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The Water Management Regime in Western Iran: A Retrospective Analysis through a Hybrid Transitions Framework

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Abstract: Continuously changing conditions of sociotechnical systems are the basis of structural changes in communities. Relationships between transition contexts and regime transformation processes and their driving factors in sociotechnical regimes are poorly understood. Moreover, not all changes in multilevel governance regimes are geared towards sustainability, as demonstrated by the case of the water management regime in Sanandaj county in the west of Iran between 1962 and 2018. The current study shows how the management regime of water resources in the case study has changed over time and identifies the institutional arrangements through a retrospective analysis. The analysis is based on three stages of data collection which included a discussion group, a Delphi survey, and a focus group survey among various types of stakeholders. The "Hybrid Transitions" framework is introduced in order to denote processes of regime change that take place in a range of different transition contexts. The findings do not identify a single transition pathway but show that a number of parallel transition pathways have occurred in the context of groundwater and surface water management and their respective institutional arrangements. The study provides a better understanding of the complexity of transition pathways that were devised at the management regime level.

Keywords: action arena analysis; institutional arrangements; transition management regime; water shortage; strategic goal

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Citation: Karimi, N.; Azadi, H.; Boussauw, K. The Water Management Regime in Western Iran: A Retrospective Analysis through a Hybrid Transitions Framework. *Sustainability* **2021**, *13*, 3323. https://doi.org/10.3390/su13063323

Academic Editor: Andrzej Wałęga

Received: 27 January 2021
Accepted: 8 March 2021
Published: 17 March 2021

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1. Introduction

The sociotechnical characteristics of communities define the sense inhabitants have of the natural resources they use, the way in which they interpret related uncertainties, and favor strategies for solving problems [1]. However, long-term changes of conditions, such as demographic growth and the development of technologies for resource exploitation, transform nature-human relationships, and communities tend to adapt to such changes [2–4]. Hence, the analytical focus of scientific sustainability analyses has moved towards analyzing transitions of sociotechnical and socioecological systems, an approach that might help understand the dynamics of such changes to pursue environmental efficiency [5]. The literature provides several transition frameworks towards sustainability, which vary in how they approach processes of transitional change and in how the complexity of interactions between actors across governance spheres are conceived in the long run [3,6–8].

There are a limited number of studies that analyze practices of transition of water resource management, applying various methods of data collection and analysis. For example, in a study by Ferguson et al. (2013) [9], they used interviews and visioning workshops with stakeholders in an attempt to collect empirical evidence of Melbourne's experiences in shifting towards a hybrid system that combines centralized and decentralized water infrastructure. From this, they drew lessons on the institutional context that enabled the shift and demonstrated significant aspects of such a shift within cognitive, normative, and

regulative dimensions. In another similar study, Pahl-Wostl et al. (2012) [10] applied expert judgment to present a comprehensive comparative analysis of complex water governance and management systems in 29 national river systems in both developed and developing countries. Their applied approach made a distinction between water governance regime, regime performance, and environmental and socio-economic context. The finding of the study provides evidence that polycentric governance regimes characterized by a distribution of power under effective coordination structures are performant approaches. Using literature review and discourse analysis, Fuenfschilling et al. (2014) [11] analyzed past and current transformation processes in urban water management sectors in the Australian water sector and assessed their degree of institutionalization. Silvestri et al. (2018) [12] applied both workshop and fieldwork reports to analyze transition management in three urban areas in Sub-Saharan Africa. Their main aim was to explore how the unsustainability of services related to water sanitation in informal settlements is rooted in current societal and governance structures, cultures, and practices. Reviewing similar previous studies shows that none of them so far applied the Delphi survey and focus group discussion to perform a retrospective analysis of a water management regime.

Although in recent years, transitions and system innovation increasingly gained attention, processes of transformation in sociotechnical systems, which include setting goals and establishing institutions, rules, and norms, are not yet sufficiently addressed in a comprehensive manner [3]. Likewise, the relationships between the context of transition and transformation processes in a sociotechnical regime are poorly understood. Analyzing these relationships is important to understand whether all changes in multilevel governance regimes are geared towards sustainability. In relating contexts to transformation processes, for instance, new approaches promise to increase the environmental performance of resource systems such as energy, agriculture, water management, etc., though, in many cases, these approaches have resulted in unintended outcomes [13]. Furthermore, some driving factors are purposefully steering regime changes, while others emerge autonomously and contribute to change. Moreover, contrary to the general academic focus on one type of regime transition towards sustainability for each case, the question may arise whether there may be several possible transformation pathways in a context of regime changes by decomposition of the management regime elements. This varies for each case, which might be related to economic, social, cultural, infrastructural, and regulative contexts [14,15].

In order to do so, we will introduce and apply a theoretical framework that we will call "Hybrid Transitions" (HT) to explore the interactions between actors and institutions involved in community planning practices. The HT framework provides a coherent understanding of the complexity of how various policies, actions, and driving factors, which are devised at a regime level, can lead to different outcomes. The framework is developed by combining the two existing frameworks of Institutional Analysis and Development (IAD) [16] and Transition Context [14], based on two considerations. First, governance regimes consist of complex dynamics of actor-driven actions that occur within the constraints of the outcomes of planning processes and policies in a changing sociotechnical system. Second, there are a plethora of transformation pathways at the regime level due to the multi-tiered nature of regimes, which means that at a particular level of "governance scale" or "action arena" (e.g., within a basin border or an administrative border), various actors with asymmetrical powers and interests take different roles based on alternative contexts and driving factors [3,17].

Therefore, this paper develops a framework to identify a number of specific alternative contexts and drivers for regime change, which are not necessarily geared towards sustainability. To define the HT framework in practice, we perform a retrospective analysis among various types of stakeholders of Sanandaj county in the west of Iran between 1962 and 2018. In Sanandaj county, the water management underwent structural changes during the considered timeframe, following a reform in the institutional arrangement. The analysis is conducted through three stages of data collection including a discussion group, a Delphi survey, and a focus group survey. The application of these three methods of data collec-

tion in the current study is a novel approach for the transition studies in a practical way. However, prior to conducting these three stages of data collection, we provided primary data through a review of both scholarly literature and published official documents. The analysis considers those dynamics, scrutinizing policies, plans, practices, and regulations issued during the timeframe. Given that the transition of the water management regime in Sanandaj county is not a unique case, the HT framework can provide a basis for developing a method for understanding changes in various contexts where important environmental issues, associated with resource management regime and policies, are at stake [1,18,19].

2. Theoretical Background: Defining the Characteristics of the Hybrid Transitions Framework

Schoon and Van der Leeuw (2015) [20] identify a system as "an integrated whole being constituted of several interacting parts or elements." Thus, a resource system is composed of ecological characteristics and societal elements such as rules, material conditions, and attributes of the community, while the interconnectivity between these elements within a certain boundary (such as a basin or an administrative area) is also part of the system. Furthermore, the components are nested and interlinked with "externalities" that are located beyond the system (Figure 1). Under certain conditions (e.g., external shocks, crises, cumulative changes in internal variables or a radical shift in the composition of components), particular thresholds may be exceeded [21–23], after which a sociotechnical system may shift from one stable state into another. However, a transition into a fundamentally new stable system is a complex process of regime reconfiguration in terms of values, patterns of social behavior, and governance on various scales, which affect each other during long term processes [21,22,24]. The literature on transition studies offers conceptual and theoretical levers to better tackle the mechanisms of transition [25]. Frameworks for the analysis of transition management regimes are mostly used in order to identify general sets of variables of the phenomena at stake and the overall relationships between them [16]. In the literature, two major categories of transition frameworks stand out: (1) Socio-Technical Transition claims to analyze the coevolution of society and technology towards sustainable development based on multi-layer regime interrelationships, while (2) Social-Ecological System transition frameworks, such as IAD, emphasize the need to consider interactions between structures and types of socioeconomic systems, and distinguish between ecosystem functions at various levels.

Another typology is "transition contexts", which differentiates between two dimensions [14]. The first dimension relates to whether change is envisaged and coordinated at the level of a regime, or whether it is the emergent outcome of uncoordinated actions of actors. The second dimension relates to the degree to which the transformation is based on elements present within or outside the regime. Relevant elements such as actors, roles, rules, knowledge, and actions are necessary to carry out the regime functions. If the elements that support adaptation are available internally, then change is likely to be more incremental, deliberate, and bottom-up. If the capacity to undertake adaptation actions is highly constrained by the lack of internal resources, then we can assume that there is an opportunity for major structural change. In this regard, four transition pathways can be distinguished: (1) "Endogenous renewal", a transformation based on coordinated responses of regime members (civil society, activists, water-user groups, and regulators) leading to internal adaptation, (2) the "reorientation of trajectories" approach, which is based on uncoordinated responses of regime members leading to internal adaptation, (3) the "purposive" or goal-oriented approach, based on coordinated responses by outsiders or non-members of a regime leading to external adaptation, and (4) the "emergent and unpredictable transformation", based on uncoordinated responses by outsiders to a regime, again leading to external adaptation [15,26] (Figure 2).

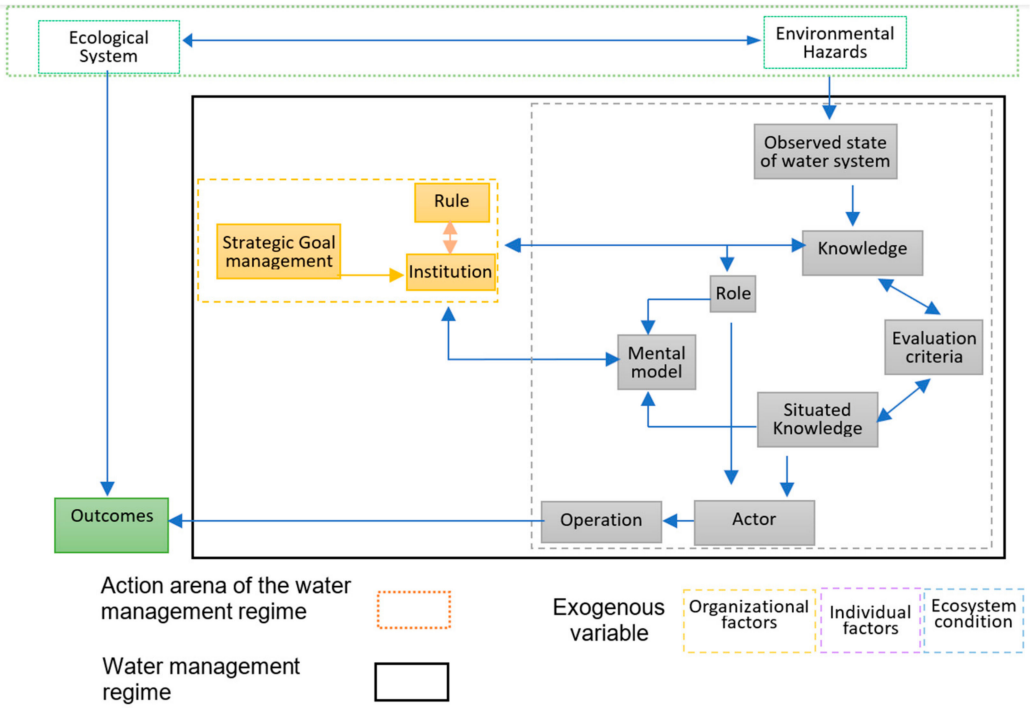

Figure 1. Elements of a water management regime, inspired by Ostrom (2011) [16] and Pahl-Wostl et al. (2010) [3].

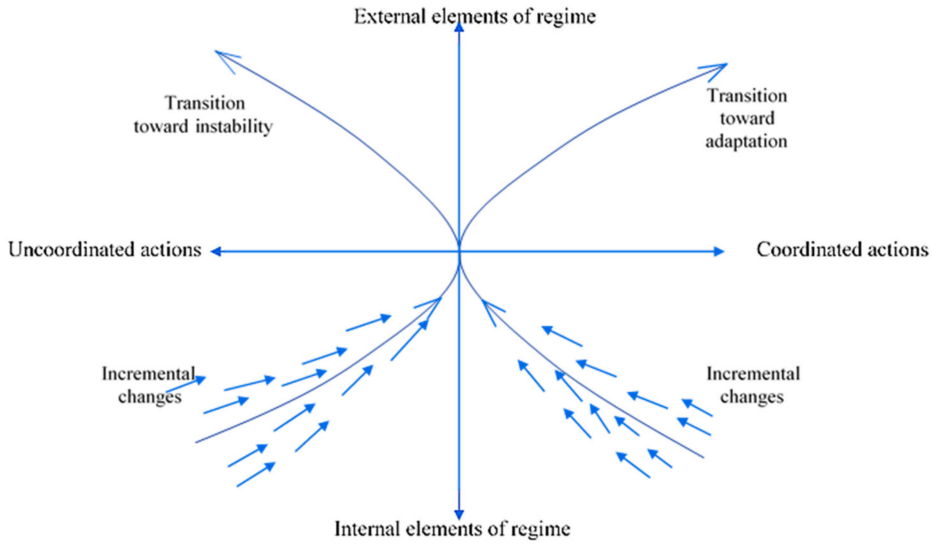

Figure 2. The hybrid transitions (HT) framework in a context of regime changes; source: The authors.

While each framework has its own constraints with respect to the balance between the various dimensions considered [23], two gaps can be identified. First, not all changes in multilevel governance regimes are geared towards sustainability, as demonstrated by the transition literature. Second, there is not necessarily just a single transition, but rather several parallel transitions that originate from a common basis and are shaped by regime-specific configurations of interests and goals. Although the gaps between frameworks can be seen as opportunities for complementarity (e.g., Pahl-Wostl et al. (2006) [1]; Pant et al. (2015) [27]), connecting different dimensions of transition from different frameworks remains a challenge in any specific situation [23]. Using or integrating the existing transition frameworks can generate theoretical inconsistencies and accumulate the risk of

mismatches, if in combining the frameworks, the foundational assumptions on the nature of system transitions and trajectories of changes or the notion of transformability grounded in diverse systems, were not taken into account [23].

To avoid inconsistency, theories must necessarily be narrowed down to those elements relevant to the particular research question [16], making assumptions on the involved variables, explaining processes, and predicting outcomes. Examples in the context of the current paper are theories of public goods and common-pool resources after the reform of the natural resources ownership regime in Iran, the employment of neo-classical economic theory to understand the endeavor of the Iranian state to allocate water rationally under conditions of scarcity and an unbalanced distribution of water, and the application of game theory to understand the rationale behind maximizing the net benefit of water end-users for groundwater withdrawal in Sanandaj county. Therefore, conducting such an analysis raises considerable challenges since regimes are composed of a wide diversity of components and processes, all of which interact with different aspects of the market, the economy, and politics at the landscape level, and with end-users at the niche level, even when there is no simple or straightforward relationship between them [20,28].

3. The Case Study (Sanandaj County, Iran): Data Collection and Analysis

3.1. Introduction of the Study Area

The challenges of water shortage are particularly acute in semi-arid areas, where temperatures are rising and droughts are occurring more frequently, such as Sanandaj county in the west of Iran [29]. The city of Sanandaj and its surrounding area, with a population of around 500,000 inhabitants, has become increasingly susceptible to water shortage. While the management regime of water resources in the county underwent structural changes from the 1960s on, the current governance structure for managing water resources in the county has become increasingly complex (Figure 3). Some characteristics of the water system of the case study are presented in Tables 1 and 2.

In terms of strategic planning, the highest level of the Iranian system is the "National Development Plan", which is prepared and approved by the Government Cabinet and the National Parliament. The plan includes major strategies regarding water resource affairs for the next 4 years at the national level. This chapter is interpreted as a "National Operational Plan" by the Ministry of Energy. In the next stages, through the interorganizational hierarchy, the National Operational Plan is translated into local plans. In the end, the state administrators are the primary actors in this operation, initiating the creation of institutions in Sanandaj, while other local public actors are working with various levels of resource management organizations within the county, such as the Natural Resource Management, Sanandaj Agricultural Administration, the Administration of Environmental Protection of Sanandaj, and the Municipality of Sanandaj.

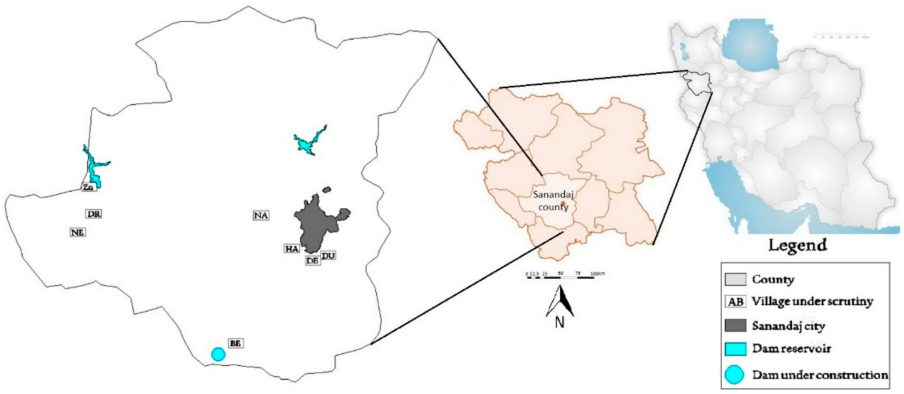

Figure 3. The City of Sanandaj, Iran, and the distribution of selected villages for analysis in Sanandaj county, including Dushan (Du), Hasanabad (Ha), Navarah (Na), Degairan (De), Zunj (Zu), Derila (Dr), Negel (Ne), and Bezlana (Be).

Table 1. General information on the case study.

Year	Area (km^2)	Population	Annual Precipitation (mm)	Freshwater Availability [1] per m^3/Capita/year	Average Domestic Water Consumption (Million m^3/year)
1966	9424	134,008	560	5500	-
2016	3637 [2]	501,402	490	3562	58

Source: The Regional Water Authority of Kurdistan (2020) [30]. [1] The available amount of water in the rivers, lakes, and the aquifers. [2] In 1994, the two counties of Divandareh and Kamyaran have been split off from Sanandaj county.

Table 2. Distribution of the land use in Sanandaj county.

Type of Land Use Area	Built-Up Area	Agriculture	Blue Surface	Forest	Other	Total
Land use area (km^2)	67.3	606.8	21	178	2764	3637
Share of each type of land use (%)	1.85	16.68	0.58	4.89	76	100

Source: The Regional Water Authority of Kurdistan (2020) [30].

The public authorities of the county attribute the vulnerability to water shortage mainly to global climate change and largely deny the link between the issue and the increasing importance of human interventions. Therefore, we identify the need to analyze in detail how the water resources of the county are managed, and how the management regime and the strategic goals at the landscape level have been transformed since 1960 and up to 2018.

3.2. Data Collection and Analysis

To analyze the transition of the water management regime of the case study, we employ a retrospective qualitative analysis in which we combine three stages of data collection. First, a discussion group was set up, which provided an analytical lens to screen the applicable variables of the water management regime. Subsequently, a Delphi method-based iterative survey, questioning a selection of local experts from Sanandaj, was conducted, in order to validate the variables. In this study, the Delphi method was applied mainly since it is a structured method that allowed us to collect data in successive rounds and to determine group consensus in order to identify and assess both the nature and the composing elements of the phenomenon under scrutiny. In addition, the Delphi method was deemed a most effective tool since face-to-face interactions with participants were difficult to organize, while a number of them preferred to remain anonymous [31,32]. Finally, the validated results were extended through a focus group survey, in order to identify patterns of transformative change at the regime level. However, before setting up these three data collection stages, we conducted a review of both scholarly literature and published official documents as primary data. Then, the three stages fed the framework based on the participants' experiences and understanding of the transformation of the water management regime, which led to the identification of a range of variables that are positively or negatively interrelated. Although an exhaustive analysis of all variables that are related to the transformation of the water system is out of the scope of this paper, the level of detail aimed for depends on the degree of information that is required to fully understand and analyze the mechanisms under scrutiny, which directly depends on the research question [23]. To cope with the complexity of potential variables, and to reveal chains of interrelations, we employed two strategies. First, we classified relevant variables based on the IAD framework, which gives an insight into the key internal and external variables that affect the action arena of the water management regime. Second, in our case study, we employed homogenous purposive sampling for the demarcation of the geographical area under scrutiny, in order to decrease the number of variables and make it fit within the scope of the research. In concrete terms, it means that we selected eight villages in Sanandaj county that exhibited the same characteristics as part of their social-ecological system, such as the type of water user groups, social heterogeneity, poverty, ethnicity, and geography. Nonetheless, the water systems of various villages

evolved differently, with contrasting outcomes. Therefore, it may be that not all variables considered during the selection of the villages are significant in the analysis, while the selected cases are still representative of the transition of the water management regime in Sanandaj county.

However, the manner in which the analysis is approached may bias the outcomes [16,23,33]. Bias can originate from putting too much emphasis on irrelevant actions, ignoring relevant actions or observing spurious relationships [6]. Therefore, an accurate analysis should be based on the knowledge that is produced through experiential and practical observation of the regime changes, by meticulously considering all the involved variables [23]. During the phase of selection of participants for the data collection, two significant challenges presented themselves. The first challenge consisted of recognizing the most suitable experts in the field, especially since the knowledge we were looking for is highly contextual [34]. The second challenge is distinguishing between two types of actors, based on their respective influences on the regime transformation under scrutiny. The first type comprises mainstream actors who are well networked and have the power to influence norms, institutional settings, and modes of regulation that formed the regime at the landscape level by way of lobbying. Second, there are niche actors who have less influence on how actions are organized and are under the influence of the more powerful actors [23]. Therefore, a rigorous selection of the participants is critical, and the group composition should reflect the diversity of valuable knowledge present. In the current research, we consider four types of expert actors [34], based on their particular role, job position, expertise, or publications on the issue under investigation.

1. Government officials: Officials were recruited from the Kurdistan Regional Water Authority, which is the most important governmental body in charge of policies, regulation, and management of Sanandaj's water resources, and from the municipal administration of Sanandaj, the Sanandaj Agricultural Authority, and the Natural Resource Management Authority.
2. Scientists and academics: This group is identified by their academic activity in the fields of ecology or social and policy-related sciences (e.g., economy, sociology or environmental management).
3. Water end-users: The group of end-users includes the rural and urban residents of Sanandaj county and farmers who are directly affected by the results of water management actions.
4. Representatives of non-governmental organizations: This category mainly comprises the members of a few active NGOs in Sanandaj county, such as the Jingaparezan foundation and individual environmental activists, and also a number of consultancy companies that are involved in the water management of the case study (Table 3).

Table 3. Number of stakeholders represented in the discussion group, by stakeholder type.

Stakeholder Type	Discussion Group	Delphi Survey	Focus Group
Government officials	75	14	5
Scientists and academics	15	3	2
Local residents	138	5	3
NGO representatives	22	6	4
Total	250	28	13

3.2.1. Participatory Observation in the Discussion Group

Initially, within the four types of stakeholders, 15 potential actors were invited to take part in an interactive platform based on the Telegram social media application, which is a popular means of communication in Iran. Then, we asked the initial participants to send the online invitation link to other actors with whom they were acquainted and who might contribute to the research. In the end, 250 individual participants took part in the discussion group for approximately 6 months in the course of 2018. This large discussion group was

well-suited as an analytical lens for distinguishing between the different variables of the county's water system and its water management regime.

In this study, a brief guide for the discussion group was prepared, which included details on the water system and the prevailing management regime, listing major open-ended questions, and a list of probes/prompts for each question. In this way, participants were given the opportunity to express their opinions spontaneously. Thus, the answers were not limited to a set of predetermined responses, which could lead to actual, insightful, and even unpredictable statements [32]. The report was drafted on the basis of three sources. First, the group discussions were summarized by the lead author of this paper, compiling what had been learned from the participatory observation within the platform. This was combined with knowledge obtained from fieldwork in the villages in the course of 2015 and with the screening of 10 official documents on water management actions in the case study area. However, for the sake of consistency and validation of the data from the discussion group, a Delphi survey was conducted which included the 28 members of the larger discussion group that accepted to participate.

3.2.2. Delphi Survey: Defining the External Variables of the Water System

In order to encourage potential participants to take part in the Delphi survey, as a repetitive method of surveying experts, we used the report as a basis to formulate four open questions, to which a summary of the previous responses by each participant in the discussion group was added:

D1. What are the core variables of the water system in the eight villages?
D2. In every case village, what changes have occurred in the variables of the water system within the timeframe considered (1962 to 2018)?
D3. Which specific practices or actions, implemented in the management of the water system, are significant for the changes in the case villages within the timeframe considered?
D4. What are the driving factors and the strategic goals behind each action?

This procedure allowed the participants to provide their own input and to explore and complement the diverse topics presented in the group discussions. The list was then sent back to the Delphi panel in order to validate the final list. The primary purpose of this round was to work towards a higher degree of consensus among the responses generated during the first phase. In the next phase, we sent the consolidated list to each participant in order to rank the variables and sub-variables, based on the scale of importance of the variables in their respective categories. In the aggregate, the experts responded to the three rounds of questionnaires, and their responses were aggregated and shared with the group after each round. The consensus obtained for each variable was represented by the mean score of the third round, which measured the extent to which the participants agreed or disagreed with the responses by the other experts from the previous rounds. Participants were invited to respond within 4 weeks.

3.2.3. The Focus Group Survey

In this stage, the remaining 13 experts from the Delphi survey continued to participate in the focus group survey. The result of the survey was presented to the Delphi group for further consideration. Then, we proposed three questions to the focus group participants:

F1. Which actors are involved in the actions taken?
F2. What specific role has each actor fulfilled in the respective action arenas?
F3. Which variables have been added to the system as a result of each action?

After identification by the focus group of the list of most influential actors with respect to each action (F1), we asked the participants to categorize the roles and responsibilities of each identified actor in the action arena of the county. The applied typology of roles was inspired by Knüppe and Pahl-Wostl (2011) [35] and by Ferguson et al. (2013) [36]. When a specific actor, either as an individual or a collective participant, sticks to one of the above-mentioned roles in an action arena, a social space for interaction or an "action-

situation" [16] is formed. The identified action-situations are the regime elements, where actors fulfill certain roles to perform certain actions [3]. In fact, when actors are assigned a role, they start to interact in an action arena, which can be described as sequences or networks of action-situations.

4. Results

We examined the outcomes of each measure based on the evaluation by the Delphi survey and the focus group participants, based on which elements of the water management regime were added or changed (Table 4). As a result of the screening of the D1, a set of 25 variables showed to be significantly important in all eight cases, while within the set, three subsets were identified: (1) Biophysical conditions, (2) attributes of the community, and (3) the rules-in-use [16]. In Table 4, we have sorted the variables in each subset based on the obtained consensus among the experts, which are represented by the mean scores of the third round. For D1/F3, 55 changes in the water system of the cases were endorsed, as reflected by the mean of the scores yielded from the three rounds and presented in Table 3. Then, for D3 and D4, out of an initial set of 12 actions, eight implemented planning actions as an outcome of eight strategic goals (SG), which were deemed significant for the changes in the water system of the case studies, were retained. The remaining four actions were eliminated as they were considered by the participants to be irrelevant to the change of the water management regime (Tables 4 and 5).

Based on the results of the focus group, we distinguish between seven types of actors' roles when it comes to managing common resources. Within this typology, the first type of actor's role is to define strategic goals by assessing the current state of the system from the perspective of the desired end condition. Strategic goals at a landscape level impose restrictions on a regime level, which can facilitate efficiency, provide focus, limit outcomes or impede progress. The role of some actors is to formulate policies, which is the result of an interpretation and refinement of the strategic goals in combination with an assessment of the system. The formulated policies bind other actors to achieve the strategic goals which apply to the entire water system. Some actors develop operational goals, which allow the assessment of efficiency and effectiveness of the implemented actions. In our case study, power actors at the national level, who are outsiders to the regime, consider all three of the above-mentioned types of roles. The provincial administrations are responsible for developing actions based on an assessment of costs and expected effectiveness, e.g., within an environmental impact assessment. County administrations, in turn, are assigned the role of implementing the actions in the field, e.g., by improving infrastructure for rural water provision. They are also capable of monitoring actions to achieve strategic goals. At this stage, the results of monitoring may examine the achievement of the strategic goals set [35].

However, some challenges have been created through the analysis of actors and their roles, including difficulties in terms of accurate identification of action-situations, a relatively blurred understanding of the real roles of each actor, and a lack of transparency in the decision-making processes. For instance, an actor who performs one role in a certain action arena may have a completely different role in another action arena. Therefore, a careful analysis of the roles of actors is needed (Figure 4).

Table 4. The results of D1, D2, and F3.

Type of Variable	D1	Mean Score			D2/F3	
		# 1	# 2	# 3	Before 1964	Currently
Attributes of the community	Scale and timing of evaluation criteria	7.89	9.21	9.32	Yearly environmental assessment	An environmental assessment at the beginning of the project
					Small scale	Large scale
	Knowledge/Social learning	8.71	8.43	8.89	Management as learning from the obtained experience	Management as controlling the environment
					Situated traditional technical knowledge from the observed system by end-users	Involved experts are from the non-users
	Methods of participation	6.86	7.36	7.39	Involving other associations in the search for effective, multi-benefit solutions	Involving other provinces in the search for water supply
					Understanding the impact of cooperation	Overlooking the impact of cooperation
					Broad actor participation	Narrow actor participation
					Collaboration means engagement in decision making	Collaboration means public relations; the public is informed only after a bill was passed
					Awareness of objectives of the system as a whole	There is only a limited knowledge of the local system by the decision makers
					Active participation in making conscious choices	Passive participation in making decisions
	Type of decision makers	7.04	7.50	7.07	Insiders	Outsiders
	Number of end-users	6.14	6.54	6.50	Fewer	More
	Geographical distribution of the end-users	5.75	6.11	5.96	Consistent	Inconsistent
	Typology of end-users	4.93	5.75	5.54	Homogenous/insiders	Heterogeneous/outsiders
	Size of user groups	4.07	4.43	4.75	Small scale user group	User group at the county level
	Water demand	4.54	4.14	4.18	Lower demand per capita	Higher demand per capita
					Real understanding of the amount of water available	Expectation of a sufficient supply of water at all times

Table 4. *Cont.*

Type of Variable	D1	Mean Score			D2/F3	
		# 1	# 2	# 3	Before 1964	Currently
	Dissemination of information	3.82	3.54	3.64	Comprehensive understanding achieved by open, shared information sources that fill gaps and facilitate integration	Understanding is fragmented by gaps
					Open and shared information sources (including linking knowledge and decision making)	Lack of integration of information sources that are proprietary
	Methods of communication	6.25	3	2.75	Face to face communication	Communication by public administration
Rules in use	Scale of governance	4.46	5.57	6.32	Polycentric governance by water associations	Centralized governance
					Local scale	Large scale
					Horizontal and collective actions	Hierarchical and complex
					Predictable pattern	Unpredictable pattern
	Governance goal	6.43	5.82	5.50	Manage demand to deal with unexpected events	Manage supply by controlling the system
					Manage sources of problems	Manage side effects of problems
					A mono-sector analysis identifies emergent problems and integrates policy implementation	Sectors are separately analyzed, which results in policy conflicts and emergent chronic problems
					Economic and environmental efficiency in meeting the demand for water-related services	Maximum security of supply irrespective of economic and environmental costs
	Policy cycle	5.25	4.61	4.54	Facilitating the cycle of policy phases	More focus on strategic goal setting and operational goals
	Boundary of the water system	3.68	4.14	4.25	Sub-basin	Administrative boundary
	Ownership right	4.21	3.86	3.74	Communal property	State and private property
					Well-defined boundary of ownership regime	Blurred boundary of ownership regime
					Local scales of analysis and management	Large scales of analysis and management
	Institutional arrangement	2.25	2.14	1.89	Institutions designed for adaptation to environmental change	Institutions designed to achieve fixed targets
					Integration of institutional arrangements to monitor and control the actions	Disintegration of institutional arrangements to monitor and control the actions

Table 4. *Cont.*

Type of Variable	D1	Mean Score			D2/F3	
		# 1	# 2	# 3	Before 1964	Currently
	Rules	1.71	1.86	1.75	Collective choice rules	Constitutional rule, Government cabinet bill, Ministry bill for operational rules, Parliament bill
Biophysical/ material conditions	Capital	4.71	5.75	6.75	Financial resources diversified from a set of private financial instruments	Financial resources concentrated on structural protection
					Each local commune was responsible for renewing and maintaining their system	The state is responsible for renewing infrastructures
					Consistency between cost/benefit calculus of individual actors and that of all groups	Inconsistency between cost/benefit calculus of individual actors and that of all groups
					Direct payment of costs	Indirect payment of costs via subsidies
					Infiltration runoff to hand-made underground tunnels and pipes, surplus underground water harvested as water supply	Infrastructure built to respond to demands, emergence of inter-basin water transfers
	Typology of infrastructure	3.93	4.96	5.39	More attention to the management of human behavior by "soft" practices besides the infrastructure	Gray infrastructure made of concrete, metal, and plastic
					Measures underground	Measures on ground
	Scale of infrastructure	5.25	4.43	4.39	Small/decentralized, desirable	Larger/centralized, assumed to perform better
					Green infrastructure	Gray infrastructure
	Types of water resource	4.38	4.14	3.96	Springs, rivers, qanats	Dams, wells
					In the region	External
	Characteristics of water resources	5.04	3.71	3.36	Less blue surface	More blue surface
					Lower evaporation due to less exposure of the reserved groundwater to sunlight	Higher evaporation due to more exposure of blue surfaces to sunlight
					Higer groundwater levels	Ground water at a lower level
					Distribution/collection in sub-basin networks is considered	Distribution/collection in inter-basin networks is considered
	Characteristics of land	3.29	3.14	268	Less soil erosion	More soil erosion
					Less land subsidence	More land subsidence
					Strong vegetation	Weak vegetation
	Environmental hazards	1.39	1.86	1.46	Less frequent drought	More frequent drought
					Less frequent flood	More frequent flood

Table 5. The results of the Delphi survey—D3 and D4.

	Before 1962			Since 1962				
D3	Development of the underground infrastructure	formation of the local water associations	Land reform	Institutional reform and setting up public administrations	Qeshlaq dam construction	Granting wells authorization	Azad and Javeh dam construction	Groundwater protection
D4	SG1: Reserve water	SG2: Regulation of the local water provision	SG3: Promoting private/public ownership	SG4: The involvement of the state in water affairs	SG5: Sanandaj water provision	SG6: Agricultural development	SG7: Regional and national water equality	SG8: Recovery and balance of aquifers

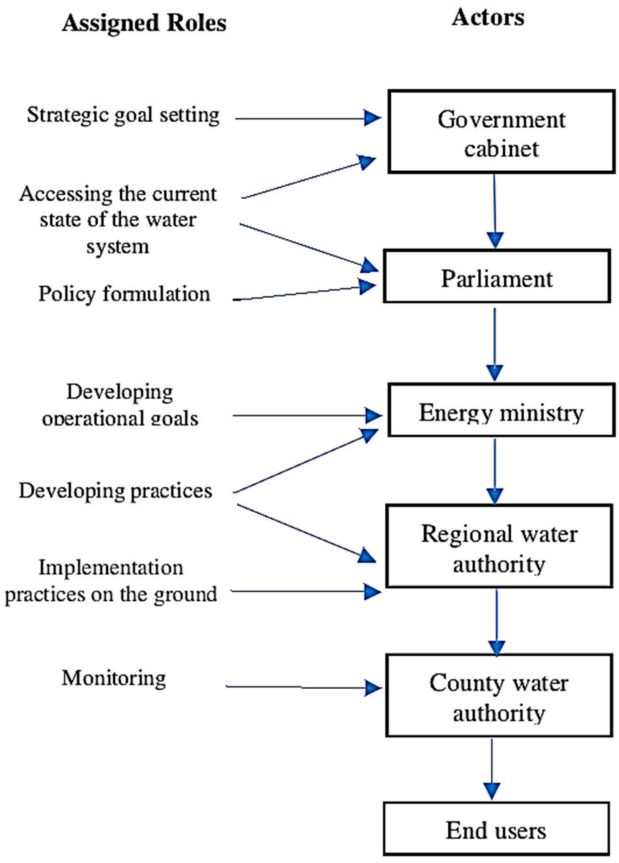

Figure 4. Accessing the current state of the water management of Sanandaj county (F1 and F2).

5. Discussion

The management of water resources in the changing sociotechnical system of the county has been subject to continuous transformation during the timeframe considered. Although we identified eight strategic goals in the action arena of Sanandaj's water management (Table 4), not all of them have the same impact on the regime. Each of them steers the transition in a different direction, while the impact of some of them was not strong enough to initiate persistent changes in the regime. Therefore, we cannot speak of one single transition, but rather of a number of parallel HT, both within the realms of ground water and surface water. In fact, these two types of water resources in the county underwent different transition pathways, stimulated by regime-specific configurations of interests and the goals of the actors involved. In this regard, we distinguish between four

classes of regime transition pathways, in line with the literature, as explained in Section 2. Even though these classes might overlap to some extent, we will discuss them separately in the next four subsections.

5.1. Classification of Management Regime Transitions

5.1.1. Endogenous Renewal: The Mainstreaming of Decentralized Policies and Soft Technologies by Innovation of Niche Actors (SG1 and SG2)

Based on our analysis, before the state entered into water management affairs in 1962, all actions in the action arena of water management, ranging from strategic goal setting to monitoring, were reiterated in an annual feedback loop. Every year, in this phase, a rich variety of local actors including local rulers, local water users, and a whole range of residents participated in water associations in the niche sphere of just a few villages where they managed the water supply by means of qanats (handmade underground tunnels which direct and retain water) and fountains. This management regime was buffered from forces external to the communities, including state powers, and decisions were often taken by those actors involved in the implementation of actions, rule enforcement, and monitoring. Dense social networks relying on frequent face-to-face contact increased the chances of participation, decreased the cost of monitoring behavior, and induced rule compliance. Traditional communities, such as the one in our case study, learned each year from the implementation of their own actions, which allowed them to reflect on their knowledge, to reform their strategic goals, and to reformulate their policies for the next year. In fact, the adapted actions were steered by interests, values, past experiences, existing capabilities, prevailing expectations, and perceptions of competitive threats within the regime. The main outcomes of their annual actions consisted of physical infrastructure improvement, in which consolidated incremental local knowledge and institutional adaptation were incorporated. However, in the long run, the accumulation of small changes in a feedback loop led to a radical transformation of the performance of the regime in terms of efficiency, demand, monitor, etc. Therefore, we will place this type of transition in the "endogenous renewal" category [15,26] since transformations that were coordinated by the members of local water associations were followed by a pathway towards internal adaptation.

5.1.2. Emergent and Unpredictable Transformation: The Entrance of the State into the Water Management Regime (SG4)

In the 1960s, in addition to the co-evolution of technologies for resource deployment and population growth in Iran, the state put into force legislation to achieve the goals of institutional reform and nationalization of natural resources. One of the main strategic goals of the reform in the realm of water resources was to cater for the increasing urban and agricultural water demand through a multilayer legislative structure, which was composed of constitutional mandates and administrative ministerial and provincial regulations. Several public administrations, ranging from the ministerial to the county level, were then created to enable and regulate provisioning, transferring, and monitoring of how water was distributed, which drastically altered the former role of local actors. The change in the state's strategic goals in this phase caused the regime to shift from a cooperative folk management regime to a new and much more centralized form of governance and had a strong influence on the nature of multilateral cooperation, network heterogeneity, social capital, and the flow of information between the actors.

In fact, the actions of the actors involved in the water management regime of the case study have transformed from organized and predictable actions by small numbers of local actors to uncoordinated actions by the public administrations (power actors). In the case study area, since the period of reform, several public administrations dealing with water affairs have been split and merged again on multiple occasions, which has regularly caused confusion regarding the authority and competence of these administrations and their regulations. Similarly, differences in power and goals between the public authorities involved have created internal conflicts on environmental decision-making, which entail

highly adverse effects on the water sector in its entirety. When one administration decides on a pathway for the achievement of a strategic goal, whether it is for social or economic development or to strengthen water shortage resilience, other administrations might encounter missed opportunities and make ambiguous environmental choices. For instance, the participants of the Regional Water Administration asserted that they agreed with the action of water transfers to the neighboring provinces. The participants of the Natural Resource Management, the Sanandaj Agricultural Administration, and the Administration of Environmental Protection of Sanandaj, however, considered inter-basin water diversion unfair and even felt it was the main cause of the drying out of areas downstream of the water reservoirs and the consequent evacuation of the affected rural areas. In this regard, while the total water capacity in the three reservoirs of the county is currently about 800 m^3, the actual volume of the stored water is fluctuating depending on the annual rainfall, which in some drought years is less than half of the reservoirs' capacities [30]. Therefore, the current challenge of management is mainly on prioritizing contrasting goals, which have caused an emergent and unpredictable transformation of interactions, routines, and actions by public administrations not very well acquainted with the problems in the field. It leads to the lack of clear coordination between the public administrations since non-members of the regime do not foster the development of internal adaptive capacities at the county level.

5.1.3. Reorientation of Trajectories: Development of Technical Alternatives to Traditional Infrastructure (SG5)

After the institutional reform, most of the roles, which stretch from developing operational goals to monitoring groundwater extraction in the county, were appointed to the Kurdistan Regional Water Administration. Since private end-users became excluded from water management actions, this unintentionally created a window of opportunity at the niche level for specific private end-users to reap advantages from the altered conditions by invading and bypassing the rules to gain immediate payoffs. They independently started making anonymous decisions on overharvesting of groundwater in their own action arenas (usually their private properties), while the state failed to monitor and control their actions. Although in some stages this public administration supported groundwater withdrawal for promoting agriculture, the high levels of groundwater withdrawal and the consequent environmental impacts had not been widely anticipated by the decision makers. As a result, the number of illegal wells in the county increased to approximately 2000 (identified), in addition to 2700 legal wells [37]. One of the participants described the issue as follows: "Regulations are not very effective when it comes to regulating away people's use of the groundwater" in Sanandaj.

As a consequence, the private end-users in Sanandaj were motivated by the failure of upper levels of government to demonstrate leadership in the realm of groundwater management. The action of the farmers, as private landowners, to dig wells within their own jurisdiction (on their own property), is their way of dealing with the drivers they encounter. Such trajectories were caused by endogenous drivers to the regime, such as the development of both technical and operational characteristics of water extraction and the introduction of new forms of cultivation by the end-users with a higher demand for water or by exogenous drivers, such as changing regulations of the water market after institutional reforms, and obstacles to the use of alternative resources, such as surface water. The conjunction of a series of such drivers in the regime of groundwater management triggered uncoordinated and unpredictable actions, radically driven by internal adaptation by members, relying on the discontinuity of actors, networks, and institutions. Nevertheless, this transition turned out to be a counterproductive reorientation; the recent intention of the Regional Water Administration to focus on internal regime functions in order to reduce groundwater extraction was not successful, partly since monitoring of the uncoordinated actions is poorly articulated and partly due to a lack of consensus on the desired end-user behavior.

5.1.4. Purposive or Goal-Oriented Transition: Increasing the Influence of the National Policy Dynamics on the Local Water Management Regime (SG7)

The uneven distribution of water, population, and industry in Iran caused a mismatch between the regional availability of and demand for water [38]. This made the state change its strategic goals towards a more equal regional water distribution at the national level. Since the mid-1980s, in particular, this was done by means of rigid blueprint plans in which local actors scarcely participated. The main local plans include actions such as dam construction or a scheme for water provision to the end-users that organize the provision of water to the urban area, rather than to the more vulnerable rural areas. In this regard, the main pathway taken by the state actors as outsiders to the existing regime includes coordinated actions to meet the challenge of water demand, in order to control surface water resources by means of physical and technological infrastructures. As a result, the sphere of decision-making changed from a basin-based demarcation to the inter-provincial level, which aimed at achieving the defined strategic goal of regional and national water equality by the state actors.

This transition was a deliberate intention and was pursued from the outset to reflect an explicit set of state expectations on regional water equality. As one of the government officials in the focus group explained, when an action occurs, "there is not much local planning involved". Therefore, the transformation of the management regime of surface water is defined by coordinated actions to reach external adaptation. The main threat caused by this type of transition is that the external decision-makers, particularly those at the higher level, do not sufficiently acknowledge the growing threats at the local level, especially when it comes to social aspects of water shortage. The risk of water shortage is perhaps best perceived by the local government officials, as they are close to the impact of water supply restrictions, even though they are not involved in defining goals and policies. The actions conducted by the state often impose uniform remedies on all kinds of water issues at the national level, while treating all subsystems as open systems without any critical reflection on the equilibrium within ecosystems. All water end-users are treated as a single stock rather than being recognized as distinct populations with different characteristics; the variability of each region is ignored.

In the case study, the main changes of the external and internal variables are rooted in the shift of strategic goals by the state, which are influenced by the driver factors and cause a feedback loop that changes the water resource system (Figure 5). For instance, following the international trade sanctions against Iran, the strategic goal of water management at the national level was changed to promoting agriculture and national food sufficiency by supporting further groundwater withdrawal and legalization of unauthorized wells. Once a shift in strategic goal setting was made and implemented, further changes in order to achieve the goal were initiated, which include the way in which actors get involved, their roles, and the level of governance across temporal and spatial scales. The changes in strategic goal setting also altered opportunities open to different social actors. Therefore, the observed Hybrid Transitions of water management in the case study area can be considered the outcome of a deliberate attempt by the state actors to change the regime in accordance with their strategic goal, which is the provision of water, food, and energy.

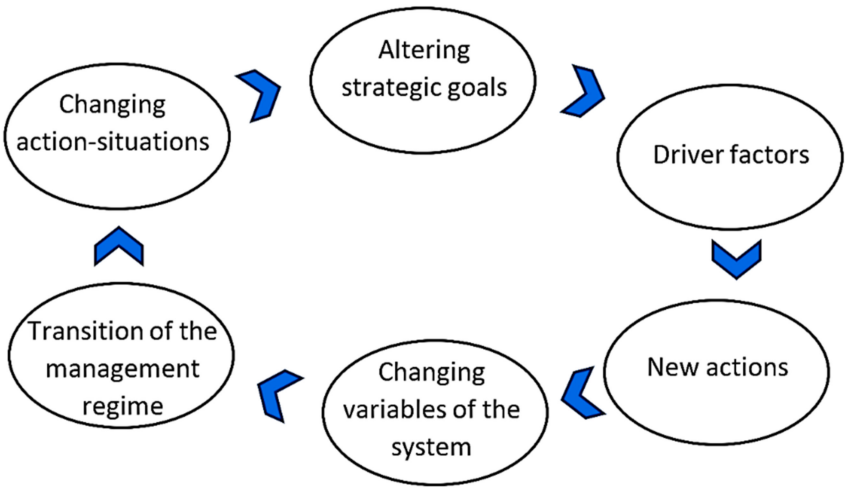

Figure 5. The transition pathway feedback loop of the water management regime of the case study; source: The authors.

5.1.5. Strategic Goals without an Impact on Transition of the Water Management Regime (SG8)

Catastrophic environmental losses, due to overharvesting of groundwater from most of the plains in the country and the county under scrutiny, and drying out rivers and regions downstream of the water reservoirs have over the last decade led to an emerging critical debate within public administrations, academia, and a number of NGOs. All of them criticize the environmental impact of the current water management approach, focusing on the productivity of water control, both at the national and local level. This rise in awareness puts pressure on the state to revise the governance regime by crafting a set of actions that would be better adapted to the current socioecological conditions of each region.

In this regard, new strategic goals have been formulated at the state level to protect the groundwater and to decrease water reservoir construction. For instance, the Regional Water Authorities oblige farmers to install smart water meters on the wells to monitor groundwater harvesting and conduct fine and sanction schemes on those who exceed the set amount of water use. However, implementation of this strategic goal was problematic for two reasons. First, regarding the protection of ground water, it is the state authority that formulates policies and attempts to enforce them, so the resulting top-down rules are not based on a shared opinion between the decision makers and the end-users on the actions which are fair or should be permitted or forbidden. Second, regarding the protection of surface water, and despite the ongoing debates at the state level to refrain from additional water reservoir construction, technical interventions are still the state's preferred actions. Since the body of power actors among public administrations and companies that conduct physical water management constructions has grown so large, it has become almost impossible for the state to bypass them. Furthermore, while hard structures are tangible and visible to the inhabitants, they may inadvertently provide a false sense of security on the water and put those behind them at further risk. Meanwhile, the community expects the municipal officials to protect them from the risk of water shortage. For instance, there is not a strong tendency among farmers to cultivate drought resistant crops in the region, resulting in agricultural water productivity of the region, which is just 30% of the nationwide average.

Although the state lists urban and agricultural water provision at the top of its agenda and is clearly aiming to meet the targets set, there is no clear roadmap for the achievement of the goals of sustainability and adaptability of the water resources or for the integration of local actors in policy discourses and decision-making processes. As indicated by one of the participants of the focus group, "by constructing new dams, we can control larger

amounts of water, so there will be a lower risk of water shortage". This is echoed in a lack of political support for future actions of adaptation, meaning that adaptation remains on a peripheral agenda. As the interviewees asserted in the focus group, decision-makers have gravitated towards a water security policy pathway which focuses on mitigation, by setting the goal of equal distribution and meeting the demand of water, rather than one which prepares for the impacts of water shortage (adaptation). They also asserted that the decision-makers overlook the risks of the implemented actions, and the county does not have the necessary local institutions (plans, policies, etc.) and lacks a collective discourse that could direct county policies to incorporate adaptive strategic planning for water shortages into their agenda. For instance, the latest version of the plan, named the "Sixth National Strategic Plan", based on our review of the document, clearly underestimates the water shortage issue. Furthermore, the pervasiveness of water shortage denial is evident at the national level, as seen in the "Adaptation to Water Shortage National Committee" in 2018, which ultimately makes it difficult to gain political support, acquire a mandate, and fund adaptation efforts.

Drawing on the experiences from Sanandaj county, we found that the transformation of the water management regime at different levels largely left the local end-users out of the decision-making process, and left local authorities without the institutions required to develop coordinated actions and to work towards internal adaptation, which could in turn effectively introduce resilience to water shortage into the community. As confirmed by our findings, part of the deficiencies of water resource management could be attributed to other resource sectors such as food and energy. In this regard, the government should focus on decreasing trade-offs between these sectors, while increasing synergies between them, such as virtual water trading programs, and replacing hydropower plants with other renewable energy sources, plans for domestic rainwater harvesting, agricultural cultivation based on low water-demand plants, and improvement of agricultural irrigation systems.

Based on the results from the research, there is a need to recognize the vulnerability of the current institutional arrangements and actions, to work towards coordinated actions by the members of the regime, to take an adaptive perspective, and to develop multiple solutions, while respecting the human scale and cultural identities. This could be accompanied by a broadening of the political focus and a reduction in the number of missed opportunities currently associated with a path which is largely mitigation-oriented. In this regard, it is essential to look back at the endogenous renewal transition by the dominant decentralized-polycentric actions of the niche actors beyond the market and the state. A polycentric governance system that increases the authority of end-users to devise their own rules could result in processes that allow social norms to evolve, increasing the probability that individuals will manage to solve collective action problems and organize internal adaptation. In this regard, the government's involvement in water management should be limited to defining national strategies and investment budgets and facilitating a learning process to build a solid body of polycentric and networked forms of self-governance.

5.2. Comparing Findings with Similar Studies Worldwide

A large number of studies consider the socio-technical multi-level perspective of transition management in a wide range of sectors such as agriculture, tourism, transportation, energy, and water resources. Most of the studies aim to explore complex processes of socio-technical transition that are geared towards sustainability and take scopes that range from the niche level to landscape level, mainly taking a goal-oriented approach and focusing on the predevelopment phase of the transition [39]. Some studies, such as Voß et al. (2009) [40], emphasize the need for reflexive governance to avoid the pitfalls of an earlier generation of positivistic long-range planning and control approaches. However, empirical applications of the framework have been criticized for being too descriptive and too structural, while downplaying the role of actors in transitions [41]. To address such gaps, several theoretical studies have stressed path creation and have drawn attention to the context of phenomena by focusing on possibilities for managing processes of co-evolution into a more sustainable

direction [14,39,42]. Although our findings with respect to the case study are in line with the transition contexts category, in this paper, we have moved forward in terms of applying the transition framework in practice and unraveled the complex context of transition by considering the role of actors and driving factors.

6. Conclusions

As discussed, under the HT framework, the shift in management regime can be understood as altering the given setting of actions and adaptive capacity in terms of pace, orientation, and involved actors. The study unraveled that the reason for changes is the outcome of a deliberate attempt for change by the state actors, who are clearly geared towards actions of mitigation. The actions taken invariably require costly maintenance and may result in complacency on the availability of water, which would ultimately impede progress towards community resilience. The risk associated with Sanandaj city and the communities of the surrounding county requires anticipatory planning in order to avoid actions resulting in poor outcomes and expensive reactionary maladaptation. Water shortage should be seen as a hazard that should directly be featured in action plans, helping the decision-makers gain a better appreciation of the phenomena's exacerbating effect on already existing environmental risks.

To highlight the main policy implication of the findings, the development of the HT framework helps frame appropriate questions on regime transformation processes and pathways in a series of consecutive, varying governance arrangements for each type of water resource. In practice, the developed framework supports water resource managers by presenting the impact of their decisions on different aspects of the water resource sector. In this way, the findings could be important for policy, practice, and transition theories and subsequent research that should inform future interventions in the socioecological system. The application of the framework at the case study allowed presenting a coherent and cumulative understanding of the water management regime transition and the impact of changing and implication of widespread strategic goal setting on the water system. Therefore, the results of this research could open discussions on policy alternatives, increase public awareness on the outcomes of each action in a pro-active manner, and trigger a feedback loop of entering new variables into the system. Future empirical and theoretical research needs to ask which possible changes in the contextual variables of the system can transform the current management regime into a more adaptive variant, and could focus on developing scenarios for water management in 2040, to provide insights to the decision-makers.

We emphasize that there is a need to improve communication between the research community and the decision-makers to enhance the understanding of the management process through a systemic perspective that links ecological, social, economic, technical, cultural, and other aspects of the local water system in an enhanced fashion. In this regard, future research could focus on developing scenarios for the future of water management in 2040, to provide insights to the managers on where they want the organization to be in years, and to understand the contribution of regime shifts to the changes of landscape level.

The main policy implications of our finding are that first, understanding of the management process through a systemic perspective is enhanced; second, the transition of the management is a rather discontinuous and long-term process with alternative policies and actions which are under the pressure of the major strategic goals; third, when a strategic goal comes into practice, it could have various implications in different parts of a resource system.

Author Contributions: Conceptualization, N.K.; methodology, N.K., K.B., and H.A.; validation, N.K. and K.B.; formal analysis, N.K., K.B., and H.A.; investigation, N.K. and K.B.; writing—original draft preparation, N.K., K.B., and H.A.; writing—review and editing, N.K., K.B., and H.A.; supervision, K.B. and H.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: We thank the local participants from Sanandaj county who provided their insight and expertise from which the research benefited.

Conflicts of Interest: The authors declare no conflict of interest.

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