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Research Article

Public value impact of environmental innovations in Mexico: Energy, Water, Agroforestry, Biocultural, and Mining cases

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Abstract

The objective is to select some Public Services Innovations (PSI) focused on sustainable strategies implemented in Mexico from 2019 to 2024. Eleven PSI are highlighted and related to five cases of public strategies regarding energy sustainability, water, agroforestry, mining, and biocultural. These cases are analyzed, focusing on their characteristics: diagnosis, solutions, agents involved, impacts on public value, and user value. An in-depth analysis of each innovation's process and considering the INDICO index (Innovation Diffusion Co-value) measures the capacity of each PSI and its impact on sustainability considering three axes: time, organization, and the behavior of the agents involved.

The findings indicate that technical management and innovations have a favorable impact on sustainability. However, if environmental degradation is higher, longer-term approaches and more complex solutions are necessary. While these may have uncertain consequences, they provide elements to deter agents' behaviors toward environmental degradation.

Keywords: Institutional theory, Environmental Innovation, Public sector, Metrics, Mexico.

INTRODUCTION

The government that has been in power in Mexico since December 2018 has introduced policies, programs, and new management elements, which align with the government's so-called 4th transformation (4T). These are related to well-being goals, diminishing unequal distribution, social justice, democracy, honesty (as the absence of corruption), sovereignty, and environmental sustainability.

In this context, the government has created a set of changes that could be considered innovations, thus challenging the theoretical and methodological precepts of studies on Public Service Innovations (PSI). This paper identifies, analyzes, and documents environmental innovations related to energy, water, agroforestry, and biocultural.

The sources of innovation come from the relations between Humans (H) with Nature (N), mediated by Technology, which generate a use value and, from this, a nature value, both regulated by the public services, contemplating a public value (Figure 1).

The evolution of relationships between human beings and nature tends to be complex, from a simple concept of nature as a set of resources to an ecological economics concept, considering nature with its value independent of human uses, considering both intrinsic and economic perspectives (Rea & Munns,, 2017 Sep, 13(5)). An intermediate notion is Nature-Based Solutions (NBS), which mitigates climate change while slowing further warming, supporting biodiversity, and securing ecosystem services (Lenka , Tatiana , & Jílková, 2010). Therefore, the complexity of nature and the current biodiversity crises requires a systemic approach to have better solutions (de Vries, Bekkers, & Tummers, 2015).

For this paper, this concept of nature is incorporated into the public value limited to the pros and cons of each innovation.

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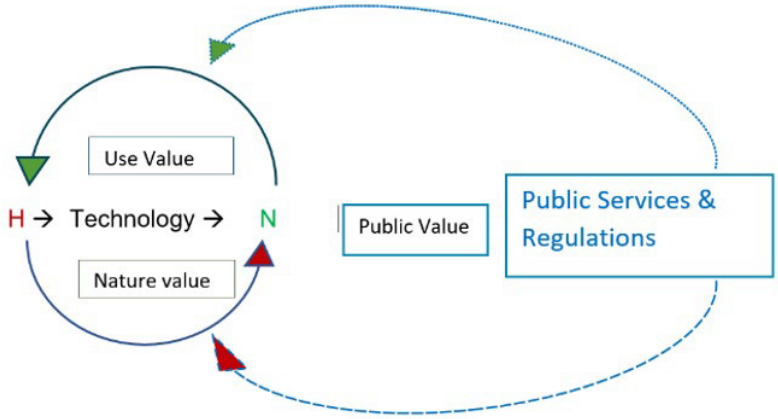

Figure 1. Relationship between Humans, Nature and the Public sector.

This study pursues two lines of research: public service innovation and its environmental impact. For that purpose, the following definitions are proposed:

- Public service innovation (PSI) focuses mainly on social well-being. It is defined as creating and implementing new processes, products, services, and delivery methods, or their discontinuity, with the participation of organizations, suppliers, and customers.
- Sustainable development (SD) is defined as meeting "the needs of the present without compromising the ability of future generations to meet their own needs." (World Commission on Environment and Development, 1987). This implies that business and policy decisions are interdependent on social, economic, and environmental dimensions. Therefore, in the current context of public change in Mexico, a methodology is developed first to capture the innovation of eleven selected current PSI in Mexico (Annex 1), based on the perception of two indicators: 1) the INDICO index, which is adapted to service innovation from an already developed for technology firms, and 2) the gain on an environmental problem, after its application. The methodology proves that it could help prioritize specific public service innovations and provide a basis for policy designing for the short- and long-term.

LITERATURE REVIEW

The main lines of this paper, public service innovation, and environment, are present in the literature. However, they are both rarely related, so the most striking policy opportunity today is to improve the coherence between environmental and innovation policies (Heaton, 2020).

Innovation began as an economic concept to explain entrepreneurial behavior in the context of crisis (Schumpeter, 1934). The trajectory from technological innovation in firms is later applied to innovation in service firms based on different thinking stages: first, the "assimilation" of the firm's technology innovation concepts to services. Second, a "differentiation" is made in the sense that specific concepts are developed for the understanding of innovation in services, such as co-value, co-creation, co-production (De Koning, Crul, Marcel, & Wever, 2016), or "hidden innovation" for creative firms (Miles & Green , 2008). An additional standpoint is that all could be considered a service-dominant logic" (Lusch & Vargo, 2016). Third, a perspective of "inversion" in which service innovation is applied to technology innovation firms, widening the view of both. The current thinking tends to be an "integration" view of innovation in goods and services (Gallouj, 2010).

Under the framework of innovation in services, a further step is its application to public services, which embrace the "user value" and the "public value" together. This comes out from the public social goals such as welfare, social inclusion, anti-corruption regulations, and human rights (Giuliani, 2016), and attends to other problems such as defense and disordered immigration, as well as societal side-effects, including environmental, social, cultural, and political implications. One important function of public services is regulation, which reduces the social cost of transactions and provides equal opportunities to firms and individuals (Figure 1).

Two alternative approaches-institutional ecological economics and free-market approaches to environmental protection-are competing [8]. However, synthesis is possible if it is under the umbrella of economic institutionalism, beneath public regulations. Therefore, as is proposed in this article, solving the interests of the agents participating in the Public-private partnership, P-p-ρ, as an alternative organization where there is "cooperation of some sort of durability between public and private actors in which they jointly develop products and services and share risks, costs, and resources which are connected with these products" (Van Ham & Koppenjan, 2001).

To investigate sustainability, the life cycle assessment (LCA) is one of the most thorough techniques considering:

(1) The Use of energy,

(2) The Use of water,

(3) The Output of material resources, including recycling and waste, and

(4) Emissions to air (Nabavi-Pelesaraei & Naderloo, A., vol 359 2022). Those resources are connected to a dynamic flow of different components and context uncertainties, such as Technology feasibility, Commercial viability, Organizational appropriability, and Social acceptability (TCOS, acronyms) (Gendron, vol. 105 2014.).

This broad definition could be associated with specific approaches to public value, such as Local Regeneration, Policy, Infrastructure, Governance, and Development (Weihe , 2006).

METHODOLOGY

As it has been mentioned above, the stages of the trajectory of innovation reach the innovation of Public Services, PSI, which implies adjusting, accordingly, first the metric to evaluate its innovativeness by assessing capacity and results through the Innovation, Diffusion, and Co-value index INDICO (Corona, Doutriaux, & Mian, 2006). Second, a metric based on three axes, Time, Space, and Organization, is used to assess the impact of the PSI on environmental issues.

INDICO Index

The INDICO Index measures innovativeness between different PSIs based on their capabilities and results, with half the ten maximum points for each aspect Table 1.

Results are the innovative content detected in services, organizations, and processes. Second, its diffusion is evidenced by replicas of it. The beneficiaries use value, and the public value is embodied to legitimize Vis society. Finally, some knowledge is involved in the product or service related to the results the innovation provides.

Capabilities include organization and process innovation, knowledge involved in the PSI, personnel training, and PSI design. Co-value capabilities depend on the user's participation in the PSI in different phases, from design to creation and delivery.

The components have a maximum score, as established in Table 1.

Environmental Assessment

For the assessment of the environmental impacts, three axes are considered:

Time, expressed in human generations, is essential because current decisions also consider future generations' well-being, which is the core of sustainable development.

Second, there is the organization of the governance of the space, whether local or with more global agents, since environmental problems have broad impacts that require action coordination at different regional levels.

Third, behavior that contrasts a selfish or individualistic attitude against awareness and collective commitment to the environment and social problems as the attention to these issues needs the cooperation of different agents Figure 2.

Table 1. INDICO INDEX for PSI.

Pillar	Concept	Component	Applied	PSI, Maximum Score
Results (5 points)	Innovation	Innovation: product, services	NA*	1.5
	Diffusion	(Intellectual Property) Replica		1
	Value	Use value		1
	Legitimation Knowledge	Social/public value		1
Capabilities(5 Points)	Knowledge	Knowledge-intensive in the product or service		0.5
	Innovation	Innovation: processes and organization		0.5
	Knowledge	Knowledge-intensive based capabilities		0.5
	Training	Training Education level		1
	Design	R&D Organization R&D Expenditure		1
	Co-Value	External-Linkages Co-Value		2
		SUM		**10**

NA*: not applicable

Source: Author Elaboration

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Therefore, by combining the perceived impacts of the PSI on these three axes, eight different degrees of environmental problem-addressing are possible, ordered from least to most significant impact: from "Recycling Economy" to "Responsible long-term global business models." They all have compatible public regulations, including public-private relationships Table 2.

To refine the assessment possibilities, each case is divided into three levels. So, there are 6 cases by axis (2 per 3), totaling 216 possibilities (63) Table 3.

The following section applies the two-mention metrics to eleven environmental innovations (Annex 1).

RESULTS

The areas of energy, water, agroforestry, and biocultural from which the eleven PSIs were chosen and implemented in Mexico since 2019 are in Table 4.

The methodology estimates their relative innovativeness and impact on the environment accordingly. The Indigenous culture shows the maximum gain in the environmental impact of 7.5 points. Others above the average of 4.71 are the Maize's PSIs (one for glyphosate use restrictions and another for its diversity) and Sowing Life. There is a low-impact group under the average: the two Energy PSIs and the two related to Water scarcity. This clustering could be explained by the short-term impact of the first group, A, while the second, B, will express more impacts in the longer term.

A regression of both groups, with eleven observations, has a positive impact of 0.71 on environmental issues per one unit of innovativeness increment over a base value of 0.89 (Figure 3):

Environment impact = 0.89 + 0.71 (INDICO) +; R^2 = 0.52, n = 11 (1).

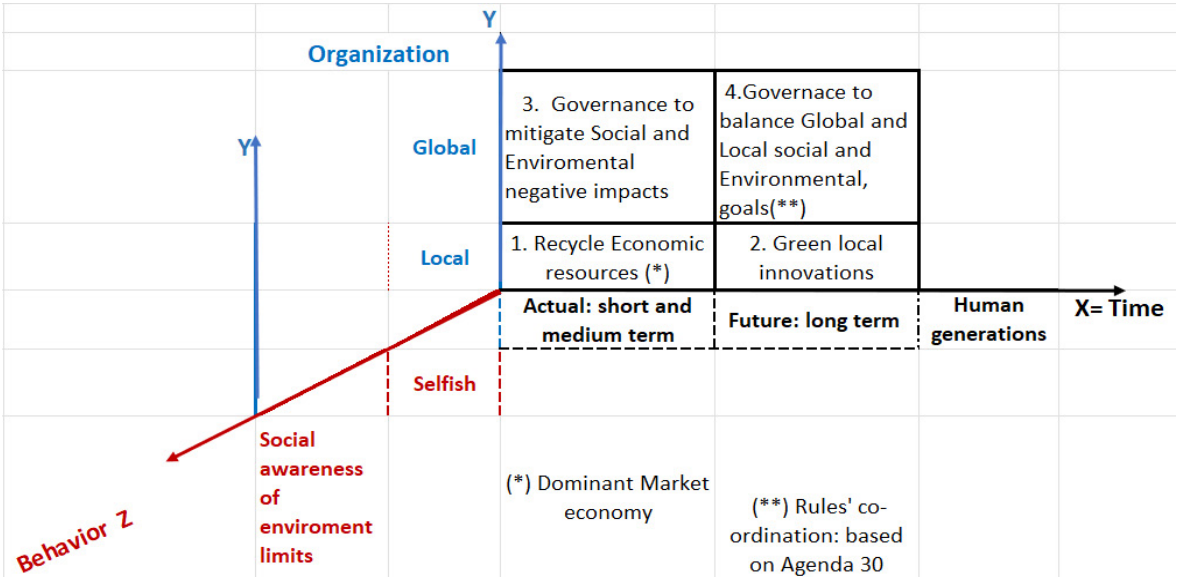

Figure 2. Types of Environmental impacts of PSI based on three Axis.

Table 2. Evaluation of environmental and social impacts in three axes: Time, Organization, and Behavior.

Number	Environmental types	Public regulations	Behavior	Organization	Time: Human generations
1	Recycle economy	P-p partnerships	Selfish	Local	Actual
2	Local Green economy				**Future**
3	Mitigate actual global impacts	Rules for international corporations		Global	Actual
4	Mitigate future global impacts				**Future**
5	Responsible local business models	Dominate Local Rules	Awareness of social problems and environmental limits	Local	Actual
6	Long term responsible local business models				**Future**
7	Responsible Business global models	Rules for goals coordination: Agenda 30+local		Global	Actual
8	Long term responsible Global business models				**Future**

Source: L Corona elaboration

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Table 3. Evaluation of environemut and social impacta in three axis: Time, Organization and Behavior.

Axis 1			**TIME: Human generations**				**Before**	**After**
	CURRENT: SHORT AND MEDIUM TERM			**FUTURE: LONGTERM**				
0	**1**	**2**	**3**	**4**	**5**	**6**		
Today	Short term	Medium term Agenda 2030	current generation (25 years)	Tendencies: Social& environment	Next generation (25-50 vears)	Long term: Prospectivefmore tha 50 vears)		
Axis 2			**ORGANIZATION**				**Before**	**After**
	LOCAL			**COLLECTIVE GLOBAL**				
0	**1**	**2**	**3**	**4**	**5**	**6**		
A place: experimental	national regional	national	International bilateral	international multilateral	international interregional	global		
Axis 3			**Behaviour: Public- Private (law and application)**				**Before**	**After**
	SELFISH (Order and Progress, one generation)			**AWARNESS of ENVIRONMENT LIMITS (more than one generation)**				
0	**1**	**2**	**3**	**4**	**5**	**6**		
From Individual culture (to social environemntal culture)	Maximizatio n of explotation: ressources and work	Technology subservient to reach social basic needs and enviromental concerns	Diffusion of new technologies for environment and social goals	Social movements for social rights and environmental limits	Welfarism to people, and Environment al protection	Goals and rules for basic social needs of next generations		

Source: Author elaboration

Annex 1: Public Service Innovations: Description and environmental impacts.

		Public service innovations
Energy	**1**	**Renegotiation of energy-related contracts with Pemex and CFE: Power transmission tariffs**
	Description	The 2013 energy reform expanded the scheme of electricity own-generation, and those involved could be registered or migrated to the category of "qualified users." These companies that generate their electricity were also given access to a preferential or lower cost rate for so-called "green carrying" for generating their own demand for electricity using wind and solar technologies. However, some firms (large commercial chains, banking, etc.) that are not self-generating were associated as users, also receiving low transmission tariffs and subsidies. The objective is to regulate to encourage competition between the CFE and the companies generating their own power supply, establishing new carrying tariffs, including the transmission of renewable energies for different voltage rates. The target population is the 303 private generating plants that are associated with 70,318 partners (electricity buyers), which distorts the model of own-supply and energy cogeneration, as previous tariffs included the use of the CFE's transmission network without paying the transmission costs, causing losses of around 7.5 billion Mexican pesos (0.375 bnD) per year. The long-term beneficiaries are the final consumers of electricity. Diminishing CFE`s subsidies will enable it to invest in the grid's modernization (García, 2020). The government is now in the process of renegotiating case-by-case those contracts.
	Environmental impacts	Although this innovation carries no direct environmental impact, it helps to make controlling and monitoring energy use more efficient. By doing this, the firms that otherwise would take advantage of these artificially low prices will now have to pay their whole amount of energy use, so the incentives related to overusing the resources due to low prices will be eliminated.
	2	**Alternative to a wholesale power market (CFE)**
	Description	The goal was for the CFE to have a 54% share in the country's total energy generation by 2024, up from 38% in 2020. One important change is that hydroelectric generation is now considered green energy, which was not the case in the 2013 energy reform. According to the (CFE, 2022), this innovation will guarantee the energy security of the country, maintaining the value chain in the electricity sector as a strategic area in charge of the State, with the purpose of offering fair rates and below inflation. Therefore, there is an upsurge in investments to modernize dam turbines and to invest in new ones. The construction of eight new power plants (six combined cycle plants and two turbo gas plants) between 2020 and 2024 will boost investment (64 billion Mexican pesos, USD 3.2 billion) will be allocated to their construction (Diaz- Perez & Ocampo-Albarrán, 2021). The CFE's share of power generation is expected to be 54%. This alternative strategy is due to the Mexican presidency proposing an electricity counter-reformation in 2022, which failed to pass because it did not receive the "absolute majority" backing in Congress (two-thirds of all votes cast).

	Environmental impacts	The environmental impact of this innovation is twofold: On the one hand, by incorporating hydroelectric energy as renewable, it increases the incentives for its development, with which the opportunity cost of using energy from fossil sources increases; and on the other hand, the increase in the market power of the state company would allow it to have decision-making power within the electricity market and use it to promote the adoption of renewable energies. Of course, this could be used in the wrong way to promote technologies harmful to the environment.
	3	**Transgenic corn**
	Description	The presidential decree (Mexico Government DOF, 2023), which replaces the one promulgated in 2020, orders the revocation of permits and no new authorizations for releasing genetically modified corn seeds into the environment, especially those intended for human consumption. Although it does not set a deadline, it is proposed that this reduction be made gradually.
	Environmental impacts	The main environmental impact of the ban on transgenic corn is focused on the preservation of the biological diversity of the country's native corn species, as well as on the control of the possible risks associated with the immersion of transgenic maize in the country's ecosystems and in the people's diet.
	4	**Herbicide glyphosate**
Biocultural	**Description**	The decree (Mexico Government DOF, 2023) also establishes the annulment of existing authorizations for permits for the import, production, distribution, and use of the herbicide glyphosate and the denial of new ones, for which a transition period is established from February 14, 2023, to March 31, 2024. This herbicide has been in the eye of public opinion due to various complaints because of its relationship with the development of physical discomfort in the people who used it, even reporting situations where those affected developed cancer. In addition, it is a herbicide to which various crops have developed resistance, so it is necessary to use more and more quantities to have the desired effects. However, it eliminates weeds without distinction, so various plants that serve as food for insects, birds, and rodents are eradicated.
	Environmental impacts	The main environmental impact of the glyphosate ban lies in protecting people's health and providing incentives to make the transition towards environmentally friendly organic herbicides that allow the controlled elimination of weeds.
	5	**Indigenous people**
	Description	The culture of Mexico is represented in its different traditional methods of agriculture that different indigenous communities have preserved. Through programs such as Sowing Life and Production for Well-being, the government has sought the preservation and promotion of these agricultural practices, since indigenous peoples are one of the most important sectors for the Mexican agri-food system, since they constitute an important part of the 85% of the small and medium-scale producers who work in the field.
	Environmental impacts	In addition to preserving the cultural values of the country, the traditional production methods of indigenous peoples are usually friendly and respectful of the environment since they incorporate organic products and products provided by nature itself into their processes. In this sense, the adoption of this type of practice reduces the impact of agriculture and promotes its sustainable development.
	6	**Natural Protected Areas**
Agroforestry	**Description**	Protected natural areas are environmental conservation schemes imposed in different areas of the country to regulate the activities carried out in the area with the intention of preserving the ecosystem assets present. This scheme dates from the beginning of the last century, but in this administration, it has gained two main nuances: on the one hand, the inclusion of the popular voice in the determination of the protection schemes, as in the case of Sierra de San Miguelito whose proposal was made by residents of the area in one of his press conferences and in whose development it presented modifications thanks to the information released by the press; on the other hand, the adaptation of public spaces abandoned or used for other purposes in areas designated for environmental protection, as in the case of Lake Texcoco, which was originally going to become an airport but, with its cancellation, ended up becoming an airport. protected natural area or as in the situation of the lands owned by the National Tourism Fund, which they plan to transform into protected areas to prevent them from being sold in the future.
	Environmental impacts	By incorporating popular demands into environmental protection schemes, comprehensive environmental preservation projects are developed where the citizens themselves are involved in this task (co-value generation), which enhances their permanence in the long term. In addition, by transforming private spaces into places where nature is protected, priorities change in the sense that the sustainable enjoyment of natural resources is located above their private use.
	7	**Sowing Life (Sembrando Vida)**

	Description	To contribute to social welfare in rural localities and make the land productive. (Secretaría de Bienestar, 2020).
	Environmental impacts	The target population is inhabitants with 2.5 hectares available to work in an agroforestry project and in municipalities with incomes below the poverty line (USD 143 per month). The beneficiaries received monthly economic support of MXN 5,000 (USD 250), the material for agroforestry production (plants, supplies, tools), and technical advice. (CONEVAL, 2020). Its main environmental impact is the reforestation of hectares susceptible to productive use by peasants in marginalized areas. By mid-2022, the program had documented a total of 1.80 million plants planted. Its goal for 2023 is to reach 1,188 million trees planted on around 1,125,000 hectares (Brooks, 2021). This program was even proposed at COP26 by the Mexican delegation, and it was Sowing Life inspired the agreement against deforestation reached at said conference. However, it provides a negative environmental impact since farmers who already have crops in their fields are left out of the program, so they will have incentives to clear farmland and thus be eligible to enter the program. In 2019, a loss of 73,000 hectares of forests was estimated because of these incentives (Warman, Zúñiga, & Cervera, 2021).
Water	**8**	Relocation of productive plants due to water scarcity: Constellation brands
	Description	A robust industrial fleet is in the north of Mexico that takes advantage of, among other things, its proximity to the United States and the industrial networks deployed in its surroundings. However, in recent years a severe water shortage has been documented in the region that has caused the suspension of activities of Constellation Brands, a beer company. As a solution, the company relocates its production processes to the country's south, where water availability is more significant. However, this would mean losing the competitive advantage represented by the northern border (Noguez, After cancellation in Mexicali, Constellation Brands will build its plant in Veracruz, 2022). In other words, water has become a competitive advantage to attract companies to a traditionally marginalized area in Mexico.
	Environmental impacts	The main environmental impact of the relocation of production plants to the south of the country is the possibility of carrying out water exploitation in a sustainable manner based on the experiences acquired with the overuse of water in the north.
	9	**Healthy Water for La Laguna**
	Description	For almost 10 years, elevated levels of arsenic have been documented in the area known as La Laguna, located between the states of Coahuila and Durango. As a way of addressing this problem, the “Agua Saludable para la Laguna” project has been implemented, which consists of the construction of diversion and purification plants, storage tanks, and conduction lines. Its main objective is to divert the water from the Nazas River to the “Comarca Lagunera” area and process it to reduce or eliminate the possible levels of arsenic that it may present. In this way, the aquifers that are currently in a state of overexploitation can begin to recover.
	Environmental impacts	Given that the surrounding population had access to water with high levels of arsenic and, at the same time, overexploited the area's aquifers by exploring ever more profound, the impact of the Healthy Water for La Laguna project is two-dimensional: on the one hand, reduces the pressure on existing aquifers allowing the deployment of recovery strategies; and, on the other hand, as it is based on the use of water from the Nazas River, whose contamination levels are lower and whose waters will go through a purification process, the water that will be provided to the beneficiary populations will be of good quality. It is estimated that one million 600 thousand people will benefit from this project.
	10	**Mining Calica Firm; Negative ecological impact**
Mining	**Description**	Vulcan Mexico´s subsidiary since 2019 is named SAC-TUN (formerly CALICA, founded in 1989), which has caused the most significant ecological impact in the Yucatán Peninsula for the extraction of stone material below the water table. Vulcan Co is claiming economic damages of 1.5 billion dollars from Mexico´s government for stopping its production activities in 2020, through an international arbitration in ICSID, that began in 2018, after the La Rosita property in Playa del Carmen was closed last May, since where he extracted stone material for export to the United States. (Vazquez, 2022).
	Environmental impacts	The ecological impact in the Yucatán Peninsula is mainly: 1) The artificially created bodies of groundwater well above that authorized in the concessions granted by CONAGUA. 2) Three cenotes were destroyed. 3) The alteration and destruction of caves and karst landscape. (Vazquez, 2022).
	11	**Mining Law Reform (Mexico`s President, 2023)**
	Description	Modification of the granting concessions of free land scheme of the first applicant, to a public tender scheme with the reduction of the duration from 50 to 30 years. Also, the prohibition of non-granting when the area does not have water availability and does not use more than 30% of the total basin or aquifer volume, as well as the final disposal of mining and metallurgical waste on protected natural areas or when the population is put at risk.
	Environmental impacts	The waste generated by the exploration, exploitation, benefit, or use of a mining concession is the permanent and non-transferable responsibility of the person who owns the concession, regardless of whether its management is carried out through a third party who will jointly share said responsibility.

Table 4. PSI with INDICO innovativeness measurement and its impact gain on the environment.

Area	Public Service Innovation for the Environment	INDICO	ENVIRONMENTAL IMPACT			
			Before (B)*	After (A)*	GAIN = After (A)-Before (B)	Gain Order
Energy	Renegotiation of energy-related contracts with CFE: Power transmission tariffs	2.82	1.73	4.69	2.96	9
	Alternative to a wholesale power market (CFE). Hydrolectric is a green energy and the CFE incremental resources are related to this kind of energy	3.89	1.73	5.39	3.65	8
Water	Healthy water for "La Laguna"	3.56	1.00	3.74	2.74	10
	Relocation of productive plants due to water scarcity	3.64	1.41	3.61	2.19	11
Agroforestry	Sowing Life "Sembrando Vida"	6.55	1.00	6.71	5.71	3
	Protected Natural Areas	7.09	1.41	6.63	5.22	6
Biocultural	Maize, glyphosate	6.64	1.00	6.71	5.71	4
	Maize, diversity	6.95	1.41	8.06	6.65	2
	Indigenous	5.07	1.00	8.54	7.54	1
Mining	Amendments to the Mining Law	6.68	2.45	7.48	5.03	7
	Calica	7.48	1.73	7.00	5.27	5
	Average	**5.49**	**1.44**	**6.23**	**4.79**	**6**

***** It is the hypotenuse of the three PSI's axes values: Time, Organization, and Behaviuor

Source: Author elaboration

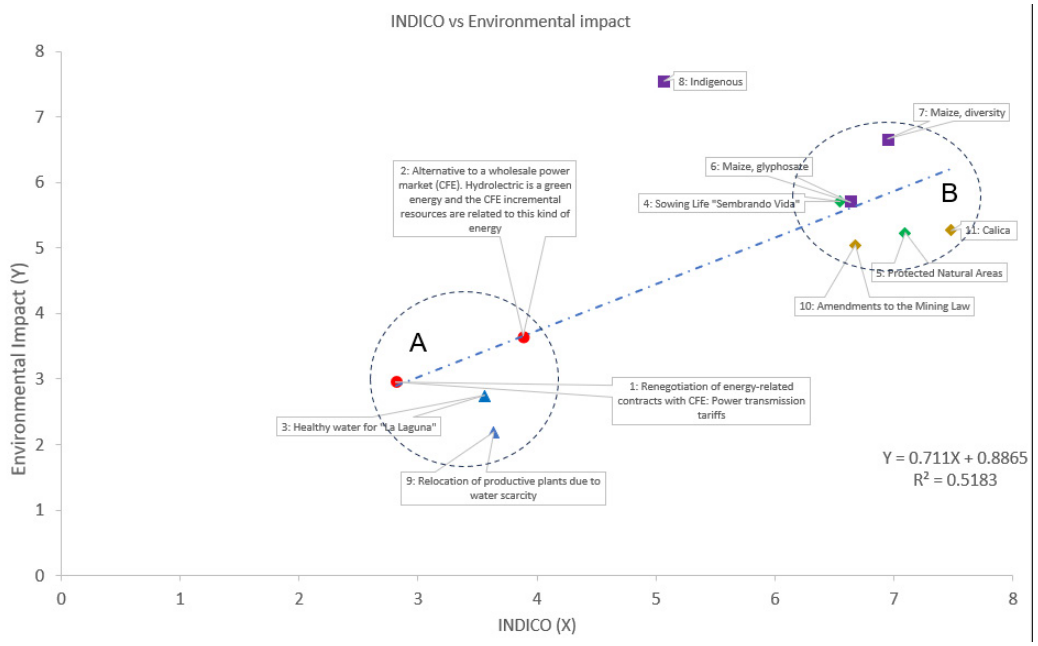

Figure 3. PSI's INDICO vs Environmental impact of PSI.

DISCUSSION

A greater number of PSIs is desirable. The incorporation of more related actors could certainly help improve and diversify their perceptions of them.

The methodology applied helps prioritize the PSIs. Metric analysis can furthermore help develop short—and long-term policies.

From the theoretical point of view, its application is an example of a viable and necessary approach based on institutional economics (regulation) combined with neoclassical, evolutionist, and ecological economics.

The eleven PSIs selected are defined top-down, so this limitation could be overcome with innovation from intrapreneurial behavior that is down-top in public organizations (Kraus, Breier, Jones, & Hughes, 2019).

The Public-private partnerships (P-p-ρ or P3s) are complex hybrid organizations that have become diffused, becoming part of a policy for infrastructure construction and delivery worldwide. They have a dual nature as they are context-

driven and socially constructed, including macro and micro (private) interests that enact efficacy and sustainability and institutionalize 'preferred' policy measures of 'public interest' (Omri, 2020). However, the economic and political power asymmetries between the public and private actors produced different impacts and conflicts of interest. An example is the mining industry, which generates contradictions with uncertain results (Clinca's 11-PSI, see annex).

CONCLUSION

The relationship between public innovation and its impact on environmental problems is scarce in the literature. Moreover, metrics suitable to public innovativeness and the state of the environment-specific problems are rarely found.

Looking at the evolution of both concepts, a double metric approach is applied to the context of changes in the Mexican government since 2019. However, the proposed methodology could be used in other contexts to measure the innovativeness of public services and the impact on public or social goals, such as the environmental problems chosen in this paper.

Applying the methodology to eleven public innovations selected (Annex 1), it is found that there is a positive impact on environmental problems. More precisely, 71% of the innovativeness is transferred to paying attention to environmental problems (equation 1).

First, PSIs are grouped in A, linked to energy and water, with the most significant environmental degradation and substantial institutional obstacles. So, their management will require more complex and longer-term solutions to discourage the agents' degradation-causing behavior. Moreover, a second PSI group, B, is related to agroforestry, biocultural, and mining, which are more efficient in solving environmental problems (Figure 3). This finding can help design specific policies for each group, but must also be concerned about its economic sector characteristics.

As most of the PSIs are approved by the Mexican Presidency, some with Decrees need to be implemented and supervised by pertinent organizations and institutional cooperation. We also need to empower communities, which are either users or consumers of the public service, as well as private firms or other associations. Innovation from entrepreneurship would complement the top-down PSIs.

ACRONYMS

CEPCyT: Center for Economic and Prospective in Science and Technology.

CSID: World Bank´s Centre for Settlement of Investment Disputes.

CFE is Mexico's power energy public agency (Comission Federal de Electricidad in Spanish).

INDICO, Innovation, Diffusion, and Co-value, innovativeness index.

LCA: life cycle assessment

P-p-p: Public-private partnership

PSI: Public Service Innovation (Opara & Rouse, Volume 58, January 2019)

Papiit, UNAM's Support Program for Research and Technological Innovation Projects

TCOS: Technology feasibility, Commercial viability, Organizational appropriability, and social acceptability.

UNAM: National Autonomous University of Mexico

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