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A Socio-Ecological System Analysis of Multilevel Water Governance in Nicaragua

Luis Montenegro [1,2,*] and Jochen Hack [2]

[1] National Water Authority, 12051 Managua, Nicaragua
[2] SEE-URBAN-WATER Research Group, Section of Ecological Engineering, Institute of Applied Geosciences, Technische Universität Darmstadt, Schnittspahnstraße 9, 64287 Darmstadt, Germany; contact@geo.tu-darmstadt.de
* Correspondence: contact@ana.gob.ni

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Abstract: Nicaragua enacted its Water Law in 2007, with the Dublin Principles for sustainable water management and integrated water resources management as its guiding framework. Implementation of the law remains a challenge, but significant efforts have been made to roll out this new water resources framework, to improve water management by enhancing a multilevel water governance system. To analyze multilevel water governance in Nicaragua and diagnose stakeholders' roles and compliance with the law, we applied a socio-ecological system framework and several methods of analysis to process data collected from 52 in-depth semistructured interviews conducted with key stakeholders in the water sector. We found that the major variables affecting multilevel water governance were social interests, administrative capacity, and political, economic, and legal arrangements. The results suggest that there is centralization at the national level, a tendency toward noncollective choice rules, little investment in water resources, and a lack of knowledge concerning conflict resolution mechanisms. For multilevel water governance, a lack of funds is the main social, economic, and political constraint, affecting interactions and outcomes. Nevertheless, there is great potential to improve water resource management in Nicaragua by enacting the self-funding schemes established in the law. Moreover, government institutions, users, and various networks are willing to participate and take action to implement the law.

Keywords: Nicaragua; multilevel water governance; socio-ecological system framework; water law; stakeholders; lack of budget

1. Introduction

Nicaragua is a Central American country with a surface area of 130,682.4 km^2 [1] and a population of 6.1 million inhabitants [2]. The central government and state institutions are based in the capital city of Managua, as are major public and private companies [3]. Nicaragua "is a water-rich country" [4] with large quantities of ground and surface waters, characterized by small rivers flowing into the Pacific Ocean, constituting the surface drainage of eight river basins, and large rivers with greater drainage areas flowing into the Caribbean Sea, distributed across 13 river basins. Regarding groundwater resources, the most important deposits in the country are the Leon-Chinandega Plain, the Carazo Plateau, the Nicaraguan Depression, the Central Province, and the Atlantic Deposits [5].

In Nicaragua, there have been significant efforts to enact and implement new policies and laws focused on improved water governance, "which refers to the range of political, organizational and administrative processes through which communities articulate their interests, their input is absorbed, decisions are made and implemented, and decision makers are held accountable in the development and management of water resources and delivery of water services" [6]. In 2007, the Nicaraguan

Water Law was enacted [7] in order to guarantee the efficient and sustainable use of water resources through interinstitutional coordination to secure water governance at all political levels and through participatory processes.

This study was developed within the SEE-URBAN-WATER project based at the Technical University of Darmstadt, which focuses on the interaction of technical infrastructure systems and ecosystems in developing countries such as Nicaragua, also being part of a Ph.D. study. This project intends to integrate the application of knowledge across technological, ecological, socioeconomic, and political measures [8].

The aim of this study was to analyze multilevel water governance in the Pacific and Central Regions of Nicaragua through the application of a socio-ecological system framework (SES) based on concepts defined by Ostrom [9], building on the institutional analysis and development framework created by McGinnis and Ostrom [10]. This framework was implemented to arrange subsumed relationships into a multitier collection of concepts and variables [11], which served to identify responsibilities at national, regional and local levels of authority [12,13].

To identify limitations and evaluation measures that must be implemented in order to guarantee full compliance with multilevel water governance (social, economic, ecological, cultural, political, and technological components), it is necessary to know the perceptions of water resource management held by water users since they are the focal actors in the resource system, as well as government institutions, organizations and networks [14]. Primary data were obtained through 52 in-depth semistructured interviews conducted with members of government institutions at the local and national level, and with members of social, community, and productive networks from different parts of Nicaragua, for a balanced perspective on the current water governance situation.

This investigation carried out objective evaluations to identify mechanisms that could be implemented to improve the living conditions of Nicaraguans through the harmonization of all subsystems. This paper also highlights actions focused on sustainable and integrated water resources management (IWRM) at all levels, for which it was necessary to perform a holistic diagnostic, to better understand the socio-ecological system [15,16]. This might contribute to tailored policies and plans that take into account collective decision making in a multilevel governance system since it is possible to find gaps in water management and governance using the framework to define key questions for decision makers and prioritize the actions and actors for context-specific solutions.

In the materials and methods section, we present a brief explanation of the socio-ecological system framework, define the variables, and describe the data collection strategy and data analysis. The results are divided into three subsections: a legal framework analysis, stakeholder mapping, and empirical results. This last subsection also identifies the limitations of multilevel water governance in Nicaragua. In the discussion section, we describe the dynamics and interactions between relevant variables to explain the outcomes of Nicaragua's water governance system [15]. Finally, we present a conclusions section based on a literature review and analysis of the 52 in-depth semistructured interviews using SES framework.

2. Materials and Methods

In order to identify and understand the interactions between variables affecting multilevel water governance in the Pacific and Central Regions of Nicaragua, we used a mix of research methods and SES framework, which is a conceptual model that provides a common language for case comparisons [17]. The results obtained from this conceptual model were processed using a qualitative statistical method that provided complementary information.

2.1. Socio-Ecological System Framework

The SES framework has been widely used to identify factors that contribute to the management of natural resources [18]. McGinnis and Ostrom [10] describe the SES framework as having multiple tiers of concepts or variables, with the higher-tier concepts then decomposed into more fine-grained

lower-tier concepts [11]. As reported by Schlüter, Hinkel [16], using the SES conceptual model, it is possible to identify variables that are considered relevant in order to answer research questions. This facilitates the systematic selection of significant variables, fundamental processes, and indicators.

In Figure 1, the higher-tier concepts include eight holistic components: (1) social, economic, and political settings; (2) resource systems; (3) governance systems; (4) resource units; (5) actors; (6) interactions; (7) implementation outcomes; and (8) related ecosystems. These eight concepts provide a basis for extending and generalizing the framework by providing clear criteria for adding new concepts and refining existing ones [17].

Social, economic and political settings (S)	**Related ecosystems (ECO)**
S1 Economic development	ECO1 Climate patterns
S2 Demographic trends	ECO2 Pollution patterns
S3 Political stability	ECO3 Flows into and out of local SES
S4 Other governance systems	
S5 Markets	
S6 Media organizations	
S7 Technology	
Resource system (RS)	**Governance system (GS)**
RS1 Sector	GS1 Government organizations
RS2 Clarity of system boundaries	GS2 Nongovernment organizations
RS3 Size of resource system	GS3 Network structure
RS4 Human-constructed facilities	GS4 Property rights system
RS5 Productivity of system	GS5 Operational-choice rules
RS6 Equilibrium properties	GS6 Collective-choice rules
RS7 Predictability of system dynamics	GS7 Constitutional-choice rules
RS8 Storage characteristics	GS8 Monitoring and sanctioning rules
RS9 Location	
Resource units (RU)	**Actors (S)**
RU1 Resource unit mobility	A1 Number of relevant actors
RU2 Growth or replacement rate	A2 Socioeconomic attributes
RU3 Interaction among resource units	A3 History or past experiences
RU4 Economic value	A4 Location
RU5 Number of units	A5 Leadership/entrepreneurship
RU6 Distinctive characteristics	A6 Norms
RU7 Spatial and temporal distribution	A7 Knowledge of SES/mental models
	A8 Importance of resource
	A9 Technologies available
Interactions (I) and Implementation outcomes (O)	
I1 Harvesting	O1 Social performance measures
I2 Information sharing	O2 Ecological performance measures
I3 Deliberation processes	O3 Externalities to other SES
I4 Conflicts	
I5 Investment activities	
I6 Lobbying activities	
I7 Self-organizing activities	
I8 Networking activities	
I9 Monitoring activities	
I10 Evaluative activities	

Figure 1. First and second tier of the socio-ecological system (SES) framework. Source: McGinnis and Ostrom [10].

This framework used to analyze the socio-ecological sustainability of systems is a multilevel hierarchy of concepts and variables identified through an empirical analysis within a wide number of case studies. The long-term goal of this framework is to capture knowledge to formulate a theory across diverse cases [19].

The SES framework has had modifications and innovations to validate its application in different fields. From the beginning, Ostrom used the institutional and development analysis (IAD) framework [20,21], based on politic processes analysis such as social, institutional and biophysics systems [22]; however, for decades, investigators have empirically identified a list of variables that affect the development of governance on multiple systems. In such a way, the SES framework builds on the IAD framework [23].

However, it was difficult to develop a set of theoretical statements for a group of variables to influence sustainability results in various cases; therefore, a non-theoretical list of potential influencing variables was conceptualized. This list is used as a guide to diagnose key variables and interactions influencing results of a specific case study [10].

In this study, the application of an SES framework has benefits for analysis of cases connecting tangible and relevant problems belonging to water resources used in decisions-making processes at different levels. It also provides a holistic understanding of interactions between actors and resources of a system, as well as the influence of the components social and ecological [18].

2.2. Identification of Actors

We started by identifying the actors in the governance system that are engaged in water management by studying the provisions of the Nicaraguan Water Law [7], which created new government institutions and binding network structures at the national and local levels. We created a list of key stakeholders within various organizations as primary sources of information for data collection and to aid in the application of the SES framework [24,25].

Once key actors were identified within government institutions and networks, they were contacted to assess their willingness to participate in the study. We aimed for balanced representation in our primary data collection. After responses were received, 52 in-depth semistructured interviews were conducted to gather the data upon which this paper is based. At this point, it should be mentioned that the interviews were only done in the Pacific and Central Regions of Nicaragua, because none of the key stakeholders from the Caribbean were available, due to distance and time constraints. It was difficult for the authors to visit the Caribbean Region due to distance, time, poor connectivity, and budget constraints.

2.3. Data Collection

We decided guided in-depth personal interviews with local government employees and the personnel or volunteers at relevant organizations was the appropriate method for primary data collection. Papers in scientific journals on water topics in Central America are few and far between [26], data scarcity is typical in developing countries [27], and information sharing between institutions is limited [25]. Therefore, it was necessary to format a narrative description interview to facilitate the flow of ideas regarding individuals' perceptions about multilevel water governance in the Pacific and Central regions of Nicaragua [28].

The interview was semistructured and consisted of 21 questions (see Table A1 in Appendix A) based on the first level of the SES framework. The questions were designed to assess local and national administrative procedures, to get a clear view of trends in participatory processes and in multilevel and cross-sectional work.

Interviews were held in late February 2020 with selected individuals who hold key positions at the national and local levels, as well as decision makers and interest groups. Figure 2 shows the spatial distribution of the interviewees' working areas: 30 local government officers from Environmental Management Units (UGA) and Municipal Water and Sanitation Units (UMAS) distributed in 30 different

municipalities; UGA and UMAS are both dependencies of Municipal Halls [29]. Interviews were also conducted with two social networks members from Basin Committees located in the municipalities of Estelí and Dipilto; 10 national productive networks (agricultural and agro-industrial organizations chairmen) with working activities in the West Pacific Region of Nicaragua; and 10 community networks affiliated to Water and Sanitation Committees (CAPS), which work in rural areas providing drinking water and sanitation services [30]) (see Table A2 in Appendix A).

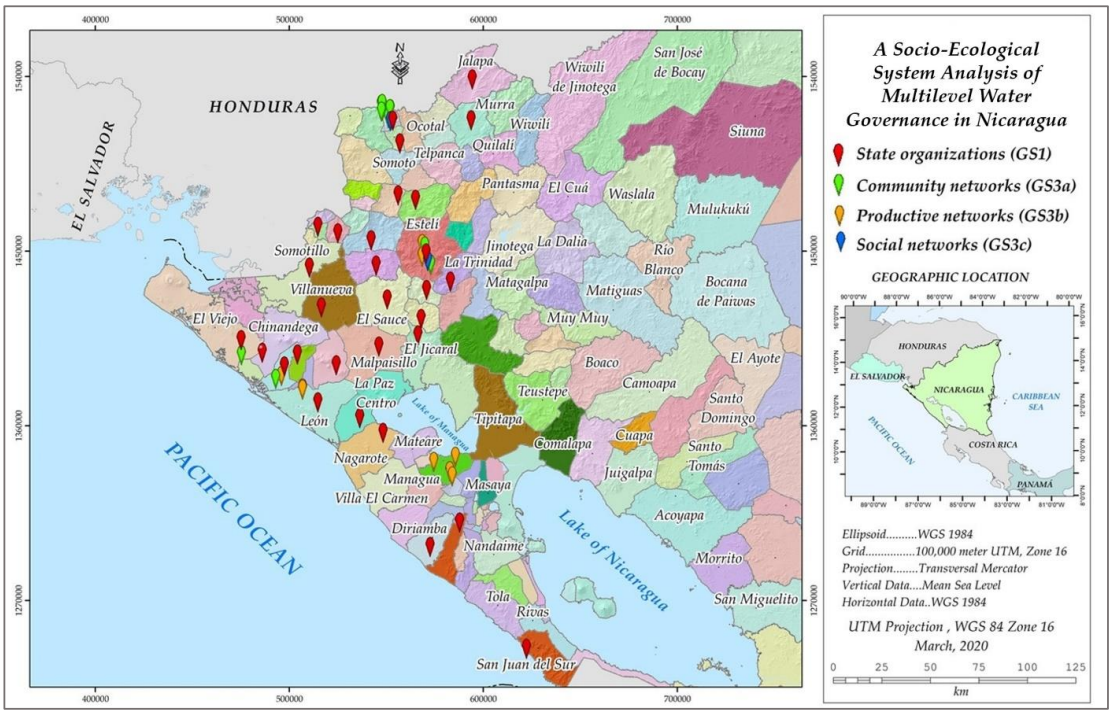

Figure 2. Distribution of actors interviewed.

These 52 interviewees were chosen in accordance with the "main roles" established for water resources management in the Nicaraguan Water Law. However, the lack of representatives of the river basin organizations (RBOs) is due to the fact that they are yet to be brought into existence, due to budget constraints.

Experiences of water governance within government institutions is highly representative because of the dependency in bridging cooperation between state institutions and other actors such as non-governmental agencies and network structures [31]; therefore, we decided to make a few more interviews to local government officers because they have the legal mandate to implement policies and plans regarding water management and to promote participatory processes at local level. In this sense, 52 percent of interviewees were held with local government officers under the consideration of a general trend in decision making to an institutional approach [32,33] that address organizational priorities for policy actors who are responsible for the water resources regulation, shape policy and strategy preferences [13,33–35]. We recognize that the perspectives of government institutions in water governance play a strategical role to determine the implementation process of water governance [36] and the long-term application of integrated water resources management.

2.4. Data Analysis

We used data from 52 guided in-depth interviews to define variables affecting water governance in Nicaragua. We note that each interviewee uses different expressions to perceive governance aspects. We scale variables by subtracting all expressions from interviewees and applying the content analysis technique to group them in discrete categorical responses [25,37,38] and finally classify those responses into the list of variables proposed by Serrano and Ramos [28]. Data were organized and summarized

in order to apply a narrative structure for the socio-ecological subsystems listed in Figure 1 to diagnose the multilevel water governance in the Central and Pacific Regions of Nicaragua. In correspondence with the procedure defined by McGinnis and Ostrom [10], we provided a brief contextualization of actors, policy implementation and legal arrangements in water management to focus our description in the second-tier variables empirically defined and complemented by literature review. In the Results and Discussion sections, we specify which question of the applied interview match which third-tier variable to facilitate its comprehension and operationalization.

To quantitatively assess the trend in responses, a measure of connectivity was applied by the descriptive statistic of density to determine the scale of gaps in third-tier variables affecting multilevel water governance, this was used as a complementary procedure of the SES framework. More complex statistical methods are available, but they were discarded due to the uncertain limits of measured variables with blurred boundaries [28].

3. Results

3.1. Legal Framework and Actors

Nicaragua enacted its Water Law in 2007 [7,39–41], with IWRM and the Dublin Principles as the basis for this new regulatory framework [24,42]. It was believed this law and its new legal arrangements would propel good water governance in Nicaragua [24]. However, it has been documented that, in Nicaragua and other developing countries, there are constraints of [11] low budget allocations [4], a partial or complete lack of accountability and transparency, and limited technical capacity and human resources [24,39,43–46], factors that limit the implementation of any governance instrument.

Policy and politics are linked since policies are guidelines and strategies already sanctioned by decision makers. Governments agree to change frameworks, in this case the legal framework for the water sector, even if they have no intention to comply with it [47–49], but van der Zaag [50] argues that a long and transparent participatory process to adopt fairness actions such as integrated water resources management is the key for a successful implementation.

Other authors, such as LaVanchy, Romano [4], state that "despite its apparent potential in an ideal world, IWRM has not been implemented effectively in the real world and has become a point of debate and criticism among scholars". Nicaragua highlights that having a long participatory process to enact a new Water Law does not guarantee a full compliance for praxis of good water governance [4,24].

Due to rapid urbanization, population growth, climate change and limited resources [4,51–53], it is important for countries to adopt a water management approach. Although all countries in the Central American region state their commitment to integrated water management, it is notable that they differ in the mechanisms and administration structures designed for such purposes [54], yet it is not clear how successful these countries have been implementing integrated water resources management [4,24,47]. Table 1 shows the different legal arrangements in Central American countries.

Table 1. Water organizations arrangement in Central American countries.

Country	Institution	Dependency	Organization Type
Belize [55]	National Integrated Water Resource Authority	Independent regulatory agency	Decentralized
El Salvador [56]	General Directorate of Forest Management, River Basin, and Irrigation	Ministry of Environment and Natural Resources	Centralized
Guatemala [57,58]	Vice Ministry of Natural Resources and Climate Change/Vice-Ministry of Rural Economic Development	Ministry of Environment and Natural Resources/Ministry of Agriculture, Livestock and Food	Centralized
Honduras [59–61]	General Directorate of Water Resources	Secretary of Natural Resources and Environment	Centralized
Nicaragua [7,59]	National Water Authority	Independent regulatory agency	Decentralized
Costa Rica [62]	Directorate of Water	Ministry of Environment and Energy	Centralized
Panamá [63]	Directorate of Water Security	Ministry of Environment	Centralized

According to Table 1, based on the type of dependency or independency, there will be a natural bias in the decisions of such institutions and may be hindered, which can be measured using methodologies that study central banks [64] or using analytical frameworks for institutions in the water sector and guidelines of institutional frameworks applied by Van Hofwegen and Jaspers [65], though it is not in the scope of this paper to analyse what level of independence the water resources regulators have in Central America.

Nevertheless, enacting the Nicaraguan Water Law was a milestone since it established basic rules for all water users in implementing water governance principles. All water rights belong to the Nicaraguan State [7], and they are regulated by an independent regulatory agency (IRA), which is autonomous and decentralized from the Central Government (as suggested by Gilardi [66]). This IRA is the highest-level authority for water resources in Nicaragua, as stated in article 24 of the Water Law [7]. The National Water Resources Council is established in article 21 of the law, and its functions are further elaborated in articles 22 and 23 [7,41], which are important functions at the national level [24]. This Council's main functions are to serve as a deliberation forum for central level institutions on national water policies and plans that need implementation at the local level. It is, in essence, a multilevel governance body that has never held a meeting since the enactment of the law in 2007.

The National Water Authority's (ANA) functions are wide-ranging and include ground and surface water [7,40]. The ANA regulates and monitors all national water resources [4,39], including water permits, and it is responsible for establishing a national water resources plan and a river basin plan. The ANA works at both the national and local levels [7].

The ANA and the 21 RBOs could theoretically be funded through a water abstraction fee paid by all water users, except for the potable water supply sector, but this fee has to be approved in the National Assembly through a special Water Tariff Law [24] (as stated in article 87 of the law). The fees raised would be managed through the National Water Fund.

The Water Tariff Law has not yet been discussed or approved due to public lobby against from large agricultural and agro-industrial corporations affiliated to the Superior Council of the Private Enterprise (COSEP) [67]. In contrast, community networks, non-governmental organizations (NGOs) and academia have also publicly expressed their support for the enactment of this law [68,69].

In the absence of abstraction fees, there is no incentive to change consumptive water uses such as agricultural practices and irrigation systems. Moreover, because of the competing uses, water resources conflicts have already emerged and will continue to be a trend with increased climate change and population growth. Not improving irrigation systems to be more sustainable is against the principles of the law [7].

The National Water Fund is established in article 90 of the law; its main objectives are to finance programs and activities related to water policies, water resources plans, and restoration activities [7]. Another important economic element established in the Water Law is "Payments for Hydrological Ecosystem Services", in article 93 [7]. These payments are supposed to serve as incentives to promote the conservation of relevant areas in river basins, such as recharge areas. The establishment of such payments requires an agreement between landowners providing ecosystem services and water users receiving the service, with the additional participation of institutions such as municipalities, the ANA, and others. Currently, there are some payment schemes, but they have mainly been developed within the private sector without the involvement of the public sector.

None of the intended funding instruments introduced by the Water Law have been implemented in terms of the provision of funds for water plans, execution, and monitoring. Therefore, the implementation of the Water Law is limited, due to its dependence on the national budget [4].

Regarding decentralization, the Water Law establishes the creation of 21 river basin organizations, which can regulate water permits and monitor river basins at the local level (under technical supervision of the ANA), but none of the 21 RBOs are currently operating, due to budget constraints [4]. The basin committees are organized through local actors who work voluntarily, they "could have been integral in educating local stakeholders on the aspects of the Law 620" [4]. Moreover, basin committees are forums for local participatory processes and there can be basin, sub-basin, and micro-basin committees, as stipulated in article 35 [7], but they have mainly been created in areas where international cooperation agencies (ICAs) fund projects.

The new water system and new institutions established by the Nicaraguan Water Law are depicted in Figure 3.

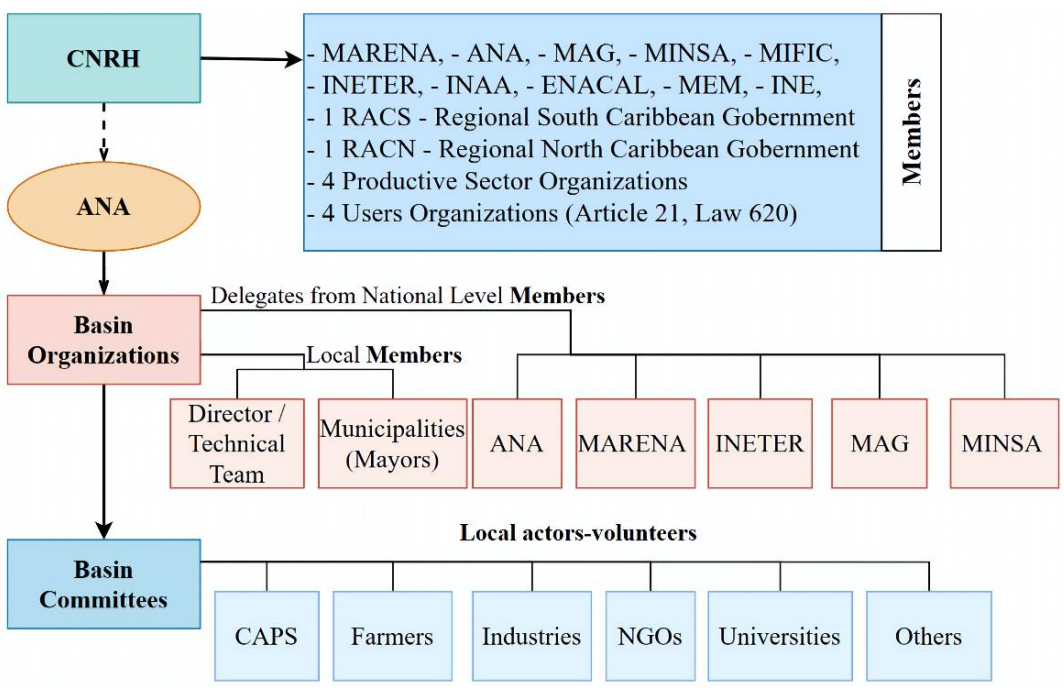

Figure 3. Nicaraguan water system. CNRH: National Water Resources Commission; MARENA: Environmental and Natural Resources Ministry; MAG: Agricultural Ministry; MINSA: Health Ministry; MIFIC: Ministry of Industry, Development, and Commerce; INETER: Nicaraguan Institute of Territorial Studies; INAA: Nicaraguan Institute for Water and Sanitation; ENACAL: National Water Supply and Sewage Company; MEM: Energy and Mines Ministry; INE: Nicaraguan Institute of Energy; CAPS: water and sanitation committees.

The new Nicaraguan water system established by the Nicaraguan Water Law was meant to promote multilevel water governance and integrated water management at all levels. In this regard, the functions of the National Water Resources Council were based with a multisectoral coordination approach, which includes the approval of national policies and settings of programs and plans at the national and local level. The National Water Authority, in fact, perform on technical and regulatory activities [59]. The ANA is not under the authority of the National Water Resources Counsil (CNRH), yet some plans and regulations have to be made by the ANA and approved by the CNRH, plus the ANA is solely in charge of water rights allocation, control and monitoring activities [4] of all water uses in the country [7].

According to the Nicaraguan Water Law, RBOs are under the financial and technical supervision of the ANA, their functions derive in operational and administrative matters related to those of the ANA [7], mainly linked to monitoring water management and local multi sectorial integration. Basin committees are formed by volunteers who work promoting the participatory processes and lobbying with local governments and national institutions to get their opinions be taken into consideration at the decision-level process [7].

RBOs should be acquiesced by delegates of government institutions from national and local level as well as local actors, there should be 21 river basins in the country in order to shorten the path for information sharing and to effectively deliver targeted outcomes [4,42]. Likewise, basin committees are integrated by local actors to provide a broad range of local understanding to implement strategic planning [70].

3.2. Stakeholder Mapping

The water governance system in Nicaragua was designed to distribute responsibilities among different institutions and organizations, "after the recognition that water problems had become multi-dimensional and multi-sectoral" [4]. In Figure 4, we describe and map the duties of each water-related institution or organization according to the Nicaraguan Water Law, as proposed by Novo and Garrido [24]. This map includes network structures that are not directly mentioned in the Nicaraguan Water Law but play important roles in the development of multilevel water governance and its implementation, such as international financial institutions (IFIs), NGOs, ICAs, and academia.

All boxes in Figure 4 represent the responsibilities established in the Nicaraguan Water Law and related frameworks. We differentiate between them by using green check marks for those roles that are being implemented and exclamation marks to designate those not being implemented. The main institutions not being implemented are the CNRH and the 21 river basin organizations. Municipalities can have water allocation rights, though they need to sign a transfer of power with the ANA, but no municipality has formally requested this agreement be signed.

This schematic representation of roles shows areas of overlap, which should not be a problem in and of itself, depending on how institutions cooperate and share information to accomplish common goals with regards to water resources management.

Governance Systems (GS)	Stakeholders	Key role: Projects Planning	Projects Implementation	Project Financing	Policy Formulation	Allocation of Water Rights	Monitoring and Evaluation	Enforcement of Water Law and Norms	Water Infrastructures Operation and Management	Consult and Research
Government Organization	ANA	◐	✓	◐	✓	✓	✓	✓	◐	✓
	CNRH				◐	◐		◐		◐
	ENACAL	✓	✓	✓					✓	
	FISE	✓	✓	✓						
	INAA				✓			✓		✓
	INETER	✓	✓				✓	✓		
	INIFOM	✓	✓	✓			✓			✓
	MAG				✓					
	MARENA	✓	✓		✓		✓	✓		
	MINSA				✓		✓	✓		
	Municipalities	✓	✓	✓	◐	◐			◐	
	PGR							✓		✓
Non-Government Organizations	NGOs	✓	✓	✓			✓			✓
Network Structures — Community Network	CAPS								✓	✓
Network Structures — Network Structures	GWP Nicaragua	✓	✓	✓			✓			
	ICAs	✓	✓	✓						✓
	IFIs	✓	✓	✓						
	Universities	✓	✓							✓
Network Structures — Social Networks	Basin Comm.	✓	✓							✓
	RBOs	◐	◐	◐	◐	◐	◐	◐	◐	◐
	Ind. Eth. Com.	✓	✓							✓

Figure 4. Stakeholder mapping of Nicaraguan multilevel water governance. FISE: Social Investment Fund; PGR: Attorney General of the Republic; Basin Comm: basin committees; RBOs: river basin organizations; Ind. Eth. Com.: indigenous and ethnic communities; GWP: Global Water Partnership, ICAs: international cooperation agencies. Source: authors' own creation, based on Novo and Garrido [24].

3.3. Socio-Ecological System Narratives

In this section, we describe the second-tier variables based in the literature review and responses obtained from actors through application of semistructured interviews. The narrative structure of second-tier variables contextualizes the responses given by interviewees to diagnose the SES of multilevel water governance in the Pacific and Central Regions of Nicaragua. This narrative style also provides an easier operationalization of third-tier variables and a better understanding of the working definitions summarized in Tables 2–4, which address the gaps for actions' prioritization. Column (e) also specifies which question from the semistructured interview matches which third-tier variable.

Table 2. Third-tier variables of the actors (*A*) subsystem, as identified by interviewees.

(a)	(b)	(c)	(d)	(e)
Second-Tier Variables	**Working Definition**	**Third-Tier Variables**	**Operationalization of Variables**	**Question (Appendix A, Table A1)**
(*A*2) Socio economic attributes	Socioeconomic characteristics affecting multilevel water governance	(*A*2*a*) Social attributes	• Lack of technical knowledge for innovation • Undeveloped multilevel environmental awareness	12
(*A*5) Leadership/entrepreneurship	Stakeholder leadership and entrepreneurship patterns affecting multilevel water governance	(*A*5*a*) Leadership patterns	• Coordination of activities by organized society at the local level	7
		(*A*5*b*) Entrepreneurship patterns	• Social networks are coordinated to apply for competitive funds with innovative projects • Social investment in water resources is carried out mainly in rural areas	10
(*A*6) Norms	Refers to rules set by good practices in society, integrating ethical and moral aspects	(*A*6*a*) Attitude toward corruption	• Opinions and willingness of citizens are partially integrated • Execution of projects without strategic planning	14, 21
		(*A*6*b*) Traditions and community values	• Appreciation of ecosystem value by local actors in rural areas • Awareness of water resource importance, and of goods and services	4, 7
(*A*7) Knowledge of SES/mental models	Knowledge and understanding of SES components and their interaction effects	(*A*7*a*) Local knowledge	• Lack of knowledge about legal frameworks and policy instruments at the local and national level	2, 16
		(*A*7*b*) Knowledge of effects of social attitudes toward MLWG	• Productive sectors link investment in water management to economic benefits and not to ecosystem benefits • Lack of integration of water governance in projects executed by government organizations	5, 6
(*A*9) Technology available	Water management technology available and accessible	(*A*9*a*) Technology available	• Local networks and organizations do not have the appropriate technology for monitoring water resources	12

Table 3. Third-tier variables of the governance system (*GS*), as identified by interviewees.

(a)	(b)	(c)	(d)	(e)
Second-Tier Variables	**Working Definition**	**Third-Tier Variables**	**Operationalization of Variables**	**Question (Appendix A, Table A1)**
(*GS*1) Government organizations	Government organizations at the local level have technical, administrative, and operational duties to protect common interests	(*GS*1*a*) Technification	• Limited technical knowledge and capabilities of human capital • Technification programs are not focused on water issues • Lack of water specialists at the local level	12, 17, 18
		(*GS*1*b*) Management capacity	• Institutions too overloaded with activities to accomplish the roles established in the Nicaraguan legal framework (little human capital)	18
		(*GS*1*c*) Decision-making processes	• Centralized decision-making • Partial presence of water management institutions throughout the country • Wide and unspecific policies developed at the national level	4, 5, 8, 9, 12, 20, 21
(*GS*4) Property rights system	Rules defining actions and their relation to multilevel water management	(*GS*4*a*) Inclusiveness	• Excludability • Sectorial bias (economic, social, and territorial)	4, 8, 9, 12
(*GS*5) Operational choice rules	Seated mechanisms and processes to take action in the water governance system at the local and national level	(*GS*5*a*) Operational rules	• Centralized allocation of water rights due to a lack of technical capabilities at the local level for project development	4, 12
(*GS*6) Collective choice rules	Mechanisms through which water governance rules are set by stakeholders	(*GS*6*a*) Collective choice rules	• Decisions do not always reflect citizen willingness • Not all organization networks are included in the choice rule set	4, 5, 13, 14
(*GS*7) Constitutional choice rules	Legitimization of multilevel contributions to Nicaraguan constitutional framework and compliance	(*GS*7*a*) Constitutional choice rules	• Perception of inequality	4
(*GS*8) Monitoring and sanctioning rules	Mechanisms and processes to monitor and sanction water management	(*GS*8*a*) Monitoring processes	• Low territorial coverage by government organizations	4

Table 4. Third-tier variables of social, economic, and political settings (*S*), as identified by the interviewees.

(a)	(b)	(c)	(d)	(e)
Second-Tier Variables	**Working Definition**	**Third-Tier Variables**	**Operationalization of Variables**	**Question (Appendix A, Table A1)**
(*S*1) Economic development	Economic resources available in Nicaragua to guarantee multilevel water governance	(*S*1*a*) Economic sector	• Limited economic resources distributed for ad hoc needs	4
		(*S*1*b*) Income sources	• Government organizations totally depend on national budget, tax collection, and grants • Inability of government organizations to generate their own funds • Limited capacity of social networks operating as consultation forums without legal status (for financial purposes) • Community networks are in an unsustainable situation	10
(*S*3) Political stability	Compliance with the functions and responsibilities of government organizations according to the Nicaraguan regulatory framework, in order to guarantee democratic processes	(*S*3*a*) Regulatory framework compliance	• Overlapping responsibilities within government organizations • Lack of coordination in the execution of shared duties	6, 5, 3
(*S*4) Other governance systems	Nicaraguan regulatory framework related to policies adopted in order to guarantee water governance	(*S*4*a*) Compliance with environmental regulatory and policy frameworks	• Legal efficiency problems (institutions not yet implemented) • CNRH and RBOs have not been implemented. The absence of RBOs especially creates a vacuum at the local level because there is no link or intermediary with the ANA at the national level (where decision-making happens), leaving little space for participatory processes	3, 4
(*S*5) Markets	Markets for water strategies and conservation mechanisms	(*S*5*a*) Incentives for conservation	• Subsidy needs for agricultural and productive activities	12
(*S6)* Media organization	Mechanisms to encourage the diffusion and implementation of water resource policies and strategies	(*S*6*a*) Media deterrence capability	• Poor diffusion of the Nicaraguan Water Law	4

The actors (*A*) of the socio-ecological system of this study are water users, government and non-governmental organizations, and networks who work in the obtainment, distribution and development of multiple goods and services [19], and are the ones who determine the multilevel governance status. (*A*2) Nicaragua is characterized by the uneven demographic distribution of the population, the dependency of the national economy on the export of primary products and its low resilience to natural events since it is the country with the lowest income per capita in Central America [71]. Despite it was not a direct variable obtained from interviews as a constrain, it is important to highlight that (*A*4) spatial demographic distribution, is connected with the availability of natural resources, as well as infrastructure and the offer of services, this helps to understand the distribution of water supply demands and the needs in multiple uses of water. (*A*5) Actually, leadership and entrepreneurship are manifested on the local level by basin committees and CAPS (*A*6), the internal norms are stablished by its members and approved by INAA. (*A*7) Projects for water management are scarce and developed in specific geographical areas, with limited diffusion of SES conceptualization. (*A*9) At local level, just a few CAPS are equipped with basic technology to monitor water flow and to measure in situ water quality; in these cases, the equipment has been granted by NGOs.

Through the content analysis of interviews, resource system (RS) and resource unit (RU) were defined in correspondence with the subtractability and excludability characteristics of the resource in order to characterize interdependencies of variables in the socio-ecological system [16,19]. It is important to notice that the conceptualization of resource system and resource unit are "closely linked in a one-to-one relationship" [19], nevertheless, we make it suitable to the concepts provided by McGinnis and Ostrom [10] and Leslie, Basurto [72], who define RS as the set of processes and particular living and working biophysical conditions, and temporal domains in which the stocks of a resource unit occurs. The corresponding SES analysis of multilevel water governance in Nicaragua is developed around (*RU*) water resources, (*RU*6) both surface and underground. (*RS*2) River basins and their hydrological processes are the resource system under analysis.

(*RU*1) water is constantly in motion, characterized by being highly heterogeneous in space and time [73]. (*RS*3) Nicaragua is hydrographically distributed in 21 river basins (*RU*5), with a total of 94 main rivers distributed all over the country; (*RU*3) eight river basins, accounting for 18 main rivers, drain into the Pacific Ocean and 13 river basins, accounting for 23 main rivers, drain into the Caribbean Sea, 45 main rivers drain into the Nicaraguan lake and eight into the Managua lake [5]. The 53 rivers that drain into the Nicaraguan and Managua lakes are directly connected to the Caribbean Sea through the San Juan River [74].

(*RU*7) We also highlight that 7.6% of the country's surface area is made up by the Nicaraguan lakes [5,75]. There are not official data on the estimates of total runoff, recharge, and production of surface and underground water in Nicaragua. The existing studies focus on some micro-basins located in the Pacific Region [71]. The most studied underground water bodies are the Leon-Chinandega plain, the Carazo Plateau, the Nicaraguan Depression, the Central Province, and the Atlantic Deposits [5]. Nevertheless, as stated in LaVanchy, Romano [4], water availability or water insecurity is not "always defined by the physical amount of water available via natural processes, but are more often the result of a convergence of issues reflecting power dynamics".

(*GS*1) At national level, the ANA is the highest authority [7]. Nevertheless, there are multiple government institutions at the national and local levels with roles defined within the water sector (Figure 4). (*GS*2) There are also a large quantity of non-government organizations established throughout the Pacific and Central Regions of Nicaragua with a working approach in rural areas, as well as (*GS*3) network structures, as is the case for 4961 CAPS with rural water supply systems installed [76]; only two basin committees are actually operating (Dipilto River and Estelí River Basin), productive networks are grouped independent of their production branches, besides the collaboration of universities. (*GS*4) The Nicaraguan Water Law frames the priority of water uses in article 46 [7], and the CAPS Law establish equity in local participation for integrated water management [30]. (*GS*5) Since the Nicaraguan water system (framework) is not in full implementation, the ANA assumed

functions of RBOs and basin committees where there is no formal presence. The ANA does not have delegates at the local level.

(*GS6*) The Sector Strategies and the Annual Operational Plans (POAs) elaborated by institutions involved in the water sector must comply with the guiding principles and other government policies, especially the National Plan for Water Resources (which is still in elaboration) [7,77]. (*GS7*) The governance system is supported by the Nicaraguan Water Law and complementary legal instruments. (*GS8*) The monitoring of water resources is done by ANA, INETER, MARENA and MINSA. INIFOM, FISE and local network structures provide monitoring within their operational approach. Sanctions are enforced by ANA via the administrative procedures [7] and PGR in the penal prosecution [78,79].

(*S1*) Although Nicaragua maintained a good growth rate between 2016 and 2017 according to the World Bank [80], it is still categorized as a low-income country [81]. (*S3*) The organs of the Nicaraguan public administration linked to the management of water resources, as a product of a sectoral approach share overlapping competences [82]; nevertheless, (*S4*) the real problem lies in the conflicts of competences between one-person or individual bodies and collective or collegiate bodies, when collegiate bodies are created without real functionality, as is the case with the CNRH [83]. (*S5*) Nicaragua does not have a diversified industrial structure, and its trading performance is correspondingly weak, relying on basic agricultural commodities [81]. (*S6*) There is not a specific mechanism to encourage the diffusion and implementation of water resource policies and strategies.

(*I2*) Government institutions that provide official data, also provides relevant information in their websites; however, technical monitoring data is not free of charge. No official mechanisms for information and knowledge sharing between organizations and networks has been stablished. (*I3* and *I6*) As stated in the Nicaraguan Water Law, participation of multiple actors in debating and lobbying activities is a provision for decision making [7]. (*I4*) According to the Nicaraguan Water Law, the ANA has water conflicts resolution competences [7].

(*I5*) In correspondence to investment activities, we notice that the economic dependence on primary production should give greater importance to the problems associated with water management because it is an indispensable resource for carrying out the most important productive activities for the Nicaraguan economy [71]. (*I8* and *I10*) Local networks are supposed to be monitored and technically supported by government institutions, such as UMAS and INAA in rural areas with independent water supply and sanitation systems.

(*O1*) The social performance measures in correspondence with interviewee answers depends on the efficiency in the formulation of projects, equity in the distribution of natural, technical and economic resources, the accountability of all the actors in the SES, and the evaluation of the real effects of the deliberation processes. According to Ingram [84], legitimate participatory decision-making processes help to reply in a consensus and democratic way to common needs and they also increase trust between actors.

Despite the heterogeneity of the interviewees, we consider each variable as the perspective of governance by stakeholder groups. In other words, third tier-variables identified, are wide in correspondence with the nature of the interviewees who provided the information. As the third-tier variables were organized according to density values obtained through a quantitative analysis of the interview findings, it was possible to ascertain the major factors influencing the interactions between system components.

As we emphasized in Section 2.3, although 52% of interviewees are local government officers, the remaining belong to multiple network structures; nevertheless, this ratio does not make a sound difference in the relationship between observed variables density value and the underlying concepts of multilevel water governance. Furthermore, differences were taken into account when placing the observed data from third-tier variables and combining them into aggregate water governance variables, as stated in Figure 5. In order to distinguish between variables in this dimension, the descriptive statistics of density works as a relative indicator of activeness and a measure of connectivity for variables according to responses. By the application of density measure, it was possible to range

third-tier variables of the SES framework from 0.0009 to 0.8365. Nevertheless, we divided these variables into five-way classification, corresponding to second-tier concepts.

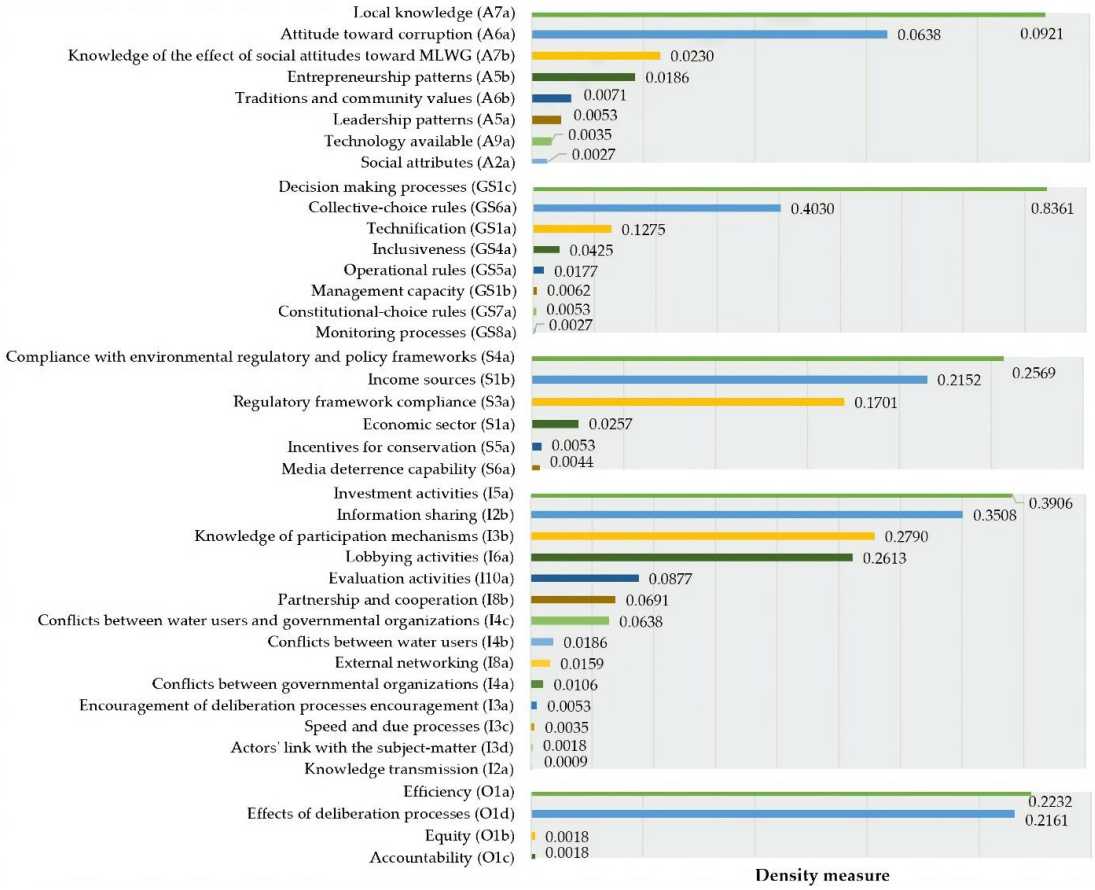

Figure 5. Density of variables affecting multilevel water management. MLWG: multilevel water governance. Source: author's own creation, based on 52 interviews using the SES framework.

The most noticeable gaps concerning the implementation of multilevel water governance in Nicaragua were linked to (*S*4*a*) compliance with the environmental regulatory and policy framework, (*S*1*b*) income sources, (*S*3*a*) regulatory framework compliance, (*GS*1*c*) decision-making processes, (*GS*6*a*) collective choice rules, (*GS*1*a*) technification, (*A*7*a*) local knowledge, (*A*6*a*) attitude toward corruption, and (*A*7*b*) knowledge of the effect of social attitudes toward multilevel water governance.

The collective actions and subsystems described can interfere with the interactions of system components, and thereby affect the outcomes. The major factors affecting interactions in the implementation of multilevel water governance were (*I*5*a*) investment activities, (*I*2*b*) information sharing, (*I*3*b*) knowledge of participation mechanisms, (*I*6*a*) lobbying activities, (*I*10*a*) evaluation activities, and (*I*8*b*) partnership and cooperation.

4. Discussion

The solutions to water problems are not limited to quality and quantity aspects, but involve other factors linked to the root of water management implementation and affect the social, economic, environmental, legal and political aspects, at local and national levels [73]. Nicaragua has a long tradition of centralized power and authority [85]. However, some may disagree with this statement, since article 7 of the Nicaraguan Political Constitution [86] establishes a clear separation between the central government and other political entities, such as municipalities, in terms of duties and

responsibilities. There are also national decentralization plans, but "the reality of what happens in Nicaragua demonstrates how the law exists on paper only" [48].

In Central America, there is no pattern to compare the mechanisms and administrative structures designed for the water sector due to the variety of legal figures that prevail in each country—the differences are set by social, economic and environmental values determined by the sociocultural and political contexts of each country; these different legal schemes lead to the creation and application of utilitarian or conservationist instruments and have a direct effect in the interactions between the resource unit and the resource system [59,60].

The challenges regarding the interactions that take place between the socio-ecological subsystems that describe the water governance regime that face the Central American countries and other developing countries are varied. The outcomes form the mechanisms and actions developed by the administrative structures may fail, which is common in polycentric systems of governance in the early stages defined by intergovernmental relations [13,87,88], it also indicates the need in the development of comprehensive policies and the implementation of actions with a multilevel approach to promote the creation and effective linking of structures at local and national level [13,34].

In the particular case of Nicaragua, outcomes are affected by a large list of variables conditioned by the resource system through resource unit and vice versa [19]; nevertheless, this investigation focuses on those variables identified by stakeholders of the water governance system as the main affecting its good implementation. Figure 6 shows the interactions between the second-tier variables identified based on interviews with water governance stakeholders, and their potential effects: either limitations or opportunities for progress in terms of collective action [89] that could help in creating an adequate multilevel water governance system in Nicaragua. One of the many challenges to understand the nested levels of the SES framework is identifying indicators that can be organized into logical attribution relationships, in a straightforward manner [11].

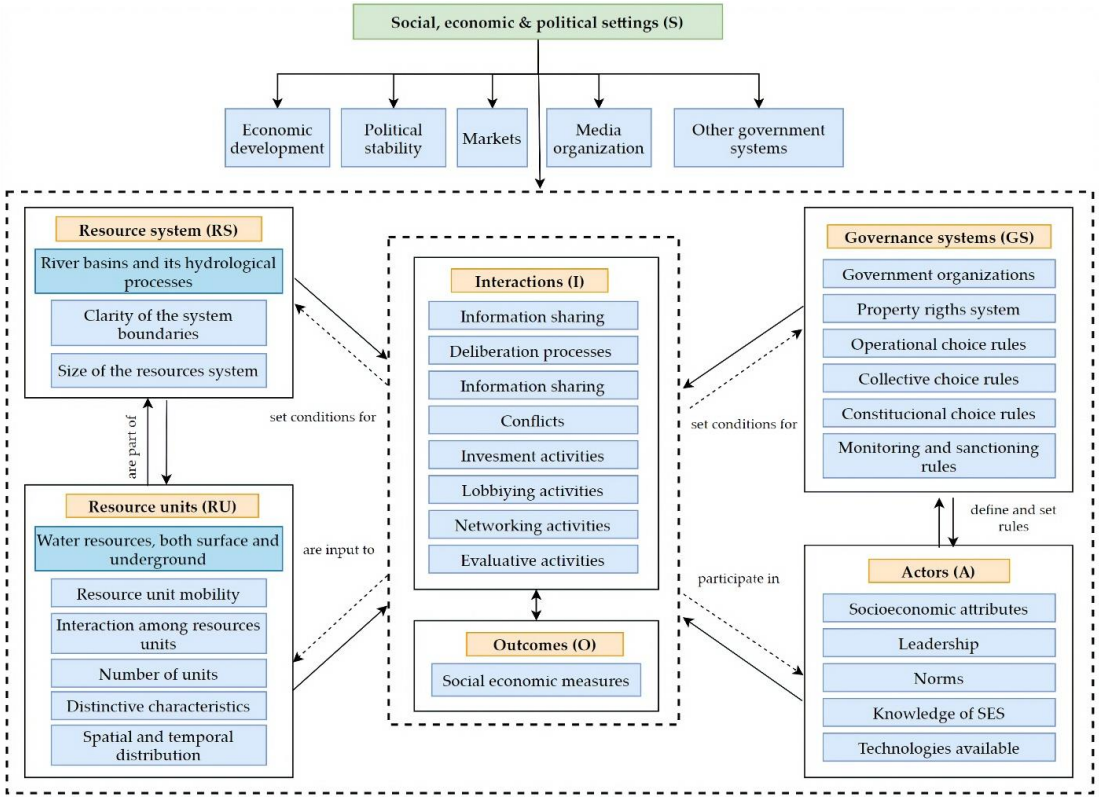

Figure 6. Socio-ecological system framework interactions of multilevel water governance in Nicaragua. Source: authors' own creation, based on Hinkel, Bots [11].

In terms of SES interactions, those occurring in local subsystems are determined by conditions in the governance subsystem. The major variables highlighted through the interviews were linked to government organizations, the property rights system, operational choice rules, collective choice rules, constitutional choice rules, and monitoring and sanctioning rules.

Regarding governance subsystems, the rules defining actions, mechanisms, and processes and their relationships to multilevel water governance are defined by socioeconomic characteristics, leadership and entrepreneurship patterns, understanding of SES components and interaction effects, and the water management technology available.

The main constraints in the governance subsystem are caused by limited economic resources [4] distributed for ad hoc needs and the fact that government organizations depend entirely on grants and the national budget, with none of the self-funding systems that are established by law [7], limiting their monitoring and enforcement capacities. This scenario involves the fragmentation and limitation of the actions carried out by government institutions and affects the lack of an integrated approach from planning to the implementation of policies, plans and projects regarding water resources [90]. We also highlight that government institutions that develop their competencies under jurisdictional restrictions that go beyond political borders often have problems in establishing funding schemes, since funding usually presents struggles for collaboration [84].

The relevant actors are seen in a negative light due to a lack of technical knowledge, expertise and innovation, the opinions of citizens being only partially integrated, a lack of willingness among citizens, the execution of projects without strategic planning, and a lack of knowledge about legal frameworks and policy instruments. Finally, local networks and organizations do not have the appropriate technology to monitor water resources or coordinate efforts in river basins, since the promotion and integration of this area (water management) has received significantly less attention or emphasize compared to other institutional approaches [26,27] which address to organizational priorities. The Nicaraguan Water Law was designed as a multilevel water governance scheme, in which the ANA is the highest national-level authority, with regulatory and supervisory functions over the RBOs, which play a similar role at the local level [7]. It would be useful to have RBOs in place, because then water users could access their rights under the law within a short distance of their communities.

RBOs are important in the implementation of the law, because they can perform monitoring and enforcement functions, such as water conflict resolution and dispute resolution, with the authority to rule "out of court" as well as ANA [24]. In contrast, the basin committees can only make unenforceable recommendations. We also recognize the importance of RBOs, because they are meant to operate based on the territorial boundaries (river basins) of the natural resource, not political boundaries [91], which would contribute to solving spatial misfits [92].

There are only a few basin committees across Nicaragua, mainly in the areas where international cooperation agencies fund projects and therefore demand their existence. This embodies the lack of formal decentralization within the country and clearly indicates that integrated water resources management does not exist at the regional or local levels, except in cases where decentralized structures, such as the basin committees, have been created and funded by ICAs. The Nicaraguan Water Law is clear on the distribution of functions and competencies within the Nicaraguan water system. The purpose of the distribution of functions is to establish an inter-organizational network for water management; however, considering the fragmentation that exists among the members of the Nicaraguan water system generates communication and coordination problems. Water management deals with complexity and uncertainty in social and physical dimensions [93]. We highlight that the existing problem is not only about competencies, but also transcends the availability of economic and technical resources for the implementation of those competences [90].

Investment, information sharing, evaluation, and partnership cooperation are affected by a lack of funds. There is also a lack of favorable spaces for knowledge exchange, communication mechanisms, and the execution of projects with strategic planning scope, as mentioned in Table 5. Attempting to solve so many problems simultaneously in terms of water resources, the demand upon human

resources with technical capacities, as well as the availability of organizational and financial resources is overwhelming. [84]. Furthermore, conflict resolution is almost nonexistent, its mechanisms are unknown to the public, and there is a lack of knowledge on local water governance, affecting water users at all levels. There is no coherence between popular understanding and the meaning of water governance [94]; therefore, the absence of a useful definition aggravates the understanding of the concept and has thus reduced its potential implementation to a minimum [73].

A lack of economic resources can be considered to be the root cause of many water management problems in developing countries such as Nicaragua, where "the challenges of water governance are most acute" [95]. This could be solved by the enactment of the self-funding water scheme that is already established by law, which would be crucial to the full implementation of the Water Law, finally enabling the multilevel water governance approach it prescribes [95,96]. However, according to Casiano Flores, Özerol [90], its well known that issuing laws or policies does not guarantee the expected results.

In addition, the literature review revealed "discrepancies between state policy and water governance in practice" [97], something also described in the 52 interviews as a lack of coordination between institutions in the execution of shared responsibilities and in further implementing the Nicaraguan Water Law by linking national and local level institutions. The interviews also revealed that decision-making processes and collective and operational choice rules are centralized at the national level, neglecting the importance of participatory processes at the local level. Different government institutions and networks have multiple stakeholders, and this diversity is an integral element in the implementation of democracy and the balanced distribution of functions and competencies of government institutions to guarantee responsiveness of such institutions to the needs of different stakeholders [73].

Our findings suggest that powerful economic and productive sectors can affect and manipulate participation processes and lobbying activities, as was the case in the enactment of the Water Tariff Law, where large agricultural corporations publicly lobbied against the law [67] without taking into consideration the opinion of community networks, academia, and NGOs. These circumstances might have influenced the interviewees, as they highlighted a lack of funds as one of the main constraints on the implementation of the Water Law. Nevertheless, it is necessary to empower actors in water governance for proactivity and long-term self-sustainability, considering that subsidiary practices without a strategic dissociation mechanisms can become, as in many developing countries, a new "thriving industry for raising of funds" [73].

The results of the 52 in-depth interviews using the SES framework were consistent with the literature review, confirming that multilevel water governance is hard to implement in developing countries. The main constraints are low budgets, centralization at the national level, noncollective choice rules, a lack of information sharing, a lack of knowledge about conflict resolution mechanisms, and insufficient human resources in terms of technical skills and expertise [13,39]. Despite the fact that the Nicaraguan Water Law was enacted based on IWRM, the scopes of the law, in practice, have been limited by the lack of practical instruments to complement the law, considering that the instruments' current existence does not provide a real guide for stakeholders in the water sector. Policy makers need to operationalize water planning, management and decision-making processes to be more rational and efficient to achieve not mutually exclusive goals and improve economic stability, distribution of income, environmental quality and social welfare [73].

Table 5. Third-tier variables of the focal action situations subsystem (*I & O*), as identified by interviewees.

(a)	(b)	(c)	(d)	(e)
Second-Tier Variables	**Working Definition**	**Third-Tier Variables**	**Operationalization of Variables**	**Question (Appendix A, Table A1)**
(*I*2) Information sharing	Mechanisms for information sharing among users, governmental organizations, nongovernmental organizations, network structures, and social and community networks	(*I*2*a*) Knowledge transmission	• No favorable spaces for knowledge exchange • Lack of communication mechanisms	19
		(*I*2*b*) Information sharing	• Low institutional technical information sharing • Lengthy bureaucratic processes to access information	19
(*I*3) Deliberation processes	Discussion and debate processes to analyze issues in water governance, integrating multiple actors and evaluating benefits and consequences prior to decision-making	(*I*3*a*) Encouragement of deliberation processes	• Lack of multisectoral citizen involvement	12
		(*I*3*b*) Knowledge of participation mechanisms	• Empiricism	7, 9, 12
		(*I*3*c*) Speed and due processes	• Long and biased processes	4
		(*I*3*d*) Actors' link with the subject matter	• Participation of foreign or external consultants who do not understand local scenarios, norms, and social attributes	9
(*I*4) Conflicts	Conflicts between water management stakeholders at the local and national level	(*I*4*a*) Conflicts between governmental organizations	• Coordination conflicts between institutions	7, 12
		(*I*4*b*) Conflicts between water users	• Conflicts between water users (water available for human consumption vs. industrial and agricultural consumption)	21
		(*I*4*c*) Conflicts between water users and governmental organizations	• Interest conflicts (economic and political)	21
(*I*5) Investment activities	Investment activities for the improvement of water management as a part of water governance	(*I*5*a*) Investment activities	• Low allocation of economic resources in the water sector • Need for economic investment in water management activities	11, 12
(*I*6) Lobbying activities	Capacity of users to coordinate lobbying activities, manage resources, and take decisions to a higher level	(*I*6*a*) Lobbying activities	• Integration of multisectoral perspectives • Lack of grassroots participation • Planning at the local level	5, 9, 13

Table 5. *Cont.*

(a)	(b)	(c)	(d)	(e)
Second-Tier Variables	**Working Definition**	**Third-Tier Variables**	**Operationalization of Variables**	**Question (Appendix A, Table A1)**
(*I*8) Networking activities	Networking and partnership activities, coordination for water management	(*I*8*a*) External networking	• Transfer of conflicts to other organizations	5, 7
		(*I*8*b*) Partnership and cooperation	• Overlapping of activities • Irregular funding for water management • Existence of multiple networks without links or communication	4, 5, 6, 12
(*I*10) Evaluative activities	Reflective evaluation of effects due to activities carried out and decisions made related to water governance	(*I*10*a*) Evaluation activities	• Need to develop activities with a strategic focus • Objective assessment of benefits	9
(*O*1) Social performance measures	Impacts of social components and concepts included	(*O*1*a*) Efficiency	• Project formulation with minimum compliance requirements • Low-level studies and research (diagnosis level)	9, 16
		(*O*1*b*) Equity	• Need to develop projects with a comprehensive approach	16
		(*O*1*c*) Accountability	• Undisclosed long-term results	14
		(*O*1*d*) Effects of deliberation processes	• Results of citizen participation processes at the local level are not considered at the national level	15, 19

All the findings of this study affecting multilevel water governance in Nicaragua and the limitations identified for compliance cannot be successfully addressed without prior discussion by decision makers regarding the integrated water management concept. It is also necessary to evacuate many questions that decision makers have not asked until now in order to ignore the complex and indisputable problems surrounding water resources that prevent strategic planning and the implementation of context-specific solutions [90]. This study highlights the issues that should be attended and integrated for multilevel water governance approach; although, decision makers should arrange a practical and landed workplan, defining the roles and methodologies involved in successful implementation [73]. We consider that general solutions are well known and the real problem is defined by the implementation of these solutions [84,90,94].

5. Conclusions

Through our research in this study, it was possible to identify the variables in the socio-ecological system (SES) for multilevel water governance in Nicaragua. These variables were identified through interviews with key actors in the governance subsystems, with roles within government institutions, organizations, and productive networks, and as community representatives. The variables affecting multilevel water governance were determined by factors directly linked to economic development in Nicaragua and are described in the discussion section.

There is great potential to improve water management in Nicaragua by implementing a multilevel water governance approach in which decisions are made through better participatory processes, and by using a strategic approach to project design and development. Local governments and community networks are willing to participate in the management of their resources, as expressed by the interviewees. Another area for improvement is information sharing between all stakeholders at the national and local levels.

With regard to multilevel water governance, stakeholder leadership and entrepreneurial goals were reflected in the SES framework, as were the rules established by society covering ethics, morality, knowledge, and understanding. Integration processes are affected by the poor mechanisms of information exchange between users, governmental organizations, non-governmental organizations, network structures, and social and community networks.

Finally, the Water Tariff Law established in article 87 of the Nicaraguan Water Law should be invoked, thus implementing a self-funding scheme of water abstraction fees, pollution fees, and environmental/hydrological service payments, since a lack of financial resources is the main barrier to appropriate multilevel water governance and IWRM implementation. This is not just the opinion of the authors—it has been well documented in the literature and was corroborated by our 52 in-depth semistructured interviews.

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Appendix A

Table A1. Model of a semistructured interview.

A Socio-Ecological System Analysis of Multilevel Water Governance in Nicaragua
This interview aims to develop an analysis of perceptions regarding multilevel water governance in Nicaragua. On the basis of field research, a socio-ecological system (SES) framework was applied for an analysis of multilevel water governance in Nicaragua and relevant semantic relationships.
Subject ID: GS___-___
Key questions for the identification of variables in the application of the socio-ecological system (SES) framework.
1. Is your institution/organization: ○decentralized, ○deconcentrated, ○autonomous, ○NGO, ○community-based
2. Does your country have a modern water law?
3. Is the Nicaraguan Water Law being implemented? ○Yes, specify: ○fully, ○partially ○No
4. What are the main constraints for the implementation of the Nicaraguan Water Law?
5. Is your institution/organization involved in major decision-making on water resources management?
6. Is there overlap between the duties of different water resources management institutions/organizations?
7. Are there "conflict resolution" mechanisms in water resources management? ○Yes, specify: ○between users, ○between users and institutions ○No
8. Is there coordination between national-level organizations and your institution/organization in terms of water resources management?
9. Are regulation/planning/implementation/financing processes in the sector part of a coherent approach, or are they ad hoc?
10. How is your institution/organization financed?
11. How is the allocation of financial resources for water management at your institution/organization? ○High, ○medium, ○low
12. What does your institution/organization need to collaborate in terms of water governance at the local level?
13. Are there processes for citizen participation on water policies and/or plans in your locality?
14. Do participatory processes reflect the will of your local citizens?
15. Are local participatory processes taken into account by national-level authorities in the formulation, evaluation, and elaboration of water resources programs and projects?
16. Are you aware of any IWRM project in your locality?
17. Does your institution/organization have specialized technicians for water resources issues?
18. If your institution has specialized water technicians, do they specifically work on water issues or do they have other unrelated functions? If so, why?
19. How would you rate access to information related to water resources? ○Bad, ○medium, ○good, ○excellent
20. Are there water-related institutions in your locality?
21. Are there conflicts of interests in terms of water resources management in your locality? If so, what do you associate them with?

Table A2. Geographic and hydrographic distribution of stakeholders interviewed in the governance system.

ID	Municipality	Department	River Basin	River Basin Code [98]
Local Government Officer (GS1-1)	Jinotepe	Carazo	Between Brito River and Tamarindo River/San Juan River	68
Local Government Officer (GS1-2)	Diriamba	Carazo	Between Brito River and Tamarindo River	68
Local Government Officer (GS1-3)	Villanueva	Chinandega	Río Negro/Estero Real	58/60
Local Government Officer (GS1-4)	Chinandega	Chinandega	Estero Real/Between Cosigüina Volcano and Tamarindo River	60/64
Local Government Officer (GS1-5)	Chichigalpa	Chinandega	Between Cosigüina Volcano and Tamarindo River	64
Local Government Officer (GS1-6)	El Viejo	Chinandega	Estero Real/Between Estero Real and Cosigüina Volcano/Between Cosigüina Volcano and Tamarindo River	60/62/64
Local Government Officer (GS1-7)	Cinco Pinos	Chinandega	Estero Real	60
Local Government Officer (GS1-8)	Somotillo	Chinandega	Río Negro/Estero Real	58/60
Local Government Officer (GS1-9)	San Francisco del Norte	Chinandega	Estero Real	60
Local Government Officer (GS1-10)	Posoltega	Chinandega	Estero Real/Between Cosigüina Volcano and Tamarindo River	60/64
Local Government Officer (GS1-11)	Estelí	Estelí	Coco River/Río Negro/Estero Real/San Juan River	45/58/60/69
Local Government Officer (GS1-12)	La Trinidad	Estelí	San Juan River	69
Local Government Officer (GS1-13)	San Nicolás	Estelí	Coco River/San Juan River	45/69
Local Government Officer (GS1-14)	Condega	Estelí	Coco River	45
Local Government Officer (GS1-15)	Pueblo nuevo	Estelí	Coco River/Río Negro	45/58
Local Government Officer (GS1-16)	San Juan de Limay	Estelí	Coco River/Río Negro	45/58
Local Government Officer (GS1-17)	El Sauce	León	Estero Real/San Juan River	60/69
Local Government Officer (GS1-18)	León	León	Between Cosigüina Volcano and Tamarindo River	64
Local Government Officer (GS1-19)	Nagarote	León	Tamarindo River/Between Brito River and Tamarindo River/San Juan River	66/68/69
Local Government Officer (GS1-20)	Larreynaga	León	Estero Real/Between Cosigüina Volcano and Tamarindo River/San Juan River	60/64/69
Local Government Officer (GS1-21)	Telica	León	Estero Real/Between Cosigüina Volcano and Tamarindo River	60/64
Local Government Officer (GS1-22)	La Paz Centro	León	Between Cosigüina Volcano and Tamarindo River/Tamarindo River/San Juan River	64/66/69
Local Government Officer (GS1-23)	El Jicaral	León	San Juan River	69

Table A2. *Cont.*

ID	Municipality	Department	River Basin	River Basin Code [98]
Local Government Officer (GS1-24)	Santa Rosa del Peñón	León	Estero Real/San Juan River	60/69
Local Government Officer (GS1-25)	Achuapa	León	Río Negro/Estero Real	58/60
Local Government Officer (GS1-26)	Dipilto	Nueva Segovia	Coco River	45
Local Government Officer (GS1-27)	Ocotal	Nueva Segovia	Coco River	45
Local Government Officer (GS1-28)	Jalapa	Nueva Segovia	Coco River	45
Local Government Officer (GS1-29)	El Jícaro	Nueva Segovia	Coco River	45
Local Government Officer (GS1-30)	San Juan del Sur	Rivas	Between Brito River and Sapoá River	72
CAPS member (GS3a-1)	Dipilto	Nueva Segovia	Coco River	45
CAPS member (GS3a-2)	Dipilto	Nueva Segovia	Coco River	45
CAPS member (GS3a-3)	Dipilto	Nueva Segovia	Coco River	45
CAPS member (GS3a-4)	Dipilto	Nueva Segovia	Coco River	45
CAPS member (GS3a-5)	Dipilto	Nueva Segovia	Coco River	45
CAPS member (GS3a-6)	Dipilto	Nueva Segovia	Coco River	45
CAPS member (GS3a-7)	Dipilto	Nueva Segovia	Coco River	45
CAPS member (GS3a-8)	Estelí	Estelí	Coco River	45
CAPS member (GS3a-9)	Estelí	Estelí	Coco River	45
CAPS member (GS3a-10)	Chichigalpa	Chinandega	Between Cosigüina Volcano and Tamarindo River	64
Productive actor (GS3b-1)	Managua	Managua	San Juan River	69
Productive actor (GS3b-2)	Managua	Managua	San Juan River	69
Productive actor (GS3b-3)	Managua	Managua	San Juan River	69
Productive actor (GS3b-4)	Managua	Managua	San Juan River	69
Productive actor (GS3b-5)	Dipilto	Nueva Segovia	Coco River	45
Productive actor (GS3b-6)	Estelí	Estelí	Coco River/Río Negro/Estero Real/San Juan River	45/58/60/69
Productive actor (GS3b-7)	Estelí	Estelí	Coco River/Río Negro/Estero Real/San Juan River	45/58/60/70
Productive actor (GS3b-8)	León	León	Between Cosigüina Volcano and Tamarindo River	64
Productive actor (GS3b-9)	León	León	Between Cosigüina Volcano and Tamarindo River	64

Table A2. *Cont.*

ID	Municipality	Department	River Basin	River Basin Code [98]
Productive actor (GS3b-10)	Chichigalpa	Chinandega	Between Cosigüina Volcano and Tamarindo River	64
Basin Comm. Member (GS3c-2)	Dipilto	Nueva Segovia	Coco River	45
Basin Comm. Member (GS3c-1)	Estelí	Estelí	Coco River/Río Negro/Estero Real/San Juan River	45

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