupied by wholesale and retail trade (55.9%) and the manufacturing industry (55.6%).

The analysis of software product use is considered in the context of participation in the processes of automated production and/or individual technical means management, the design of training programs and scientific research. On average, the largest share in the business sector is occupied by the use of management software (20.1%), while there is a significant variation in the context of individual types of activity. So, the highest values of 50.2% and 45% are given by IT organizations and manufacturing enterprises, the lowest value (4.9%) is provided by the firms engaged in real estate transactions.

35% of manufacturing and construction organizations use software for design, 25- 29% of energy supply, transportation and storage companies, as well as mining companies, use training programs. The largest share of organizations using digital technologies for scientific research (10.6%) are the organizations engaged in professional, scientific and technical activities, which is 2.8 times higher than the average for the entrepreneurial sector.

Thus, in the context of economic activity types, the most prepared for the use of digital technologies are wholesale and retail trade organizations and manufacturing enterprises, in addition to the companies operating in the field of IT and telecommunications. The lowest level is demonstrated by the organizations engaged in the operations with real estate, which is difficult to explain, since, firstly, these are often the firms with a staff of 2-3 people, which are easier to train in ICT; secondly, the practice of assessment requires a database development; thirdly, experts must have a special higher education and use special programs for object evaluation in their work.

If we consider the social sphere separately, we can single out the organizations of higher education that show the highest level of digitalization in the context of electronic document management systems, the use of electronic reference and legal systems, training programs, financial calculations and the solution of organizational, managerial and economic problems. All these parameters vary in the range of 77-84%. In health care and the provision of social services, in addition to the electronic document management system, comparable to the university indicator, the other parameters are 10-20% lower. As for training programs, their share is quite insignificant and amounts to 11.4%.

An important characteristic of digitalization development is interaction with state and municipal authorities. The data analysis shows that the share of services received from state and municipal authorities in electronic form is slightly more (41.9%). Although this indicator increased by 10% for the entire analyzed period, over the past 6 years the growth rate was only 1.02-1.05, which is clearly not enough to achieve the level of digitalization in developed countries.

A detailed analysis of some indicators characterizing the introduction of modern digital technologies in certain areas and types of activities, the business sector and households allows you to see the features and take into account their specifics. It makes it possible to develop an action plan in more detail and pointwise to increase the intensification of the economy digitalization processes and the use of geoinformation technologies.

The use of GIS technologies in the organizations of various types of activities can be assessed, in particular, by interaction with the Unified State Register of Real Estate (USRRE). On average, this type of interaction in the business sector was carried out by 32.7% of organizations in 2017. More often they interacted only with extra-budgetary social funds for the purpose of reporting (49.5%). In the context of individual types of activity, the largest share of organizations interacting with Rosreestr is demonstrated by the firms providing electricity (42.7%) and manufacturing enterprises (39.8%). Hotels and catering (24.8%) and real estate firms (24.2%) account for the smallest share.

4.CONCLUSION

Baes on the results, the vast territory of our country requires more active implementation of GIS technologies, on the one hand, and taking into account the indicators of their development level in some of the complex indicators, on the other.

Currently, 13 international ratings are used that characterize the problem under study. Our country occupies the highest positions, falling into the first 15-16% of the countries by the global cybersecurity index and the e-government development index. Russia represents the first quarter of countries in terms of ICT and inclusive Internet development indices (Indicators of the digital economy: 2020).

It should be noted that for the most part international indicators and indices assess the technical aspect of the digital economy formation and development, which is not entirely correct, since we deal with a difficult complex phenomenon. It is associated with the process of social-economic institutions of society informatization, and the process of globalization leads to their transformation at the macro level. According to the author, additional assessment criteria may be the growth of population digital literacy, the level of GIS technology mastering, and also taking into account the mentality of each country.

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