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Articles

Cross-border sanitation project evaluation in Ambos Nogales. Identifying the homogeneous from the diverse

Evaluación del proyecto de saneamiento transfronterizo en Ambos Nogales. Identificación de lo homogéneo y lo diverso

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Abstract

This article aims to characterize the Ambos Nogales population according to the opinions of the impacts generated by the expansion and modernization cross-border sanitation system project during 2000-2018 and identify *ex post* evaluation criteria to strengthen governance strategies for the public policies on water and sanitation. A representative random survey was applied at the city level. The information analysis was performed using the hierarchical cluster and multiple correspondence analysis methods. The results show the formation of groups of cities or population segments with high internal homogeneity and high intergroup heterogeneity. This empirical evidence allows us to build a

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typology of public opinion. Finally, to improve public opinion on this project, a series of actions aimed at promoting sustainable transboundary governance are proposed.

Keywords: Ambos Nogales, multiple correspondences, cross-border sanitation.

Resumen

Este artículo tiene como objetivo caracterizar a la población de Ambos Nogales en función de sus opiniones sobre los impactos generados por el proyecto de ampliación y evaluación de proyectos de modernización del sistema de saneamiento transfronterizo durante el periodo 2000-2018, para identificar criterios de evaluación *ex post* que fortalezcan estrategias de gobernanza de políticas públicas en materia de agua y saneamiento. Se aplicó una encuesta aleatoria representativa a nivel ciudad. El análisis de información se realizó mediante el método de conglomerados jerárquicos y el método de análisis de correspondencias múltiples. Los resultados evidencian la conformación de grupos o segmentos de población con alta homogeneidad interna y alta heterogeneidad intergrupal en ambas ciudades, evidencia empírica permite construir una tipología de grupos de población. Como conclusión, se propone una serie de acciones con el objetivo de impulsar una gobernanza transfronteriza y sostenible tendiente a mejorar la opinión pública sobre dicha obra.

Palabras clave: Ambos Nogales, correspondencias múltiples, saneamiento transfronterizo.

Introduction

The Ambos Nogales sanitation system, a binational transboundary metropolitan area comprised of the cities of Nogales, Sonora, and Nogales, Arizona, has historically required close collaboration between Mexican and U. S. water authorities at the national, state, and local levels since the topographic characteristics of this area cause approximately 60% of the wastewater generated on the Mexican side to flow by gravity to the U. S. side (Acta 206 Operación y mantenimiento común del sistema sanitario internacional de Nogales, Comisión Internacional de Límites y Aguas entre México y los Estados Unidos, 1958). Given this situation, it has been technically and economically more feasible to treat wastewater on the U. S. side since the Mexican side does not have the necessary space for a project of this nature, and if there were, it would be very costly to pump the treated water for reuse in the city.

The demographic and economic transformation of Ambos Nogales during the 20th century required the expansion of the transboundary sanitation system in 1972, when a new international wastewater treatment plant (NIWTP) and an international sewer were constructed by the U. S. section of the International Boundary and Water Commission (IBWC) and the government of the city of Nogales, Arizona. The government of Nogales, Sonora, built a sewer that carries wastewater to the international border. Over

the years, this transboundary system was insufficient to meet the sanitation needs of a growing population. In 2000, the U. S. authorities implemented the NIWTP expansion project, replacing the international collector interceptor (CI) and portions of the Nogales, Arizona wastewater collection system. The objective of this project was to expand the wastewater treatment capacity from 454 to 973 liters per second to treat wastewater from Ambos Nogales, *80% of which comes from the Mexican side*. Similarly, in 2004, the Mexican authorities implemented the Nogales, Sonora, sewer system rehabilitation project, which consisted of the rehabilitation of approximately 30 000 linear meters of drainage, almost the entire sanitary sewer system of the city (Banco de Desarrollo de América del Norte [BDAN], 2004). Subsequently, in 2012, the Los Alisos wastewater treatment plant, located south of Nogales, Sonora, came into operation. It is not part of the transboundary sanitation system but represents an alternative for the city to treat and take advantage of a larger volume of treated wastewater (Meranza-Castillón et al., 2017; Tapia-Villaseñor et al., 2020).

The design and implementation of these works resulted from a *binational public policy* strategy that recognized the *transboundary* nature of the Ambos Nogales sanitation system, a system governed by the international water treaty between Mexico and the United States signed in 1944. To this end, Aguilar Villanueva and Bustelo Ruesta (2010) comment that the new management aimed at solving public problems requires evaluation mechanisms to know its results since they can improve the functioning or operation of the action or policy implemented, strengthen the accountability of the different public and private actors involved, and improve future measures.

It should be noted that the issue of transboundary waters in Ambos Nogales, which corresponds to the Santa Cruz aquifer, has been the subject of scientific research. Nevertheless, no studies have analyzed the impact on the population's opinion of the works or projects derived from transboundary public policy. Most of these investigations have addressed topics such as hydrogeological simulations of that basin (Tapia Padilla, 2005), future water demand and availability due to the effects of climate change and population growth in Ambos Nogales and Tucson, Arizona (Scott et al., 2012; Tapia-Villaseñor et al., 2020), and, in the transboundary region of Mexico and the United States in general (Varady et al., 1999), the discharge of wastewater in transboundary sanitation systems or the design of conceptual frameworks to assess ecosystem services of treated wastewater inflows (Norman et al., 2013).

Considering the complexity inherent to the management of this type of project, which encompasses technical, legal, topographical, and governmental dimensions and, above all, involves fully providing a human right as essential as access to water and sanitation, it was considered scientifically relevant to find out the opinion of the population on how they perceive the impacts generated. In the case presented here, the proposed *ex-post* evaluation can become a feedback mechanism to assess the project's economic, social, urban, and environmental impacts and generate empirical knowledge to become an analytical input for designing management mechanisms in future transboundary sanitation policies or measures.

With this background, *the objective of this study is to characterize the population of Ambos Nogales in terms of their opinions and perceptions of the impacts generated by the project to expand*

and modernize the transboundary sanitation system in order to identify ex-post *evaluation criteria to strengthen public policy management strategies in the area of water and sanitation.*

This work is structured as follows. The first section explains the theoretical and conceptual framework used in this research based on the relevance of public policy evaluation mechanisms. This explanation is followed by a discussion of the methodological strategy, which consists of five stages: explanation of the selected evaluation criteria, construction of indicators, description of the source of information, method of analysis, and spatial and temporal framework. The results obtained in Ambos Nogales, both on the Mexican and U. S. sides, are analyzed below. Then, based on these results, a series of issues that, in the authors' opinion, are relevant for strengthening the management strategies or mechanisms of public policies related to water and sanitation are briefly developed. Finally, the concluding remarks and conclusions are presented.

Evaluation of public policies

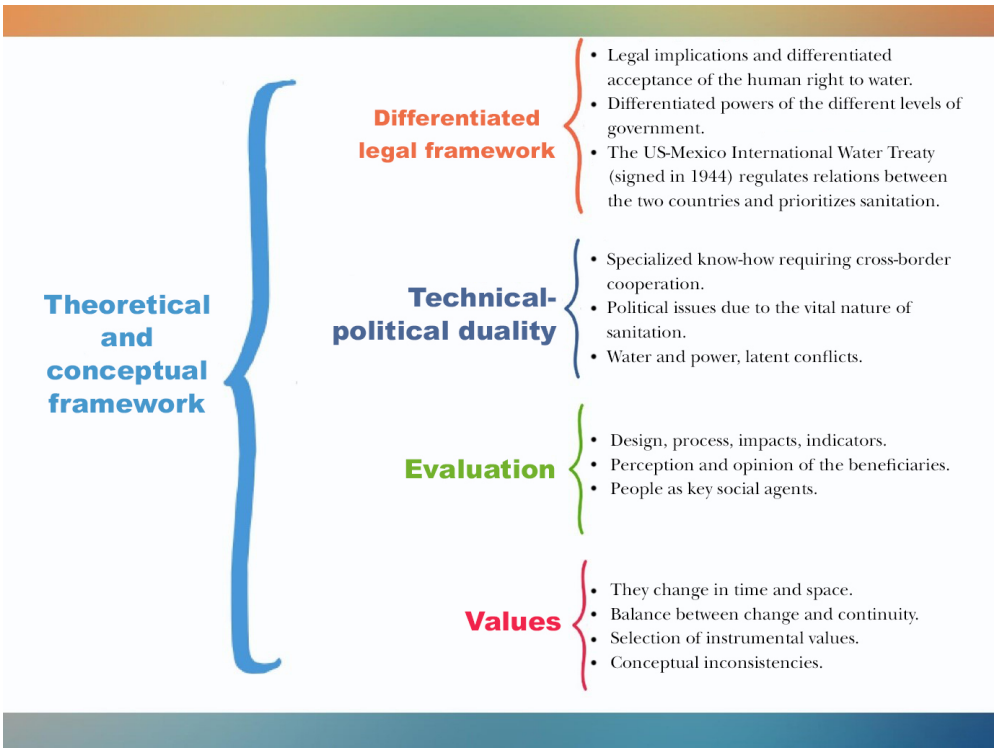
Public policy evaluation is a discipline that focuses on the analysis of results, effectiveness, and efficiency of actions implemented by governments at different levels to solve public problems. As Lara Caballero and De León Calderón (2018) point out, this discipline is gaining scientific relevance within the social sciences since it involves knowing, in addition to how management is carried out, the results or impacts derived from government actions. Accordingly, Aguilar Villanueva (2015, p. 42) issues a warning about a "reactivation of the public nature" in the sense that these should be oriented to the benefit of the population and, in addition, citizens should take part in "the deliberation of public affairs, as well as in their implementation and evaluation" (Aguilar Villanueva, 2015).

Given the specific circumstances of the object of study, i. e., its inherently cross-border nature, it is considered that the *ex-post* evaluation of the project in question can generate relevant empirical knowledge on the subject of binational public policies since it involves knowing the results obtained from actions implemented by the governments (at all levels) of two countries. To this end, Figure 1 summarizes schematically the theoretical framework with which this research is approached, which is described below.

First, two different views are identified between Mexico and the United States on the legal nature of this issue. In Mexico, the human right to water and sanitation was enshrined in the constitution in 2012, whereby the State must guarantee that "... everyone has the right to access, provision and sanitation of water for personal and domestic consumption in a sufficient, safe, acceptable and affordable manner" (Comisión Nacional de los Derechos Humanos [CNDH], 2014, p. 5). The United States, on the other hand, while promoting the universality of this service, does not accept that this responsibility is legal through the concept of human rights. Regardless of these legal views in both countries, the international water treaty, which dates back to 1944, establishes that Mexico and the United States are obliged to resolve border sanitation

problems in a preferential manner (Comisión Internacional de Límites y Aguas entre México y los Estados Unidos [CILA], 1944). The variety of actors and decision-makers and both countries' constitutional, legal, and institutional frameworks make this type of public policy a complex issue.

Figure 1. Conceptual framework



Source: created by the authors based on Aguilar Villanueva (2015), Lara Caballero and De León Calderón (2018), and Méndez Martínez (2020)

In Mexico, water administration is the federal government's responsibility through the National Water Commission (Comisión Nacional del Agua [Conagua]), although state and municipal governments have some powers. In the United States, management is carried out by cities and towns through commissions regulated by state-level entities. The federal agencies that look after the interests of each country in border areas are the International Boundary and Water Commission in Mexico and the International Boundary and Water Commission (IBWC) in the United States.

Aguilar Villanueva (2015) points out that public policies are characterized by a technical and political duality, an approach confirmed in this study's specific case. On the one hand, every sanitation policy has a *technical component* since the projects derived from this type of policy require specialized knowledge in engineering, system design, measurement, and evaluation of wastewater pollution levels. On the other hand, it has an *inherently political component* since, by satisfying such an essential human need as water and sanitation, it seeks the social benefit of the population. Moreover, it cannot be ignored that the vital nature of water makes it a factor of power to such a degree that

treated wastewater itself is acquiring an increasingly important economic value (Scott & Raschid, 2012), whether for its role in the sustainability of water resources in the urban context (Li et al., 2020; Scott & Pineda Pablos, 2011), for its use in the agricultural sector (Hamilton et al., 2005), or for its ecological value in maintaining water levels in rivers (Alcon et al., 2012), especially in arid regions with high water stress such as the Sonora-Arizona transboundary zone. Cáñez Cota (2022) states in this regard that the management of transboundary waters between Mexico and the United States requires trust between the institutional actors of both countries, trust that is enabled through a shared ethic that, in turn, materializes in concrete actions that evidence binational cooperation, but at the same time faces cultural obstacles due to the different styles of socialization between these actors. These assumptions infer that any transboundary sanitation system, although it necessarily requires technical cooperation between specialists from both countries, also requires adequate political and institutional management since the use or disposal of treated water can be a matter of controversy.

On the specific evaluation issue, Méndez Martínez (2020) states that there is a whole series of alternatives for evaluating public policies, for example, evaluation of objectives, progress, personnel, or impact. Similarly, Salazar Vargas (2009) discusses design, process, results, impact, and indicator evaluations. This case corresponds to *an impact evaluation* in that it seeks to know the effects produced exclusively by the transboundary sanitation project implemented based on a binational public policy: the *ex-post* changes produced by the system's modernization. Furthermore, *the opinion and perception of the population are incorporated as a methodological contribution that complements the analysis of objective indicators traditionally used in this type of evaluation.* Traditional indicators refer to quantitative indicators such as additional volume and quality of treated water, percentage of population with access to water and sanitation, evolution of gastrointestinal diseases before and after drainage construction, and others. Therefore, it is proposed that the subjective or public opinion indicators constructed here can become a relevant input for analysis to comprehensively understand the impacts produced by the project in question, whereby people acquire the role of key social agents. If the main purpose of public policy is to achieve the population's well-being, it is essential to know their opinion and perceptions regarding the concrete results of these policies.

Nevertheless, it should be pointed out that public policy evaluation does not occur in a spatial-temporal limbo. In spatial terms, it is clear that this is a sanitation project implemented in two cities that make up a binational cross-border metropolitan area with *its own economic, social, and cultural dynamics.* In temporal terms, the values inherent to the evaluation exercise of any public policy are emphasized since these values are relative in time. Lara Caballero and De León Calderón (2018) point out along these lines that if values were constant or invariable over time, it would be very difficult to achieve any change at the individual or social level, but if they were completely unstable, it would also be impossible to achieve continuity. Consequently, values or priorities change to achieve a balance between individual and social change and continuity, but, above all, they set the tone for analyzing the stability of the decisions made regarding public policies (Rokeach, 1973).

Lara Caballero and De León Calderón (2018) comment in this regard on five instrumental values that influence the criteria for evaluating public policies (see Table 1): *i*) equity, *ii*) freedom, *iii*) fraternity; *iv*) efficiency; and, *v*) economic growth.

Table 1. Implicit values in the implementation and evaluation of public policies

Value	Description	Source
Equity	Compensate for initial conditions, for example, of those born into poverty. Equal opportunity. Fairness in the distribution of goods and services	Lara Caballero & De León Calderón (2018)
Freedom	Acting without restrictions or control	
Fraternity	Sense of community, sense of unity and solidarity	
Efficiency	Perform activities and functions inside the available budget	
Economic growth	Economic income as a driver of economic and social development	
Sustainability	Sustainable development replaces mere economic growth. The ecological dimension is incorporated by proposing that economic growth should promote respect for the environment and social welfare	Original proposal

Source: created by the authors

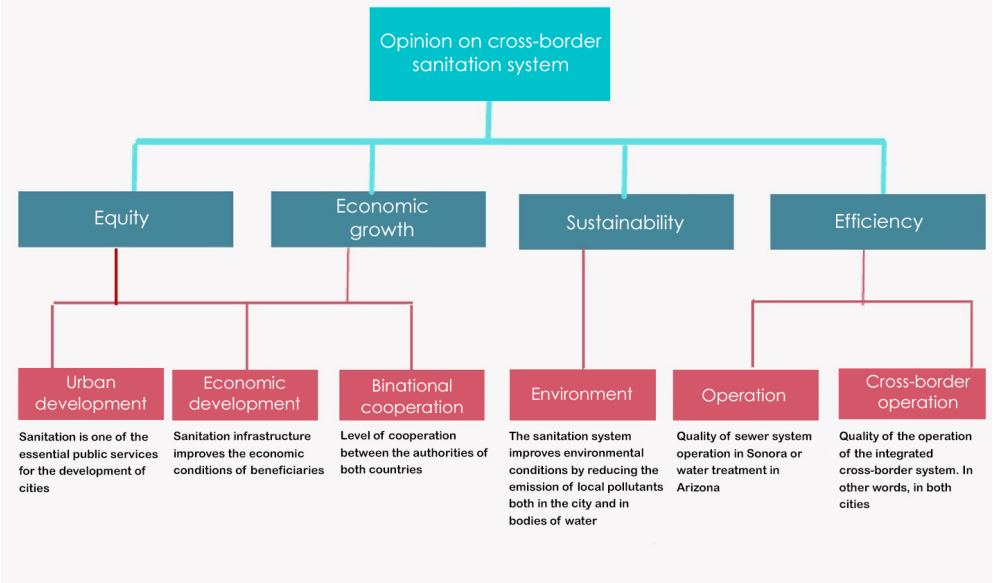
To this end, two points are raised in this paper. Firstly, it is considered necessary to incorporate the value of environmental sustainability given that since the 1970s it has been recognized as an axiological criterion that questions economic growth as the key indicator of development. Given this situation, the proposal is to add the value of sustainability to incorporate ecological and environmental issues, which are already present, at least discursively, in practically every development policy or instrument at all levels of government. Second, it is important to highlight what Lara Caballero and De León Calderón (2018, p. 41) call "conceptual inconsistencies" among these values, in the sense that they cannot all be assigned the same weight when evaluating public policies so that each particular public policy, depending on the time and space in which it is implemented and evaluated, will carry different value loads implicitly. At this point, each society determines its priorities regarding public policy, which derive precisely from the values established and identified by the evaluators. Accordingly, it is considered that this work is of conceptual and methodological significance for the subject since it analyzes the opinion of an international cross-border population. This information provides an opportunity for a comparative evaluation of how the societies of two border cities, belonging to two countries, assess the results of a specific public policy on sanitation.

Methodology

Dimensions

In order to measure the opinion and perception of the population in Ambos Nogales on the impacts generated by the transboundary sanitation project, indicators were constructed for six specific topics (see Figure 2): *1*) *urban development*; *2*) *economic development*; *3*) *binational cooperation*; *4*) *environment*; *5*) *system operation*; and, *6*) *transboundary operation*. On the other hand, from the six instrumental values summarized in Table 1, the following four are used: *1*) equity; *2*) economic growth; *3*) sustainability; and, *4*) efficiency. From this perspective, the values of fraternity and freedom were excluded based on the arguments of Lara Caballero and De León Calderón (2018) discussed in the previous section on the variability and applicability of values over time.

Figure 2. Values and dimensions analyzed



Source: created by the authors

In order to select these indicators and values, interviews were conducted with key stakeholders who witnessed the changes in Ambos Nogales due to the implementation of the transboundary sanitation project. Seven semi-structured interviews were conducted: four with public officials, two from Sonora and two from Arizona, three with users knowledgeable about water and sanitation, two from Sonora and one from Arizona. In other words, the instrumental values of this specific public policy and the *ex-post* impact indicators were selected according to the opinions of key stakeholders. The information collected and subsequent discussion and analysis made it possible to build this framework to evaluate the project results based on the population's opinion and perception.

Data source

Once the indicators were defined, a perception survey with statistical representativeness at the city level was applied to determine the social acceptance of the population living in the area of influence of the infrastructure works implemented. Following what was explained about the characteristics of the transboundary sanitation system in the introduction section, on the Mexican side the questions referred to the drainage project, while on the U. S. side they were about the international outfall and the NIWTP. The results are summarized in Table 2.

Table 2. Descriptive statistics in Ambos Nogales

Location	Topics	Opinion					Average
		Very high (5)	High (4)	Neither high nor low (3)	Low (2)	Very low (1)	
Nogales, Sonora	Operation	11%	51%	21%	12%	5%	3.5
	Economic development	5%	66%	26%	3%	0%	3.7
	Environment	9%	44%	32%	12%	4%	3.4
	Urban development	13%	60%	23%	3%	0%	3.8
	Binational cooperation	21%	56%	22%	1%	0%	4.0
	Cross-border operation	17%	16%	16%	37%	13%	2.9
Nogales, Arizona	Operation	25%	61%	6%	6%	2%	4.0
	Economic development	13%	63%	20%	4%	0%	3.9
	Environment	8%	71%	17%	4%	0%	3.8
	Urban development	6%	75%	16%	3%	0%	3.8
	Binational cooperation	12%	70%	15%	2%	1%	3.9
	Cross-border operation	84%	10%	3%	2%	1%	4.7

Source: created by the authors based on the results of the survey applied

The sample size in each city was determined as follows: the total population located in the area of influence of the drainage works in Nogales, Sonora, is approximately 80 000 inhabitants, a population that resides in about 28 000 homes in 1 107 blocks. The Nogales water utility provided the user information list to estimate a sample size of 650 households ($N = 650$), with a confidence level of 99% and a margin of error of 5%. In the case of Nogales, Arizona, the target population resides in the vicinity or margins (left and right) of the international outfall that concentrates the wastewater flow of Ambos Nogales, which amounts to approximately 20 000 inhabitants. This selection is based on the fact that this area is home to the population that directly perceives the operation of the drainage and wastewater treatment system. The sample size was calculated the same as in Nogales, Sonora, resulting in a sample of 96 people ($N = 96$), although at the end of the fieldwork in Nogales, Arizona, a total of 100 people were surveyed.

Respondents' answers on the six indicators were categorized according to a Likert scale composed of five rating levels that measure people's opinion or perception of the impact generated by the transboundary sanitation project, which was assigned the following scores: *a*) very high, 5; *b*) high, 4; *c*) neither high nor low, 3; *d*) low, 2; and, *e*) very low, 1. Table 2 summarizes the descriptive statistics of the results obtained with

this survey, specifically the percentage of cases grouped in each category and the average score obtained.

Information analysis

In order to characterize the population according to the levels of responses obtained in the six indicators considered in this study, the pattern of relations between the categories of the indicators and the cases was determined through multiple correspondence analysis (MCA). MCA is a multivariate analysis technique that graphically visualizes the relation pattern between categories (variables or columns) and cases or subjects (rows). This graphic representation is shown in a factor map comprising two or a maximum of three dimensions.[1] The procedure begins with identifying the dimensions or factors with their respective values (*eigenvalues*) ordered hierarchically. The abscissa or *X*-axis, the first dimension, has a larger eigenvalue than the second dimension, the ordinate, or *Y*-axis. This procedure is similar to principal component factor analysis (ACP). Nevertheless, an essential difference between the two is that ACP works with continuous (quantitative) variables expressed in different measurement scales, while MCA works exclusively with categorical variables that can be nominal or ordinal.

Now, the pattern of relations between the variables shown in the factor map is an expression of the difference between the row or column profiles (profiles of the cases or categories of the variables) and the average profiles (same row or column). The origin of the coordinates in the factor map (Cartesian plane) corresponds to the average profile, and the distance between points expresses the similarity of profiles, i. e., the closer two or more points are, the more similar they are, and the farther apart, the more different they are. A key concept within the MCA is *inertia*, defined as the chi-square value divided by the total number of cases ($\chi 2/N$) and that measures the difference in dispersion between the profiles (row or column) and the mean profile. The origin of the factor plane, the point where the dimensions or axes cross, is called the center of gravity, and the points that are close to the origin have the lowest inertia since they represent the average profiles. On the contrary, the points farther away from the origin have higher inertia and represent the profiles that are more distinguishable from the average profiles. In this way, the point clouds, both the categories and the cases observed in a factor map, provide insight into the level of distinction in a given population on a specific topic. In this case, the distinction is based on the opinions expressed on the six indicators used to measure the impact of the transboundary sanitation project.

Once the pattern of relations between the categories of the six indicators analyzed was identified, a *k*-means cluster analysis was applied to identify groups or segments of the population with two main characteristics: *i*) high internal homogeneity, that is, the members of each group or cluster are very similar to each other in terms of their opinions expressed about the sanitation project; and, *ii*) high intergroup heterogeneity, which means that the groups found present a statistically representative differentiation. The *k*-means cluster analysis showed that the *diversity*

[1] Obviously, it would not make sense to talk about more than three dimensions, since it would be impossible to visualize the results graphically and, thus, the methodological advantages of the ACM would be lost.

of opinions held by the population of Ambos Nogales on the impacts generated by the transboundary sanitation project is internally *homogeneous* and heterogeneous among the population groups.

Results

In order to achieve this work's central objective, a population typology was first identified according to their views on the cross-border sanitation system. For this purpose, the pattern of relations between the categories of each dimension in Sonora and later in Arizona was analyzed.

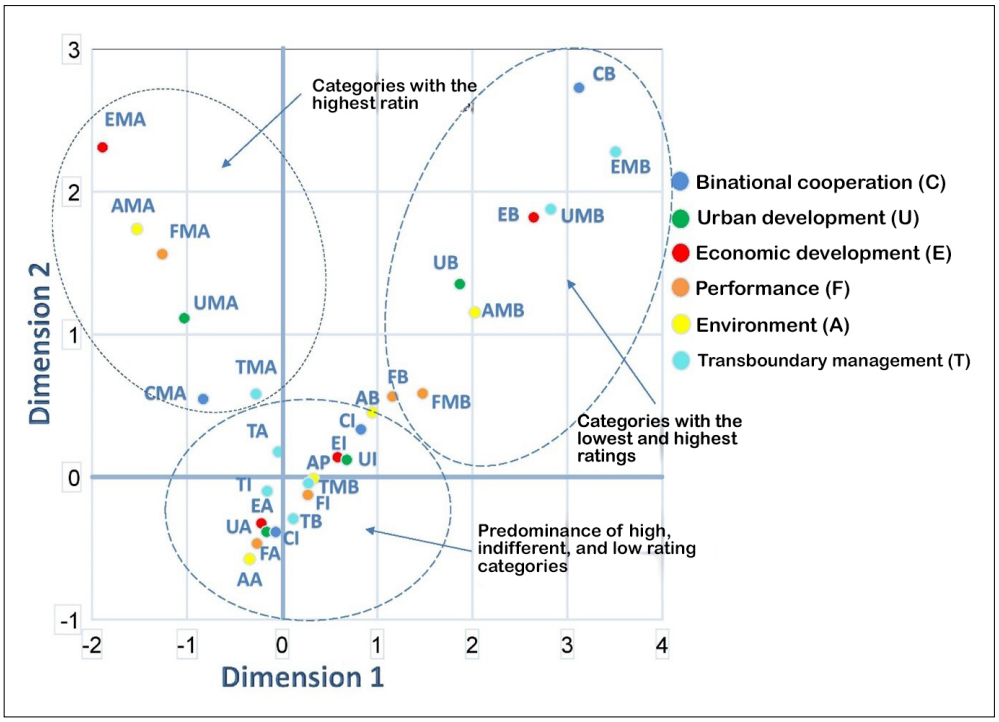
Nogales, Sonora

Figure 3 shows the results of the MCA applied to the results obtained in Nogales, Sonora. The spatial distribution of the categories corresponding to each of the six indicators analyzed forms a pattern that clearly distinguishes the population according to their opinions or perceptions.

The point cloud forms a kind of vertical ellipse with the focal axis at the bottom, a distribution known as the *Guttman* or *horseshoe effect* (Husson et al., 2017, p. 120). This effect means that the factor map's first dimension (*X* or abscissa axis) opposes categories with extreme values, i. e., from lowest to highest. In contrast, the second dimension (*Y* or ordinate axis) opposes extreme categories (*Very high* or *High* categories) with intermediate ones (*Neither high nor low*).

Table 3 shows precisely the coordinates of all the categories in the factor map ordered from lowest to highest. Note how the most negative values of the first dimension, which in Figure 3 are to the far left of the origin, correspond to the categories with the highest levels of acceptance of five of the six indicators analyzed. As these values increase toward the right of the origin, the categories with the lowest acceptance levels are identified. This dimension explains 60.5 % of the total inertia. In the second dimension, which explains 34.5 % of the total inertia, the largest negative values (-0.576 ≤ and ≤ -0.325) are at the lower end of the origin and correspond to the intermediate categories of all six indicators analyzed, i. e., those expressing regular levels of acceptance. Then, as the values go up until reaching the top of the second dimension (1.113 ≤ and ≤ 2.728), it is seen that the categories related to the extreme levels of acceptance, whether *Very high* or *Very low*, are found. This distribution of the point clouds in the factor map (Gutman or horseshoe effect) confirms a distinction among the population of Nogales, Sonora, regarding the levels of social acceptance of the sanitation project.

Figure 3. Factor map with the location of the categories of the indicators analyzed in Nogales, Sonora



Source: created by the authors

Generally, a trend starts in the upper left quadrant with the highest acceptance categories, then moves to the lower left and right quadrants with the intermediate categories, and ends in the upper right quadrant with the low and lowest categories of the indicators analyzed.

Recognizing the distinction of categories explained above makes it possible to identify groups or segments of the population with similar characteristics. As explained in the methodology section, to characterize this typology of population groups or segments, a *k*-means cluster analysis was applied according to the position (coordinates) of each case (persons) in the factor map, as shown in Figure 4.

Figure 5 summarizes the information for each cluster corresponding to its size and average score obtained in the six indicators analyzed. The height of the bars indicates the average score, and the width indicates the percentage of the population that makes up each cluster. The joint analysis of both parameters helps to understand each case's position and cluster membership.

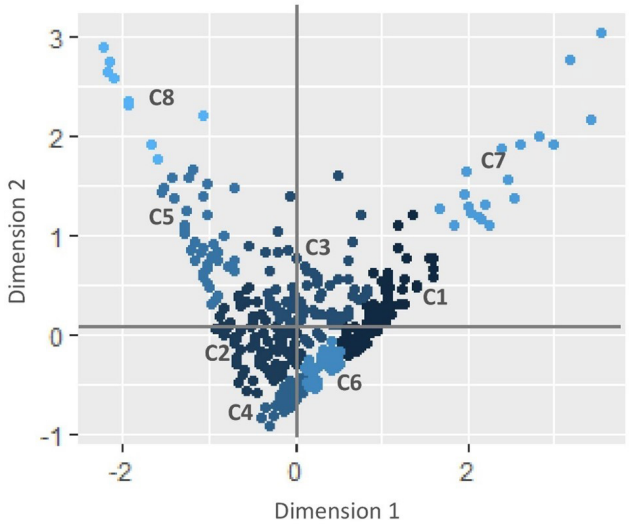
Table 3. Coordinates of the dimensions corresponding to the six indicators on the factor map

Dimension 1 (60.5 % of the inertia)			Dimension 2 (34.5 % of the inertia)		
Indicator	**Category***	**Centroid**	**Indicator**	**Category***	**Centroid**
Very high economic development	EMA	-1.889	High environment	AA	-0.576
Very high environment	AMA	-1.527	High performance	FA	-0.467
Very high performance	FMA	-1.261	High binational economic cooperation	CA	-0.386
Very high urban development	UMA	-1.029	High economic urban development	UA	-0.385
Very high binational cooperation	CMA	-0.831	High economic development	EA	-0.325
High environment	AA	-0.342	Low cross-border operation	TB	-0.293
Very high cross-border operation	TMA	-0.275	Indifferent operation	FB	-0.126
High performance	FA	-0.265	Independent cross-border operation	TI	-0.1
High economic development	EA	-0.219	Very low cross-border operation	TMB	-0.044
High economic urban development	UA	-0.164	Indifferent environment	AI	-0.013
Independent cross-border operation	TI	-0.157	Indifferent urban development	UI	0.12
High binational economic cooperation	CA	-0.068	Independent economic development	EI	0.138
High cross-border operation	TA	-0.041	High cross-border operation	TA	0.176
Low cross-border operation	TB	0.117	Low binational cooperation	CI	0.333
Indifferent operation	FB	0.271	Low environment	AB	0.452
Very low cross-border operation	TMB	0.277	Very high binational cooperation	CMA	0.546
Indifferent environment	AI	0.33	Low performance	FMB	0.564
Independent economic development	EI	0.584	Very high cross-border operation	TMA	0.581
Indifferent urban development	UI	0.68	Very low performance	FI	0.585
Low binational cooperation	CI	0.829	Very high urban development	UMA	1.113
Low environment	AB	0.95	Very low environment	AMB	1.153
Low performance	FMB	1.161	Low urban development	UB	1.352
Very low performance	FI	1.478	Very high performance	FMA	1.562
Low urban development	UB	1.869	Very high environment	AMA	1.738
Very low environment	AMB	2.027	Low economic development	EB	1.82
Low economic development	EB	2.646	Very low urban development	UMB	1.877
Very low urban development	UMB	2.826	Very low economic development	EMB	2.279
Very low binational cooperation	CB	3.123	Very high economic development	EMA	2.311
Very low economic development	EMB	3.508	Very low binational cooperation	CB	2.728

* The acronym corresponds to the indicator in Spanish
Source: created by the authors

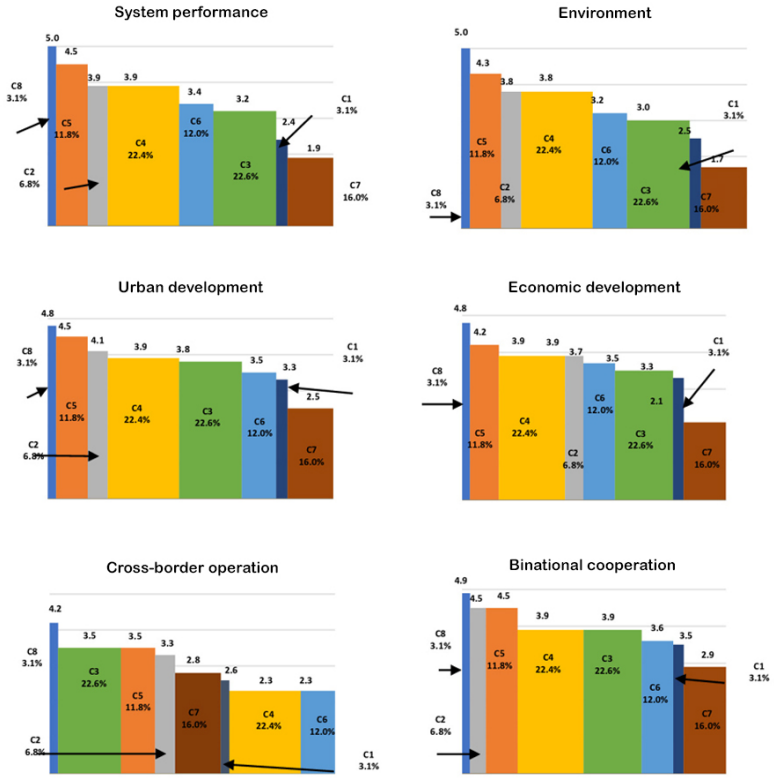
It is then seen in the factor map that the point cloud pattern of the cases starts with cluster C8 at the top left of the factor map. The fact that this cluster is the furthest away from the origin means it is very different from the average profiles, i. e., those close to the origin. For this reason, only 3.1 % of the population belongs to it. Note in Figure 5 how the main characteristic of C8 is that it presents the highest scores in all indicators. Next, C5 (11.8 % of the population), whose cases are located in the upper left part of the factor map, but—unlike C8—it is closer to the origin so that the cases (people) that make it up, although still distinguishable from the average profiles, are not as different as those of C8. In general terms, it can be seen that C5, except for the *Cross-border operation* indicator, shows high values for all indicators.

Figure 4. Factor map of cases (people) located and grouped according to their opinions expressed in Nogales, Sonora



Source: created by the authors

Figure 5. Size and average score of clusters identified in Nogales, Sonora



Source: created by the authors

Four clusters were then identified (C2, C3, C4, and C6), which, according to their position on the factor map (close to the origin), most closely resemble each indicator's average profiles.[2] Together, these clusters group 71 % of the population and, as shown in Figure 5, occupy the intermediate places in all the indicators as they are ordered in descending order according to their score, except for *Cross-border operation*. Regarding this last indicator, it is the only one that differs from the rest, both in terms of the scores obtained (generally lower) and the position of the clusters in the bar graphs. For example, C4 and C6 have the lowest average scores in *Cross Border Operations* (2.3 in both cases), and the other five have intermediate values.

Finally, clusters C1 and C7, which account for 19.1 % of the population, are characterized by the lowest levels of social acceptance. The factor map shows that these two clusters are located in the upper right part, indicating their distance from the average profiles. This fact is why, in all cases except for the *Cross-border operation* indicator, these two clusters have the lowest average scores. Nevertheless, it is worth highlighting C1, which, despite having an insignificant weight (it groups only 3.1 % of the population), differs from C7 in the indicators of *Urban Development* and *Economic development* since it presents scores that are close to intermediate.

In summary, the results obtained in Nogales, Sonora, confirm the importance of identifying a typology of the population based on their opinions about the cross-border sanitation project. A gradual differentiation was identified starting with clusters C8 and C5 (14.9 % of the population) with a high rating, followed by C2, C3, C4, and C5 (71 %) with intermediate values, and ending with C1 and C7 (19.1 %) with the lowest scores.

Nogales, Arizona

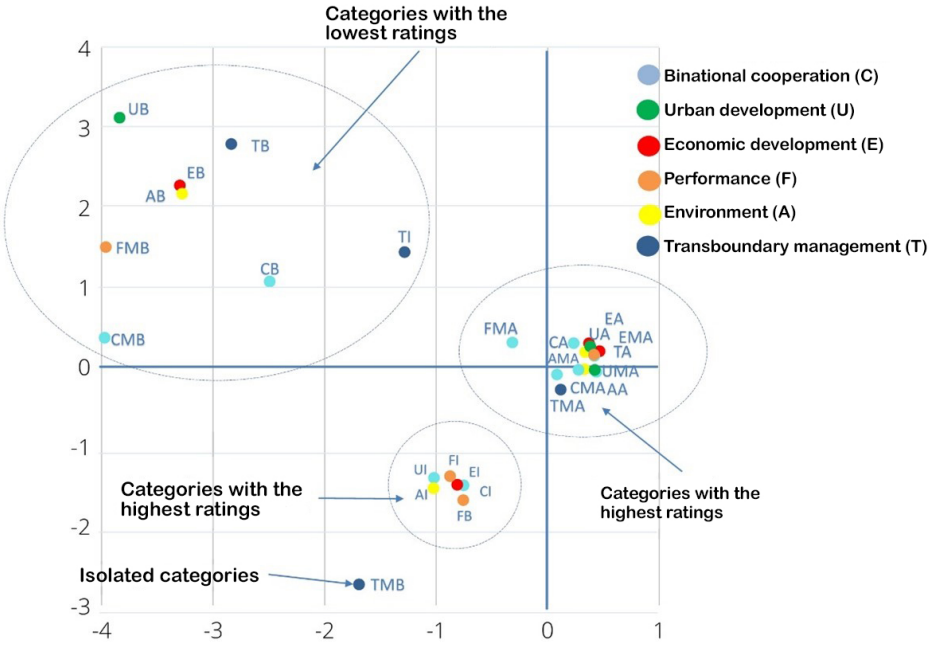
On the U. S. side of Ambos Nogales, Figure 6 shows the factor map with the location of the categories of the indicators analyzed, while Table 4 summarizes the information on the coordinates corresponding to the centroids of these categories. The factor map shows that three-point clouds are formed, which differs greatly from those identified in Sonora (see Figure 3). In this case, the first dimension explains an average inertia of 55.5 % and discriminates the categories according to their extreme values. Note how at the left end of the origin are the categories with the lowest values of the abscissae, which are related to the lowest perceptions or assessments of the population in all indicators, and as these values increase to the right, the level of assessment of the categories also increases (see Table 4). The second dimension, which explains 30.8 % of the inertia on average, discriminates the categories corresponding to intermediate ratings from the rest of the categories in all variables. This second dimension was also found to discriminate the category with the lowest rating for the *Cross-border operation* indicator from the rest of the categories.

The distribution shown in the factor map permits the identification of three large groups. In the center of the origin is a point cloud formed by most categories expressing the highest perceptions in all indicators. The fact that these categories are close

[2] Note how the average scores of these four clusters are very similar to the overall averages for each indicator shown in Table 2.

to the origin means that they group the average profiles of the population, thus implying (as will be seen below) that most of the Nogales, Arizona, population perceives the sanitation works favorably. Then, another group of categories was identified in the upper left quadrant of the factor map that is related to low or very low ratings of some indicators; nonetheless, the fact that they are so far away from the origin is evidence that the proportion of the population belonging to each of these categories is marginal. As for the third group, the categories comprising it are located in the lower left quadrant of the factor map, mainly linked to indifferent evaluations. In other words, the population in these categories thinks the cross-border sanitation project had no high or low impact on Nogales, Arizona.

Figure 6. Factor map with the location of the categories of the indicators analyzed in Nogales, Arizona



Source: created by the authors

Figure 7 shows the factor map corresponding to the location of the cases (individuals) and their belonging to their respective clusters, while Figure 8 shows the size of each cluster with its respective average score in each of the six indicators analyzed. Cluster C1 groups 75 % of the total cases and presents the highest average scores in all indicators, and considering that this cluster is located around the origin, it can be inferred that the average profiles of the population are very similar to those obtained

here. In other words, most of the population of Nogales, Arizona, expressed a high appreciation for the transboundary sanitation project. Here, it is worth noting that, contrary to what was observed in Nogales, Sonora, the *Cross-border operation* indicator was the best evaluated on the U. S. side. This point will be addressed later, but these differences between the two cities are worth noting for now.

Table 4. Coordinates of the dimensions corresponding to the six indicators on the factor map, Nogales, Arizona

Dimension 1 (55.3 % of the inertia)			Dimension 2 (30.8 % of the inertia)		
Indicator	**Category***	**Centroid**	**Indicator**	**Category***	**Centroid**
Very low binational cooperation	CMB	-3.973	Very low cross-border operation	TMB	-2.739
Very low performance	FMB	-3.962	Low performance	FB	-1.68
Low urban development	UB	-3.839	Indifferent environment	AI	-1.532
Low economic development	EB	-3.299	Indifferent binational cooperation	CI	-1.494
Low environment	AB	-3.278	tIndifferent economic development	EI	-1.487
Low cross-border operation	TB	-2.837	Indifferent urban development	UI	-1.4
Low binational cooperation	CB	-2.493	Indifferent operation	FI	-1.38
Very low cross-border operation	TMB	-1.692	Very high cross-border operation	TMA	-0.103
Independent cross-border operation	TI	-1.283	Very high urban development	UMA	-0.07
Indifferent environment	AI	-1.023	Very high environment	AMA	-0.046
Indifferent urban development	UI	-1.02	Very high binational cooperation	CMA	-0.037
Indifferent operation	FI	-0.875	High performance	FA	0.13
Indifferent economic development	EI	-0.811	High cross-border operation	TA	0.147
Low performance	FB	-0.757	High urban development	UA	0.179
Indifferent binational cooperation	CI	-0.754	Very high economic development	EMA	0.19
Very high performance	FMA	-0.317	High environment	AA	0.25
Very high cross-border operation	TMA	0.084	High economic development	EA	0.289
High binational cooperation	CA	0.233	High binational cooperation	CA	0.291
Very high binational cooperation	CMA	0.329	Very high performance	FMA	0.299
High urban development	UA	0.336	Very low binational cooperation	CMB	0.358
High economic development	EA	0.371	Low binational cooperation	CB	1.064
High environment	AA	0.382	Independent cross-border operation	TI	1.434
High cross-border operation	TA	0.416	Very low performance	FMB	1.497
High performance	FA	0.42	Low environment	AB	2.168
Very high environment	AMA	0.423	Low economic development	EB	2.271
Very high urban development	UMA	0.436	Low cross-border operation	TB	2.791
Very high economic development	EMA	0.466	Low urban development	UB	3.122

* The acronym corresponds to the indicator in Spanish
Source: created by the authors

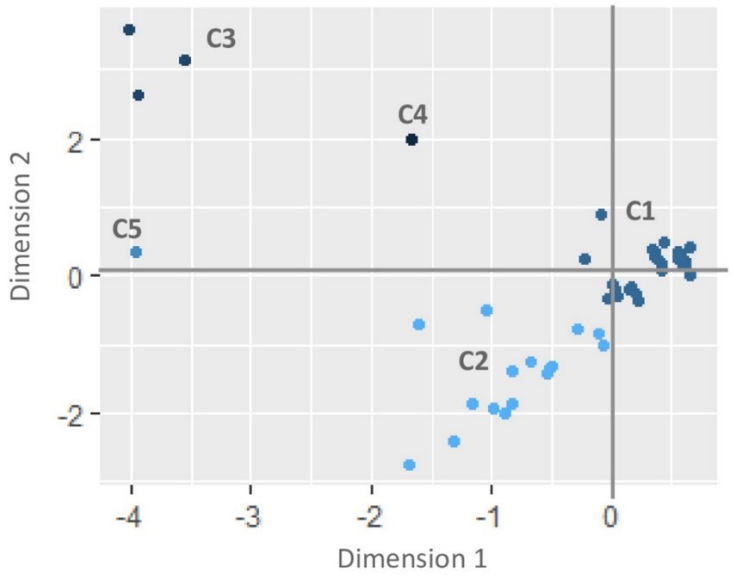
The factor map shows that Cluster 2 comprises 20 % of the population and is the second largest. Their average scores are intermediate for all indicators (between 3.1 and 3.4), except for *Cross-border operations*, where a high score (4.8) was obtained. The results of this cluster show that one-fifth of the population of Nogales, Arizona, thinks that the cross-border sanitation project did not affect five of the six indicators analyzed

and, on the other hand, confirms the high valuation of the *Cross-border operation* indicator by the majority of the population.

The remaining three clusters are marginal as they comprise a small proportion of the population. For example, C3 (3 % of the population) has intermediate scores for most indicators; C4 (1 %) has high values for all indicators except *Economic Development*; and C5 (1 %) has low values for all indicators.

In summary, the results obtained in Nogales, Arizona, confirm the importance of establishing a typology of the population based on their opinions about the cross-border sanitation project (as in Nogales, Sonora).

Figure 7. Factor map of cases (individuals) located and grouped according to their expressed opinions in Nogales, Arizona

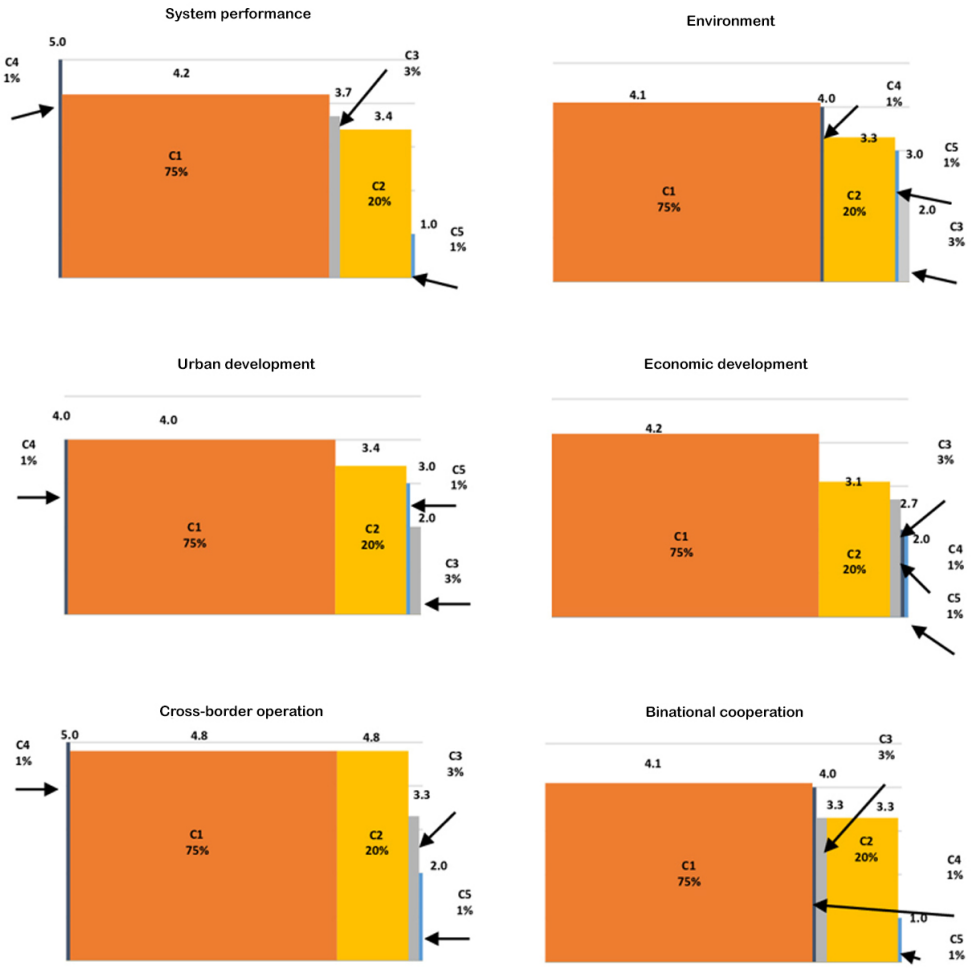


Source: created by the authors

Inputs for public policy evaluation

Identifying a typology or characterizing the population benefited in Ambos Nogales by the cross-border sanitation project is an empirical input that can be used as feedback to complement traditional evaluations of public policies based on objective indicators that measure. By recognizing that there are homogeneous groups or segments of the population based on the heterogeneous range of opinions regarding the impact of public policies, it is possible to design and implement targeted adjustments based precisely on the inherent characteristics of these groups. Accordingly, the implications of the results obtained in this research are discussed below as analytical inputs for evaluating the cross-border sanitation policy in Ambos Nogales.

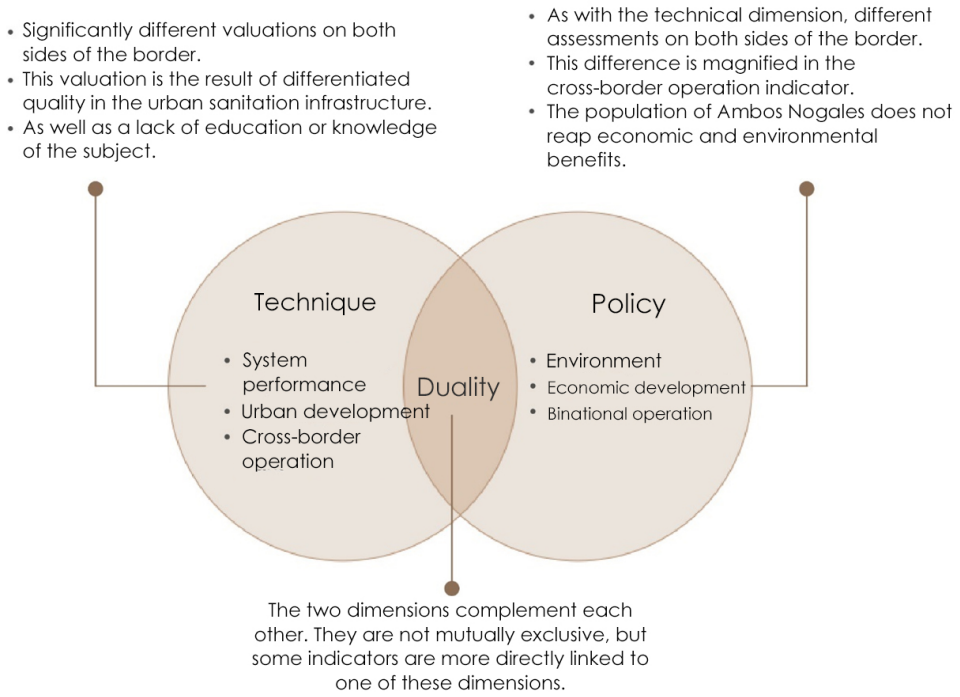
Figure 8. Average size and score of clusters identified in Nogales, Arizona



Source: created by the authors

Figure 9 schematically shows the inputs identified to strengthen public policy management strategies for transboundary water and sanitation. As anticipated, and following Aguilar Villanueva (2015), the political and technical duality inherent to all public policy is recognized, which, in this specific case, is expressed in a linkage of three indicators in each of the two dimensions. This distinction, it should be noted, is in no sense exclusive; rather, what is important to highlight here are the main characteristics of this duality, recognizing that there are points of convergence between the two dimensions.

Figure 9. Technical and political implications of the Ambos Nogales sanitation project

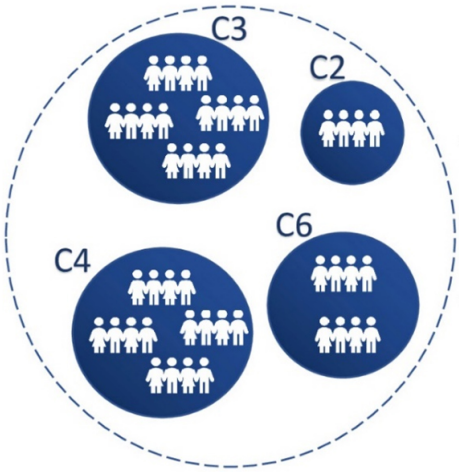


Source: created by the authors

Thus, it is postulated that the indicators *System operation*, *Urban development,* and *Cross-border operation* take on a mainly technical connotation. Furthermore, the indicators *Environment*, *Economic development,* and *Binational operation* are associated with the political dimension. Regarding the formation of population groups or clusters according to their opinions on the cross-border sanitation project, the results differentiate between the two sides of the border (see Figure 10 and Figure 11).

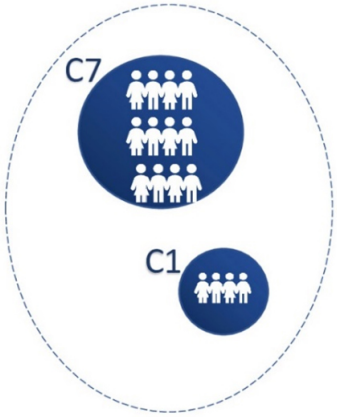
On the Mexican side, the majority of the population (63.8 %), composed of four groups (C2, C3, C4 and C6), have opinions that vary between indifferent and favorable in almost all the indicators analyzed, groups that were denominated as the *undecided* (see Figure 10); two others (19.1 % of the total) have an unfavorable opinion (C1 and C7), for which they were denominated as the *unsatisfied*; while two others (14.9 %) have a very favorable opinion (C5 and C8), which is why they are called *satisfied.* On the U. S. side (see Figure 11), the *satisfied* belong to a single group (C3) representing the majority of the population (75 %); another group representing one-fifth of the population (20 %) was denominated as the *indifferent* since their scores are intermediate, i. e. (C2); while the remaining three groups, being comprised of marginal segments of the population, without statistical validity, were denominated as the *marginals.*

Figure 10. Characterization of the population in Nogales, Sonora



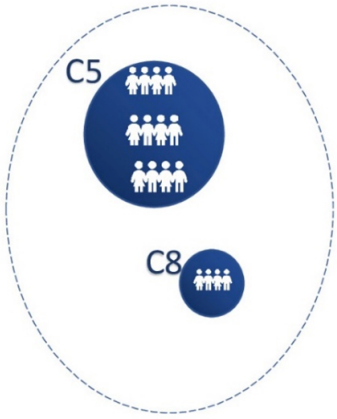
Undecided

- The majority of the population of Nogales, Sonora (63.8 %), comprises these three groups called the *undecided*.
- They have intermediate or high average scores in all the indicators analyzed except for *Cross-border operations*.
- In *Cross-border operations*, C4 and C6 have the lowest ratings.



Dissatisfied

- These two groups account for approximately one-fifth of the population (19.1 %).
- The dissatisfied presented the lowest scores on all indicators.

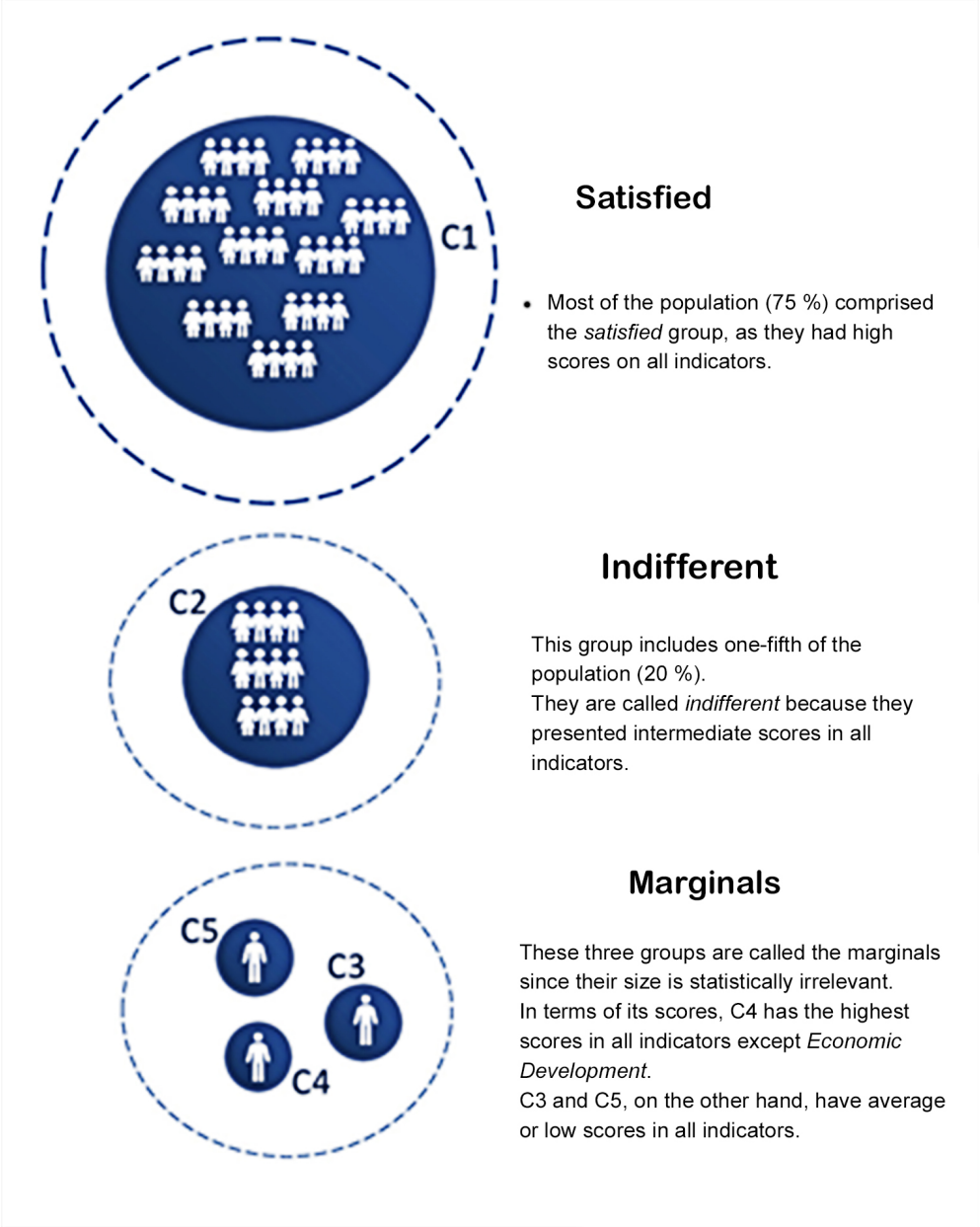


Satisfied

Almost 15 % of the population comprises these two groups, known as the satisfied.
Satisfied respondents had the highest ratings on all indicators.
Only in *Cross-border operations* did the C5 group present an intermediate average rating (indifferent).

Source: created by the authors

Figure 11. Population characterization in Nogales, Arizona



Source: created by the authors

The population group typology shows differentiated opinions about the sanitation project in Ambos Nogales, both in the indicators associated with a technical dimension and those more linked to the political dimension. The key question is why these differences of opinion exist in the identified population groups on both sides of the border? Based on interviews conducted with a series of key stakeholders in Ambos

Nogales, all knowledgeable about the topic (see methodology section), a series of causes or determinants were inferred as hypotheses. It is considered that these hypotheses may lead to future studies that will delve more deeply into the issues addressed.

Differing quality of urban infrastructure on both sides of the border and lack of knowledge about its functioning

As mentioned above, three indicators evaluated have been linked to a mainly technical dimension. The *System Performance* indicator refers to the effectiveness and efficiency of operating a sanitation system with different functions on both sides of the border. On the Mexican side, the drainage system directs the flow of wastewater until it reaches the U. S. side, and on the U. S. side, it directs the flow of wastewater from Mexico to the NIWTP where it is treated and discharged into the Santa Cruz River.

On the Mexican side, the results indicate that the modernization of the drainage system has benefited the population (see Figure 10). Nevertheless, its operation has been constantly affected —even collapsing—during the rainy season (June-September) every year since the city does not have a storm drainage system. This situation causes rainwater to enter the sanitary sewers and mix with sewage, causing the system to collapse and water to overflow into the streets. According to García et al. (2019), a high proportion of the population perceives that when the drainage system collapses on the Mexican side during the rainy season, the public transportation system fails, the streets are dirtier due to garbage and landslides, and more accidents occur (Milenio, 2022).[3] On the U. S. side, on the other hand, it is rare for the rains to cause the havoc they do on the Mexican side.[4] This difference is precisely why an inherent link is inferred between the indicators *Functioning of the sanitation system* and *Urban development*. In other words, the poor functioning of the transboundary sanitation system implies poor urban development. The results show that the undecided and dissatisfied, who make up 85 % of the population of Nogales, Sonora, have medium and low opinions regarding these two indicators (see Figure 10).

Similarly, when the sanitation system collapses on the Mexican side, the operation of the international collector on the U. S. side is also affected, a situation that affects the segment of the population that lives in that area of the city. As a hypothesis, it is inferred that this is why the indifferent group (one-fifth of the population) has an average opinion of the *Urban Development* indicator on the U. S. side.

It is worth noting that the differences between the two cities have been the subject of study not only in terms of infrastructure quality, but in general, in different dimensions of development, such as economic and social well-being, safety, and environment. The book *Why Countries Fail*, written by Daron Acemoglu and James Robinson, analyzes the differences in welfare levels between cities in different countries and begins precisely with the case of Ambos Nogales. The authors pose the question, "How can the

[3] The reader can watch the video linked to this bibliographic reference (references section) to get an idea of the severe problems caused by the rains in Nogales, Sonora.

[4] There is a whole series of popular comments in Nogales, Sonora, about this situation, which is expressed with the following question: why is it that if it rains the same in Ambos Nogales it is only here (in Nogales, Sonora) that the avenues are flooded and disasters occur?

two halves of what is essentially the same city be so different? There are no differences in climate, geographic location, or types of diseases present in the area..." (Acemoglu & Robinson, 2012, p. 18). Their conclusions point to the differences between the two cities due to their institutions or, more precisely, to the incentives that the institutions of both cities create for their inhabitants.

Regarding the *Cross-border operation* indicator, it was found that this is where the greatest differences between the two cities are found. It is important to emphasize that the opinion on the cross-border operation implies the recognition of factors that benefit or harm the population on both sides of the border. The results showed that the *undecided* and *dissatisfied* groups predominate in this indicator on the Mexican side, while on the U. S. side, almost all (95 %) are satisfied (see Figures 10 and 11, respectively).

According to Garcia et al. (2019), there are two determinants of these results. The first is that the differences that exist in the quality of public water and sanitation infrastructure between the two cities, as in the case of system operation and urban development, determine these differences of opinion, i. e., indifferent and unfavorable on the Mexican side, and very favorable on the U. S. side. The second is that a significant segment of the population on the Mexican side is unaware of how the transboundary sanitation system works since, in their daily lives, they do not see how wastewater flows to the other side of the border. On the US side, on the other hand, the population knows that the wastewater from both cities is treated there since the NIWTP is located a few kilometers from the city, and they pay the corresponding fees for the operation of the plant. These two points can be valuable empirical input for future research to address this issue in particular and improve the water and sanitation policy in Ambos Nogales.

For example, to correct infrastructure deficiencies, the construction of a storm drainage system has been considered, as well as a system of small dams to contain rainwater in the upper parts of the streams of Nogales, Sonora. It should be noted that the Instituto Municipal de Planeación Urbana de Nogales has had the executive projects to conduct both schemes for at least 10 years. Nevertheless, as of 2023, they have not been carried out. Moreover, as for the results obtained in the *Cross-border operation* indicator, it seems evident that there is a need to inform society about how the sanitation system operates through some communication strategy that promotes education and general knowledge about the intrinsically related nature of the sanitation system in Ambos Nogales. Implementing these two proposals could have a multiplying effect on other indicators such as urban development, economic development, and the environment. For this reason, it is reiterated that the technical and political dimensions are not mutually exclusive since there is a meeting point between the indicators analyzed.

Who benefits from treated wastewater?

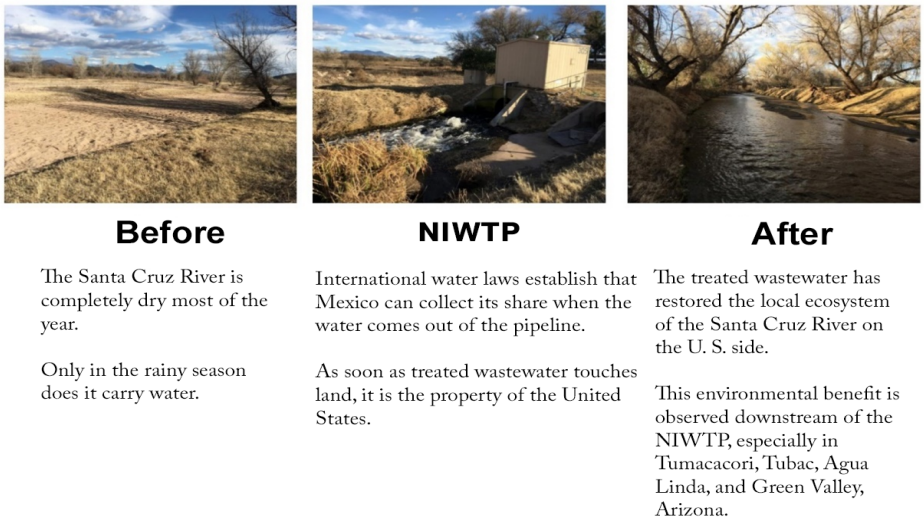
The results obtained for the indicators *Environment*, *Economic development*, and *Binational cooperation* show the policy implications for sanitation in Ambos Nogales (see Figure 5 and Figure 8). These implications are related to latent conflicts concerning the economic and environmental benefits of treated wastewater being taken advantage of in other locations, i. e., outside Ambos Nogales. Based on the comments gathered from key stakeholders and on visits to the study area, it was found that the main economic and environmental benefits derived from the transboundary sanitation system have been produced in localities located north of the NIWTP, downstream of the Santa Cruz River.

As shown in Figure 12, the Santa Cruz River is completely dry most of the year in the stretch that crosses Nogales, Arizona, between the binational border and the NIWTP located in the town of Río Rico (only in the rainy season are there days when it carries a considerable volume of water). On the contrary, north of Río Rico, just after the place where NIWTP discharges treated wastewater, the panorama changes radically since the Santa Cruz River carries from this point a considerable volume of water with a permanent flow that is mostly composed of treated wastewater (between 500 and 950 liters per second, depending on the time of day and time of year), *of which approximately 80 % is water coming from Mexico*. Treated wastewater (mostly from Mexico) has led to a regeneration of the local ecosystem downstream of the Santa Cruz River that has generated positive economic impacts in towns north of Nogales, Arizona. These positive impacts are due to the economic spillover generated by ornithological tourism, which, in the case of the Santa Cruz River, produces about $21 million annually (Arizona Public Media, 2018).[5]

It can be seen then that the main positive impacts derived from the transboundary sanitation system, both environmental and economic, have occurred outside the Ambos Nogales area and specifically on the U. S. side. This information is empirically relevant as it reveals that a transboundary sanitation policy designed to benefit the population of Ambos Nogales has economically and environmentally benefited the population of other communities located on the U. S. side, north of the NIWTP.

[5] Every year, millions of songbirds migrate from their wintering grounds in Mexico and Central America to their summer breeding habitats in Canada and the northern United States. In particular, they move along the Bravo, Colorado, Santa Cruz and San Pedro rivers (see video in Arizona Public Media, 2018).

Figure 12. Differentiated environmental benefits



Source: created by the authors

As for the *Binational Cooperation* indicator, while the results show that the majority of the population clusters on both sides of the border have a favorable opinion, the undecided and dissatisfied groups on the Mexican side (85 % of the total) and to a lesser extent the indifferent on the U. S. side (20 % of the total), expressed unfavorable or indifferent opinions on this indicator. Thus, it was found that historically there has been binational cooperation between the authorities and institutions of Ambos Nogales. Nevertheless, it was also found that this cooperation should be improved since there are latent conflicts that, at any moment, could appear and complicate such cooperation. For example, on the U. S. side there are opinions expressing disagreement with the lack of payment by the Mexican authorities. These opinions exist because the Mexican authorities have not paid the agreed annual fee for wastewater treatment for several years, which demonstrates Mexico's non-compliance with its commitments to build and operate the Río Rico NIWTP. On the Mexican side, some local stakeholders claim that the Mexican water treated at the NIWTP is used in Arizona by companies in the tourism and service industries. As noted in the previous section, it is also perceived that only on the U. S. side do they benefit from the positive environmental and economic impacts of treated water.

Cáñez Cota (2022) points out that adequate transboundary management in the administration of treated wastewater requires trust between the institutional actors of both countries, promoting a shared ethic that is materialized in transparent management of the sanitation system.

The situation described above enables a series of measures to be proposed as feedback. Recognizing the above-mentioned latent conflicts, one measure that should be

analyzed is the possibility of treating a proportion of the wastewater on the Mexican side and using this resource for different purposes. For example, one project that the Mexican authorities have considered is to pump the gravity-fed wastewater to the U. S. side to be directed to the Los Alisos treatment plant located south of the city. Nevertheless, such a move would significantly affect the restored ecosystem on the U. S. side by reducing the flow of water in the Santa Cruz River and, as a consequence, the economic spillover to the towns north of the NIWTP, in addition to the high economic cost of the energy required to pump the treated water.

This situation reflects the transboundary nature of the sanitation system in Ambos Nogales and, as a consequence, the need to strengthen an integrated, *transboundary treated water management system*. An example of this management would be, as pointed out by Norman et al. (2013), to design and implement methodological frameworks and payment systems for environmental and ecosystem services that benefit the population and local governments on both sides of the border since they are the ones who have borne the costs of the sanitation system. Another example that has been considered by the municipal authorities of Nogales, Sonora, is that if a greater volume of wastewater flow from the transboundary sanitation system is transferred to the Los Alisos treatment plant (as mentioned in the previous paragraph), a greater proportion of this resource, or even all of it, could be used to irrigate the city's parks and gardens. Even with a transboundary approach, the discharged and treated water from the Los Alisos plant and the Río Rico NIWTP could be used to form artificial wetlands that provide ecosystem services to the inhabitants of Ambos Nogales. Nevertheless, and as a counterpoint, such a measure would imply a high economic cost for the Mexican authorities since they would have to pay for the energy required for pumping water to change the direction of wastewater flow.

The fact that the Mexican authorities have the right to dispose of all the wastewater generated in Nogales, Sonora, is an element that they can and should take advantage of in future negotiations and measures on the management of this resource.

Conclusions

The characterization and typology of population groups based on their opinions about the impacts generated by the modernization of the cross-border sanitation system in Ambos Nogales constitutes a relevant empirical input to evaluate and improve the results of public policies. Based on these characteristics, the proposed typology represents a strategy that complements traditional descriptive or inferential studies since it helps focus efforts to design and implement projects for future water and sanitation policies according to the needs, requirements, and opinions of the different population groups.

The results demonstrate a differentiated composition of population groups in Ambos Nogales. On the Mexican side, eight population clusters were identified, which, according to their scores, form a continuum ranging from satisfied to indifferent and ending with dissatisfied. On the U. S. side, two large clusters were identified, one grouping most of the population (75 %) and characterized as satisfied, and the other with a significant proportion (20 %), characterized as indifferent. By identifying homogeneous population groups in terms of the diversity of opinions on the modernization

of the Ambos Nogales cross-border sanitation system, an empirical input can be used to evaluate the policies of this work and implement other types of projects to improve the system further.

Along these lines, some measures that could be implemented in the future were mentioned. For example: *i*) strengthening participation and cooperation among key actors under a multilevel management scheme and with a shared ethic that results in greater transparency and inter-institutional trust; *ii*) implementing in Nogales, Sonora, communication strategies that make indifferent and dissatisfied population groups aware of the functioning of the system, both in each city and transboundary, as well as the ecosystemic benefits it generates; *iii*) conduct technical and economic feasibility analyses of projects for the reuse of treated wastewater in both Mexico and the United States; and, *iv*) build the necessary infrastructure to treat a greater proportion, or even all, of the wastewater on the Mexican side and reuse it precisely in Nogales, Sonora.

Finally, it is important to highlight the systemic nature of transboundary sanitation in Ambos Nogales. The balance analogy can be applied here: if all of the wastewater in Nogales, Sonora, is used, the balance tips to the Mexican side, but with significant economic and energy costs. If the situation remains, the balance is tipped to the U. S. side. Nevertheless, if a comprehensive transboundary strategy that optimizes the benefits in Ambos Nogales is considered through transboundary ecosystem services schemes and the reuse of treated wastewater, the balance would be in equilibrium. Only through collaboration between different actors, be they governments, academics, non-governmental organizations, and, in general, civil society, will the population of Ambos Nogales have access to such an essential service as access to water and sanitation sustainably and equitably.

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