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Governing The Water Conservation in The Urmia Lake Basin: Addressing Macro Systems' Fit and Micro Users' Behavior

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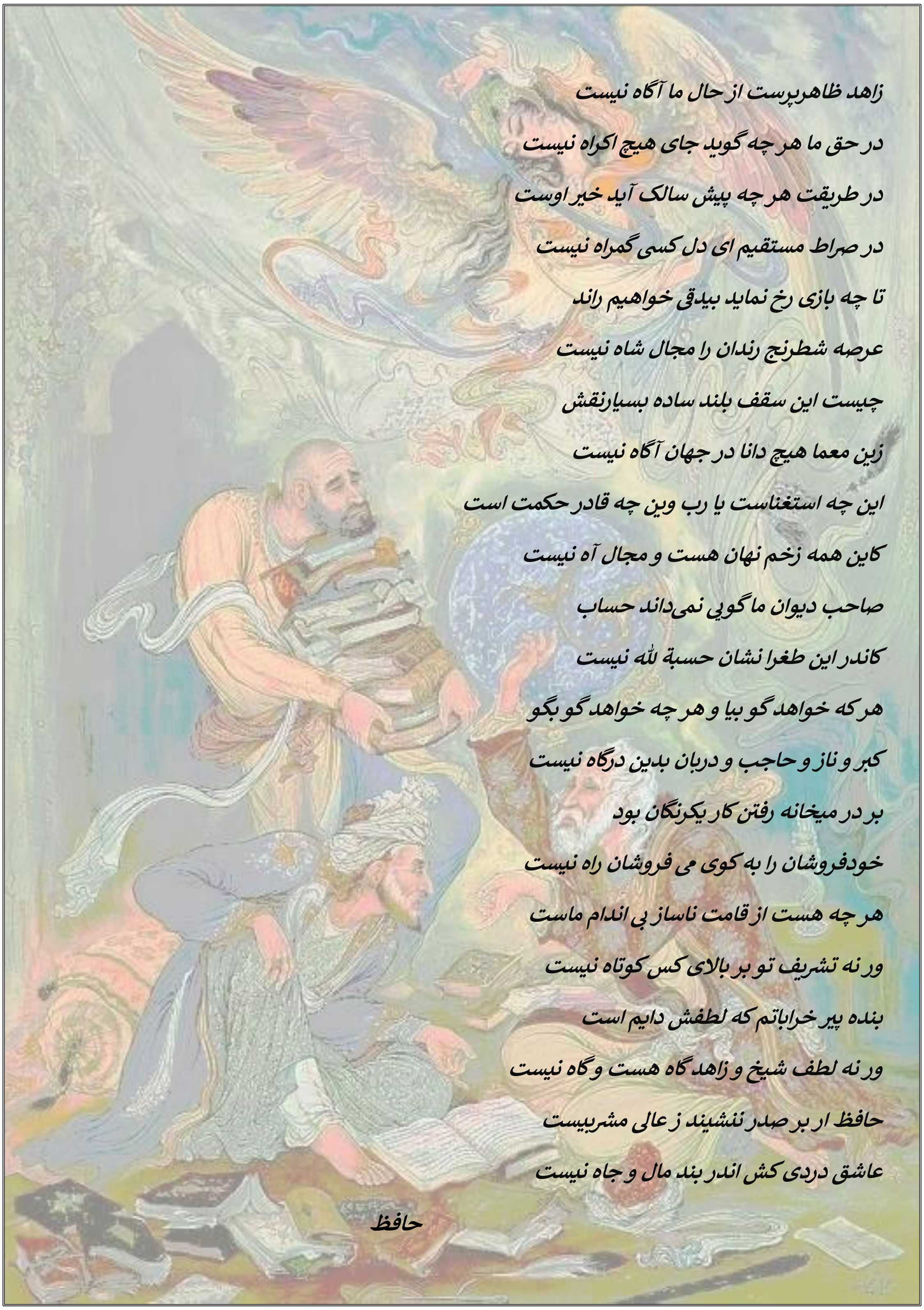
Esame finale anno 2023

To the consciousness, earth, water and air;

Urmia Lake;

my family;

all circumstances directed me to this research!



زاهد ظاهرپرست از حال ما آگاه نیست
در حق ما هر چه گوید جای هیچ اکراه نیست
در طریقت هر چه پیش سالک آید خیر اوست
در صراط مستقیم ای دل کسی گمراه نیست
تا چه بازی رخ نماید بیدقی خواهیم راند
عرصه شطرنج رندان را مجال شاه نیست
چیست این سقف بلند ساده بسیارنقش
زین معما هیچ دانا در جهان آگاه نیست
این چه استغناست یا رب وین چه قادر حکمت است
کاین همه زخم نهان هست و مجال آه نیست
صاحب دیوان ما گویی نمی‌داند حساب
کاندر این طغرا نشان حسبة لله نیست
هر که خواهد گو بیا و هر چه خواهد گو بگو
کبر و ناز و حاجب و دربان بدین درگاه نیست
بر در میخانه رفتن کار یکرنگان بود
خودفروشان را به کوی می فروشان راه نیست
هر چه هست از قامت ناساز بی اندام ماست
ور نه تشریف تو بر بالای کس کوتاه نیست
بنده پیر خراباتم که لطفش دایم است
ور نه لطف شیخ و زاهد گاه هست و گاه نیست
حافظ ار بر صدر ننشیند ز عالی مشربیست
عاشق دردی کش اندر بند مال و جاه نیست

حافظ

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List of Acronyms and Abbreviations

AC: Awareness of Consequences
AR: Ascription of Responsibility
CC: Climate Change
CFA: Confirmatory Factor Analysis
EOE: Expression of Emotions
FAO: Food and Agriculture Organization of the United Nations
HBM: Health Belief Model
IIASA: International Institute for Applied Systems Analysis
IT: Institutional Trust
MFM: Mean Field Model
MOE: Ministry of Energy (Iran)
NAM: Norm Activation Model
OECD: Organization for Economic Co-operation and Development
PAF: Place Affect
PAT: Place Attachment
PDE: Place Dependence
PID: Place Identity
PMT: Protection Motivation Theory
PN: Personal Norms
PS: Perceived Severity
PV: Perceived Vulnerability
RC: Response Cost
RE: Response Efficacy
SE: Self-Efficacy
SEM: Structural Equation Modeling
SEU: Subjective Expected Utility (Theory)
TPB: Theory of Planned Behavior
TRA: Theory of Reasoned Action
UL: Urmia Lake
ULB: Urmia Lake Basin
ZALF: Leibniz-Centre for Agricultural Landscape Research

Abstract

To change unadapted water governing systems, and water users' traditional conducts in line with climate change, understanding of systems' structures and users' behaviors is necessary. To this aim, comprehensive and pragmatic research was designed and implemented in the Urmia Lake Basin where due to the severe droughts, and human-made influences, especially through the agricultural development, the lake has been shrunken drastically. To analyze the water governance and conservation issues in the basin, an innovative framework was developed based on mathematical physics concepts and pro-environmental behavior theories. Accordingly, in system level (macro/meso), the problem of fit of the early-shaped water governing system associating with the function of "political-security" and "political-economic" factors in the basin was identified through mean-field models. Furthermore, the effect of a "political-environmental" factor, the Urmia Lake Restoration Program (ULRP), on reforming the system structure and hence its fit was assessed. The analysis results revealed that by revising the provincial boundaries (horizontal alternation) for the entity of Kurdistan province to permit that interact with the headquarter of West Azerbaijan province for its water demand-supply initiatives, the system fit can increase. Also, the constitution of the ULRP (vertical arrangement) not only could increase the structural fit of the water governing system to the basin, but also significantly could enhance the system fit through its water-saving policy. Besides, in individual level (micro), the governing factors of water conservation behavior of the major users/farmers were identified through rational and moral socio-psychological models. In rational approach, incorporating PMT and TPB, the SEM results demonstrated that "Perceived Vulnerability", "Self-Efficacy", "Response Efficacy", "Response Cost", "Subjective Norms" and "Institutional Trust" significantly affect the water-saving intention/behavior. Likewise, NAM based analysis as a moral approach, uncovered the significant effects of "Awareness of Consequences", "Appraisal of Responsibility", "Personal Norms" as well as "Place Attachment" and "Emotions" on water-saving intention.

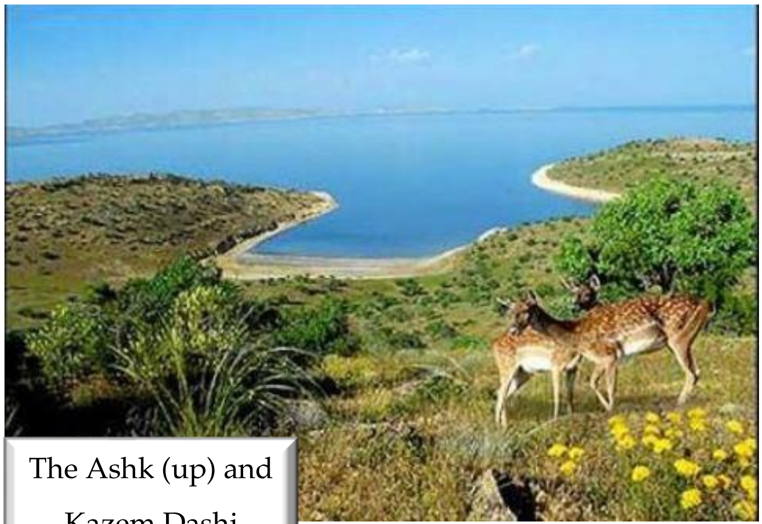
Summary

Climate change (CC) has greatly altered the state of water resources during the recent decades. Specifically, in (semi)arid regions the droughts and water scarcity have become more significant. This issue has triggered the perception of consistent adaptations in many water-stressed regions. Water conservation is associated with its governance. Humans and their crafted systems governing the water affect it in line with their requirements and objectives. These objectives commonly are shaped by the security, political, social, economic and other goals of territorial governance systems. Such objectives might not have met essentially the environmental needs subsequent to climate change. Therefore, understanding the (aged/unadapted) water governing system structures in relation to their (ex-)objectives can help identify the water conservation governance issues in dry regions. To this end, Iran was selected as a (semi)arid area where water resources and water bodies have critically been influenced by both human and climate change. Correspondingly, the Urmia Lake Basin in northwest Iran was focused as the case study of this research. To identify the water governance and conservation challenges in the basin, a specific approach was tailored. In this scope, comprehending the territorial development and political-security objectives, the water (demand/supply) governing system structure was appraised in the basin. To do so, besides the Urmia Lake Basin as the spatial scale level of the study, a temporal scale level was adopted based on the latest official national level report(s) of the basin. Benchmarking spatiotemporal scale levels, the political-administrative system structure for water demand-supply was identified in respect to the interacting entities based on the administrative-jurisdictional rules for interaction. Thereupon, the problems of fit arising from the mismatch between the human-designed water governing system and hydrological system (the Urmia Lake Basin) were detected. To this aim, a new framework was developed–by means of statistical mechanics approach in presence of Hamiltonian cost–which gauged the system fit based on the system cost. As a matter of fact, besides the natural factors such as CC effects and the water resources availability, the political-economic factors such as agricultural development plan have affected the water allocation and demand/supply volumes (J) in the basin. In addition, the provincial/jurisdictional divisions and the administrative-jurisdictional interaction rules form the water demand-supply interaction configuration (αm), including the number of entities (i). Therefore, governing the water demand-supply system is associated with a (Hamiltonian) cost interlinking to the joint function of the abstract of external forces (h) and interaction forces ($\alpha J m$) in relation to such factors. This cost, which is the yield of the sum of the individual costs of entities in association with their politically/administratively permitted interactions for water

demand/supply, is a measure of the governing system structure fit to the basin. In the fitter system structures, the overall/system cost of such permitted interactions becomes smaller than the unfit system structures' cost. The outputs of this study relevant to macro/meso level, calculatedly revealed how a reform in horizontal and vertical dimensions of the governing system structure can lead to the variation of system fit and cost. To this end, based on the case context, neglecting the provincial boundaries in the region for the entity of Kurdistan province and changing the interaction rules for that entity to let it interact with the headquarter of the West Azerbaijan province, the system cost was reduced. This reduction reflected the better fit of the concepted structure to the basin. Furthermore, in vertical/institutional dimension, the inclusion of the ULRP entities associated with their interactions with the headquarters (provincial entities), led to system cost diminishing. This endowment was particularly significant when a 40% water demand-supply reduction in the agricultural sector was assumed based on the ULRP policy. Hence, such vertical (re)arrangement in the system structure also could result in the fitter water (demand-supply) governing system to the basin. Accordingly, the more the governing system fit the less its cost. After scanning the problems of fit associating with the macro/meso level factors and system(s) behavior in the basin, the water conservation issues in micro level were investigated through the pro-environmental behavior theories. In this scope, the governing factors of water conservation intention and behavior were assessed in the major water consuming community. The agricultural sector, as the major consumer of water in the basin, considerably affects Urmia Lake and water resources. Hence, incorporating appropriate socio-psychological models, the water and environmental conservation behavior of the farmers was investigated. Considering the contextual circumstances, Urmia Lake drying up consequences, and local data, two main streams were followed in this regard. First, relevant to a rational approach, the water conservation intention of the farmers was evaluated by means of Protection Motivation Theory (PMT) and the Theory of Planned Behavior (TPB). The PMT analysis results revealed that the "Perceived Vulnerability" (PV), "Self-Efficacy" (SE), "Response Efficacy" (RE) and "Response Cost" (RC) are the significant determinant factors of water-saving intention in the original model. However, within the extended model, the "Institutional Trust" (IT) also contributed to the combination of the significant factors. Besides, the TPB analysis results also implicitly endorsed the effect of PMT variables and added the "Subjective Norms" (SN) to their combination as a determinant of water-saving intention/behavior. Second, as a moral method, the Norm Activation Model (NAM) was used to recognize the altruistic determinants of water conservation intention and behavior in the farmers' community. The results of this assessment reflected the eventual significant effect of the interplay of "Awareness of Consequences" (AC), "Appraisal of Responsibility" (AR), "Personal

Norms” (PN) as the original model constructs, together with “Place Attachment” (PA) and “Emotions” factors as the extended variables, on water-saving intention and behavior. The outputs of this research measurably, traceably and immediately uncovered that within the basin, at macro level, the political-security and political-economic factors have influenced the fit of the water governing system structure, thus its behavior, through formulating the interaction set up (m, α) encompassing the range of entities (i) and governing the water volumes (J) in line with their objectives. Withal, the recent environmental development program, the ULRP, as a political-environmental factor affects these variables in a balancing way by reforming the system structure and decreasing the interaction rates $(\alpha J m)$ in obedience to its objectives. Also at micro level, the above-mentioned individual level identified factors were addressed as a set of major variables governing the individual water conservation behaviors. These exogenous factors can also influence the water demand/supply amounts (J) and hence the system level interactions rates $(\alpha J m)$ and cost. An efficient water conservation governance in the basin needs the consideration of both macro/meso and micro level factors orienting them to fit pro-environmental behaviors. The outcome of this research can place an evidence-based source of information to design tailored-made policies and strategies for water and environmental conservation and governance in line with adaptation to climate change.

Chapter 1



The Ashk (up) and Kazem Dashi (down) Islands, Urmia Lake

1 Introduction

1.1 The issue of water governance in the fast-changing world

Water is a common pool resource. It is utilized for various purposes. The trend of water usage has started increasing since 1900 (Gleick, 2000). This fact became prodigious after 2000 which hit the extent of around sevenfold more freshwater withdrawals comparing to the beginning of the century (Rulli et al., 2013). The water demand rise associated with population growth initiated seeding tensions and conflicts for its exploitation since the late 20th century (e.g. Gleick, 1993; Eckstein, 2009). Nevertheless, extreme water conflicts exclusively exacerbated from 1990s (Dinko, 2022). On the other hand, due to the dramatic rise in magnitude and rate of the human imprint in nature since around 1950, the Climate Change (CC) impacts began to be sensed and addressed frequently during the last decades (Steffen et al., 2015). The issue has been reported as the influencer of water resources by many scholars (e.g. Arnell, 1999; Vorosmarty et al., 2000; Blöschl and Montanari, 2010; Ceola et al., 2016; Papalexiou and Montanari, 2019; Anaraki et al., 2021). Particularly, during the recent two/three decades, CC affected water resources has been increased globally (e.g. Gosling and Arnell, 2016; Pokhrel et al., 2021). As a whole, the water demand growth in one side and the alternation of water resources on the other side have complicated the management of water resources and challenged their governing systems (e.g. Cooley et al., 2014; Romano and Akhmouch, 2019).

Governance, perceivable as the course of governing systems' function, prehends the regulatory processes and their interaction in line with particular objectives' achievements (Baumgartner and Pahl-Wostl, 2013). Extending this denotation, the water governance embraces a set of social, economic, political and administrative systems developing and managing water resources as well as water services according to the requirements of the societies (Rogers and Hall, 2003). Generally, creating such systems encompasses policy framing, standard setting, resources mobilization, allocation, and coordination etc. (Conca, 2005). The importance of water governance became overt when the water and environmental crisis evidenced recurringly (Woodhouse and Muller, 2017). Recently, the problems of governance have been stressed as the major hurdle in water resources management. In this domain, At the World Water Forum in the year 2000 (The Hague, Netherlands), the Global Water Partnership (GWP) Framework for Action (GWP, 2000) argued that "*the water crisis is often a crisis of governance*" (Hall, 2003). Even more, according to the United Nations' World Water Development Report 2 (2006), over the last two decades, the growing crisis in water resources has been defined by many as being largely a problem of governance. Likewise, FAO, 2017 outlined that "*a sustainable and reliable management and use of water particularly in countries where overall demand is outstripping supply, is as much about water governance, power relations and resolving conflicts of water tenure as it is about understanding and monitoring what is going on between the rain clouds and the water users*".

Although there are strong emphasizes on the seriousness of water governance, their regimes still struggle to employ suitable steering models (Wiek and Larson, 2012). In spite of international efforts initiated in 1977 at Mar del Plata through UN water conference and further developments through new institutions to compose global norms of governance, based on the 1992 "Dublin Principles", still there are debates about how water governance could and should respond to the challenges of sustainable development (Woodhouse and Muller, 2017). According to OECD (2015a and 2015b), the diversity of circumstances in water access and use makes it to hardly define a single coherent policy for its governance. Similarly, Woodhouse and Muller (2017) argued that a single conceptual framework for the study of human-water systems has yet to be identified.

The scope of water governance has been manifested by several definitions. For instance, in OECD's "water governance initiative" (2015), the water governance is defined as the "*range of political, institutional and administrative rules, practices and processes (formal and informal) through which decisions are taken and implemented, stakeholders can articulate their interests and have their concerns considered, and decision makers are held accountable for water management*" (Woodhouse and Muller, 2017). Or Jiménez et al. (2020) outlined: *"Water governance is a combination of functions, performed with certain attributes, to achieve one or more desired outcomes, all shaped by the values and aspirations of individuals and organizations"*. Even so, Gumeta-Gómez et al. (2021) express water governance *"as a set of interactions used to make decisions among different stakeholders and institutions with common objectives to manage water resources"*. Indeed, as distinguishable, while the majority of these arguments try to place a thorough meaning for the dimension of water governance, yet there is not existing the same agreed definition (Tortajada, 2010). Such discrepancy in perceiving the water governance substance or its practical meaning is interconnected with the context where the water has been governed (Özerol et al., 2018). In this chamber, the term water governance can be appraised differently in disparate countries/states (Woodhouse and Muller, 2017). **Although the water governance definitions are fluctuating, in common they share the apprehension of the**

concept with emphasis on a sort of interactions (e.g. performed functions) and their evoking exogenous factors (e.g. political, institutional and administrative rules and practices).

Another aspect is the complexity of water governance whenever constitutes a multilevel structure. A complex system is a non-linear interactive system which can possess a revamping substance if is able to adapt to the changing environment. Such an environment is interwind by biophysical, political, social, economic and other determinants (Pahl-Wostl, 2009). In such systems, different entities interact in respect to sovereign rules of interaction (Ostrom, 2005). As a matter of fact, water governance arena is perceivable through the actors, activities and a specific environment of interaction which is formatted by a set of pertinent rules. The interactions within such context happen to satisfy the exclusively determined objectives. Therefore, the design of objectives is key to lead the water governing systems in a stipulated stream. An alternation in objectives can embark changes in the structure of such systems. This resembles a reform in line with requirements of newly (re)set goals. Verily, the behavior of a system is associated with its objectives. Thus, the variation in system objective can induce changes in system behavior. Such changes can be commenced by transformations in vertical (e.g. institutional) and/or horizontal (e.g. geographical) dimensions of the water governance body. This can nevertheless occur by acts in various levels of institutional, spatial and other relevant scales. Correspondingly, the presence of multiple levels is associated with the complexity that is embedded in each level and their cumulative function to achieve the given objective(s).

Typically, the early shaped water governing systems which haven't seen deliberately the effects of CC during the years of their confiscation, may confront with recently emerged environmental complications within their territories. Generally, there, based on the contemporary conditions a force majeure object of water and environmental conservation can emerge. Such an issue can trigger an evolution within the water governing system formations. This matter has been pinpointed in the scope of adaptive governance (Huitema et al., 2009) in which elements of governing systems adapt in association with the gain of experience by altering their rules, structure and, hence, behavior (Pahl-Wostl, 2009). The inclusion of environmental priorities within the objectives of governing systems has imported a distinct consideration on water governance significance. Thereupon, the problems arising from ineffective governance of a natural resource as water is distinguished as contentious (Simms et al., 2016). To this end, the so-called "problems of fit" between administrative and biophysical systems has been concerned by many researchers (e.g. Gibson et al., 2000; Young, 2002; Rogers and Hall, 2003; Cash et al., 2006). In water governance, the problems of fit arise from the unfit of institutional/administrative scales to the hydrological ones (Gupta and Pahl-Wostl, 2013). This issue results in inefficiencies and spillovers in spatial scales (Moss and Newig, 2010). To solve such problems, new formal institutions are commenced in many countries customizing the hydrological principles within legislations (Pahl-Wostl et al., 2023). However, overcoming the problems of fit is still in need of innovative solutions (Pahl-Wostl, 2009).

Other possible issues in water governance as a socio-environmental context, can be uncertainties, ethical complexities, and policy crux regarding societal values etc. (Funtowicz and Ravetz, 1994). Uncertainties may not only connect to precision and accuracy in data, but also there could be epistemic uncertainties relevant to the functioning of a given system (Funtowicz and Ravetz, 1994; Di Baldassarre et al., 2016), besides there may exist an ambiguity distinguishable through presence of multiple valid and, at the same time, conflicting ways of framing a problem (Brugnach and Ingram, 2012). Commonly, epistemic uncertainties and ambiguity could be intertwined with debates about the real problem identification and framing in political arenas between actors with disparate interests (e.g. Mukhtarov and Gerlak, 2014; Cabello et al., 2018).

In fact, the water governance issues cannot be pinpointed and answered through one lens. A multidisciplinary lens is required to realize the main meaning of the problem which is displayed through various screens of exogenous actors contributing from different sectors to problem definition. The associated methodology can get to grips with the entities, rules and legislations, institutions, communities, policies, and tackle biophysical, social, political and economic circumstances. Pondering this vision among players and policy makers, water governance scope should not hang on more in scene of contestation between developmental and environmental goals and in contrast both should be kept jointly in the loop (Woodhouse and Muller, 2017).

Hence, the concepts involving in water governance concerns can be summarized as: i) scales/levels issues associated with territorial context in line with political-administrative structuring of the governing systems as well as spatial-jurisdictional partitioning of the areas. ii) Governing systems' objectives (e.g. development or environmental) and iii) the matter of uncertainties as well as the certainties. Dealing with such a complex system, it is required developing deliberated analysis devices to overcome its intricacy.

Prominently, water governance is critical in countries where overall water demand is outstripping supply (Batchelor et al., 2016). Accordingly, the water demand dimension is well noticed in water governance realm. This aspect in water governance reveals the importance of water demand management which is interlinked to the water consumption management, responsible water usage, and water conservation. Hence, the water governance substance is twisted with the function of water users in addition to the system level performances (e.g. institutional; administrative). This scope mainly tackles the individual level consumptions which take place based on users' attributes. Therefore, the water governance feature encompasses the top-down arrangements by systems and bottom-up (re)actions by users on (availed) water influencing its conservation. This means that within the world where the water resources have been stressed by the population growth and CC, both systems' and individuals' impacts on water have to be seriously considered for water governance.

1.2 Water governance and the concern of its conservation in Iran as a water-scarce territory

Within the (semi)arid regions, specifically during the last three decades CC has adversely affected the water resources states (Yu et al., 2019). To this end, the prolonged droughts have influenced the availability of water resources in many of those areas (Vicente-Serrano et al., 2020). Eventually, the joint product of water demand increase and water availability decline have started challenging the water management and governance in such territories (e.g. Falkenmark et al., 1989; Ragab and Prudhomme, 2002; Silva et al., 2021).

Relevantly, in Iran, the droughts have been reported as dramatically intensive in recent years (e.g. Ghamghami and Irannejad, 2019; Sharafati et al., 2020). Besides, the increase of population has reached by around two times since 1980 (Hosseini et al., 2019). The population rise is associated with water demand increase and the intensification of droughts can lead to less water availability. These contingencies have triggered significant water problems in such a (semi)arid region (Madani, 2014). Thereupon, since the last decade, the government has started developing more focused programs on water and environmental issues (Zebardast et al., 2021). This movement recognized as the realization of water governance as a key concern in the body of the regime (Hu et al., 2021).

Undoubtedly, there is a close relationship between the physical flow of water and the socioeconomic flow of humans (Daniell and Barreteau, 2014). This matter highlights the water's candidacy as a potential factor in the political-spatial segmentation of regions. Overlooking this issue can lead to complications in territorial governance (e.g. Brown and Shucksmith, 2017; Suárez-Gómez et al., 2021). To this end, Iran's country partitioning basis backs to the years 1937-8 (Etaat and Nikzad, 2016). Based on the contemporary circumstances, the country divisions were tailored with major attention to security terms (Etaat, and Nikzad, 2016). On the other hand, by coming into force the fifth development plan of the country during 1970s (at the time of previous political regime), the expansion of agriculture was slightly initiated (e.g. Afshar, 1985; Nabavi, 2017). Hence, the demand for water started increasing. This trend was particularly promoted during 1990s due to the policies of the contemporary government which boosted the water consumption considerably. The circumstance based on such trend, led to consumption of 97 and 124 (based on the selected scenario) bcm water in the years 2000 and 2021 (Ardakanian, 2005). This scale wasn't envisaged deservingly in horizontal (spatial) and vertical (institutional/administrative) provisions of the governance model (Saatsaz, 2020).

This issue revealed the inconsideration of the dimension of water as a distinct objective in forming the structure of the governing system within certain water basins of the country (Ketabchy, 2021). Thereupon, water management was considered a secondary issue to be handled within the provincial subsystems of the governing body. Therefore, while water demand increased due to the rise in population and agricultural practices in diverse regions of the country (Keyhanpour et al., 2021), water management struggled to receive the required level of institutional-jurisdictional reforms. This issue was further exacerbated by CC loads and gave rise to uneven water and environmental problems during recent years in many parts of Iran (Madani, 2014).

Indeed, the founded governance mechanisms satisfying the dominant objective of (military) security (Etaat, and Nikzad, 2016) with politically fed essences in 1930s might not be able to consider the forthcoming climatic issues deliberately. Thus, the legatees of those preliminary systems needed to do appropriate reforms and modifications according to the concurrent circumstances. Nevertheless, such overhaul should be set timely, knowingly and rigorously to be efficient enough in improving water governing systems and conserving water resources. In this scope, although after the Iranian revolution in 1979, some goals like food self-sufficiency (McLachlan, 1986) were followed particularly beside the security objectives, water and environmental conservation didn't receive their required attention until the catastrophes got visible (Khosravi et al., 2019). So, corresponding to the over-shown of water-linked environmental disasters, the water governing system tried to revamp the (water and environmental) management mechanisms (e.g. Salimi et al., 2019; Hamidi et al., 2021). However, such implements have not been reported as efficient in the majority of Iranian regions (e.g. Madani, 2014; Nabavi, 2017). Conceivably, if such developments were incorporated timely and appropriately, their impacts may become more efficient.

In Iran, the Ministry of Energy (MOE) was established in 1975. This ministry has been founded to handle the water and power initiatives in the country (Nabavi, 2017). To this aim, MOE assigned as the responsible organization for licensing of water developments along with other tasks associated with water and wastewater, electricity or other sources of power. Explicitly, after the revolution (1979), the new regime ceased the development policies followed by the former one for around a decade. To this end, after the regime change, the political discourses and ideology for leading the country were extremely altered. This substitution intruded the duality of "development and social justice" instead of "modernity and preservation" which was articulated and persuaded during the previous constitution of the country in years 1966 -1979 (Nabavi, 2017). As a consequence, the new constitution tried to pull out the emphasizes on western urbanization and industrialization and aid rural areas' development manifesting the term justice with this provision. Such inclination was further flamed by the plan of the privatization of the development during 1989-1997 which was facilitated by the International Monetary Fund and the World Bank subsequent to the end of the war with the neighbor country, Iraq (Hoogland, 2009). Thereupon, harnessing water for agricultural plans became a central in the contemporary government's administration and agricultural practices were expanded significantly. This issue backfired dramatic water and environmental problems when coincided with the severe droughts (Madani et al., 2016). Therefore, although the mechanism of water governance technically should be steered by the MOE in respect to water and environmental sustainability, due to the political-ideological effects, its navigation distracted from the sustainable path. This matter not only can be associated with the absence or even presence of interfering rules, regulations, legislations etc. (Nabavi, 2017) but also, is relevant to their degree of enforcement for execution.

Another aspect is the distribution of power and authority to the executive arms of the MOE—such as regional water, and water and wastewater companies—grounded by the jurisdictional boundaries. In this domain, based on the law which came into force in 2005 as 'Water Independence of Provinces' the communication among water authorities took up a new form (Islamic Parliament Research Center of the Islamic Republic of Iran, 2005). Upon this law, the regional companies were transformed as independent provincial firms. This shift in water governance form was placed by the devolution of power from a regional level to a provincial level administration. Nevertheless, the overarching power for authorization of comprehensive studies in the basins and inter-basin water transfer or water allocations to different sectors and setting water resource development policies etc. still retained by the MOE. In light of this alternation, the local utilities within distinct cities or townships of the provinces were incorporated to set the provincial entities' programs and services.

While all water management instruments were sourced from the MOE, the Ministry of Agricultural due to its equal institutional rank in the body of government, has remarkably influenced the water governance course in Iran. As mentioned, this matter was transparently revealed in 1990s when the country president tried to boost the water resources development for agricultural growth. This fact was tuned by the political-economic objectives which helped him earn the nickname of "commander of construction" (Povey, 2015) in the period of presidency. Thus, since both ministries (Energy and Agriculture) were under the same president's direction, water governance could be predominantly led to attainment of the haphazardly planed developmental (agricultural) goals rather than satisfying the conservational (environmental) requirements. Like as MOE, the ministry of Agriculture has had its provincial organizations as well as their local entities in various cities of Iran implementing its plans. Hence, in general the local users' service in different sectors is carried out by the local utilities of various sectors. These sectors majorly include the Drinking, Industrial and Agricultural contexts.

Institutionally, the provincial organizations resemble the headquarters of the local entities. They are the focal authorities within different provinces of the country that manage the water demand-supply initiatives in the level of their affiliated province. Upon the above-mentioned circumstance (Water Independence of Provinces), the local entities of each sector can only interact with their relevant provincial organization for water requirements, and not with the other entities. As a matter of fact, the political-spatial partitioning of the country determines the provincial borders by means of jurisdictional-administrative boundaries. Such segmentation is essentially designed according to the security-political-economic objectives to govern the country. Hence, the water catchments and basins which are furnished on natural-geographical scales can be contested over the local/provincial competitions, contradictions, conflicts and so on. On that account, the water governance constitution faced with controversial challenges in many parts of the country (Madani et al., 2016). To solve such problems either the institutional (vertical) or the spatial (horizontal) reforms, moreover their combination are necessary (Moss, 2003).

As mentioned in the former section, the water governance encompasses the systems and individual behaviors to serve water for a diverse range of uses. Thereupon, although the role of governmental systems is key, the acts of individual users is also radical. To conserve water, both the systems and individuals' function shall align in a way that reasonably can save the water. Whereas this fact is outlined by experts (Nigussie et al., 2018), its practical occurrence is reported as hardly possible in Iran (Rahimi-Feyzabad et al., 2022). Indeed, diverse factors contribute to this issue. While recent public implements try to reduce water consumption through their programs and strategies, the users' water (and environmental) preservation cognition and intention role play greatly in conserving water. This matter has been clearly indicated by Yazdanpanah et al. (2015) that the success of top-down plans and policies to protect the water and environment is associated with the acts of the individual water consumers. Therefore, another fold of water governance in the water scarce territory of Iran is to persuade the users to accompany the conservation strategies helping the water and natural systems' survival. This affair mirrors the orientation of bottom-up behaviors in line with the top-down performances. Notwithstanding, in Iran the agricultural sector is the major consumer of freshwater resources. Accordingly, in the individual level associated with this sector, farmers' role is determinant on the progress of water governance and conservation plans. However, the majority of agricultural practices and farming is operated by the traditional and old methods (Karami, 2006). Such methods often are not able to satisfy the water-saving targets, besides, due to socioeconomic circumstance, commonly, it is not easy to convince farmers to change their farming and irrigation systems to less water consuming ones. Thereupon, in Iran not only because of the political-spatial partitioning of the regions with administrative-jurisdictional independencies, the water catchments have strived to get their attentive management, but also with cursory expansion of agricultural practices and water resources development for them, it is challenging to reduce water consumption in agricultural sector and convince farmers to save water.

1.3 Urmia Lake Basin (ULB) in Iran as the focused area of the study

Among the six major Iranian basins (FAO, 2008), the Urmia Lake Basin (ULB) in northwest Iran (coordinates 35° 40′-38° 30′ N; 44° 07′-47° 53′ E) was selected as a befitting region for the purpose of this study where besides the CC effects, human-caused water and environmental problems have been reported frequently (e.g. Karami, 2018; Amini, 2019; Schmidt et al., 2021).

Urmia Lake (UL)—the world's second largest hypersaline lake before its shrinkage (Figure 1.3.1)—is an endorheic lake in northwest Iran. The lake is a UNESCO protected biosphere and a recognized wetland in the Ramsar convention (Nhu et al., 2020). It has been a safe breeding refuge of migratory birds such as Flamingos and White Pelicans (Eimanifar and Mohebbi, 2007). Furthermore, some endangered species such as the Iranian yellow deer have been habituated in its main islands (Asem et al., 2014). Also, it constitutes a particular environment for the living of various bacterial species, halophilic phytoplankton, or the brine shrimp *Artemia urmiana* (Asem et al., 2014), despite its quite high natural salinity of 140-280 gL^{-1} (Karbassi et al., 2010; Sharifi et al., 2018). However, due to its tremendous volume loss during the recent decades which has caused the rise of salinity to more than 300 gL^{-1} , the lake ecosystems have been adversely affected (Eimanifar and Mohebbi, 2007).

The area of that in its largest extent has been reported 5000-6000 sq.km with an average depth of 5-6 m (Sabbagh-Yazdi et al., 2020). The body of UL with its neighboring plains within the altitude of around 1280-2000 m amsl, covers almost 35% of the total basin area (Jalili et al. 2012).

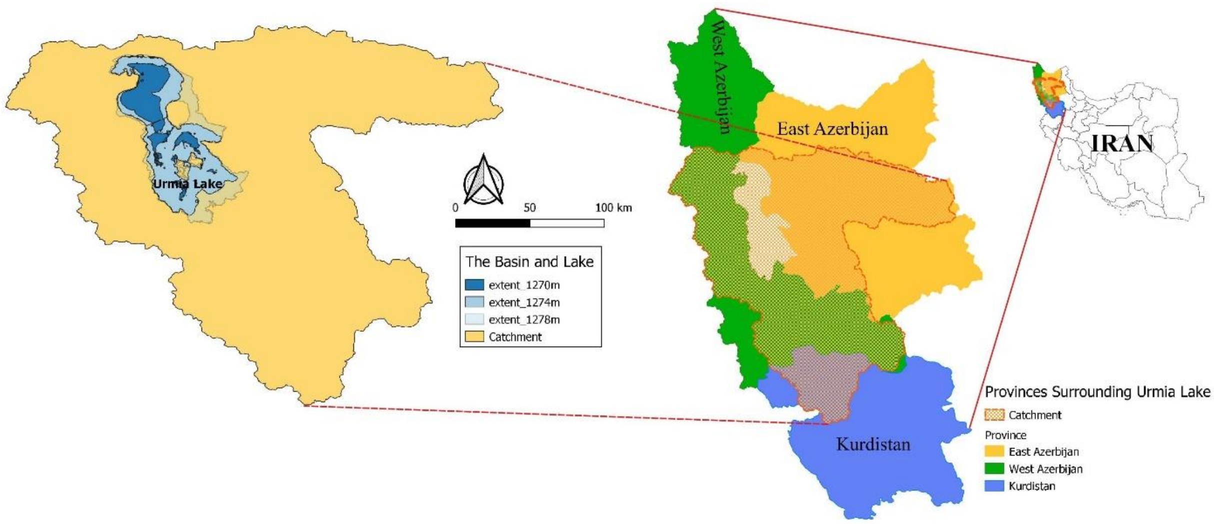


Figure 1.3.1 Urmia Lake and its basin

The area of UL basin is 52000 sq.km with around 6.5 million inhabitants (Bakhshianlamouki et al., 2020). The ULB is surrounded by mountainous terrain which the maximum elevations in the west, south, and east of the lake are respectively around 3608, 3332, and 3850 m amsl (Jalili et al. 2012).

The region is classified as Mediterranean pluviseasonal–continental climatic category with the mean annual winter temperature of quasi-below -10 °C and summers of around 40 °C temperature (Sharifi et al., 2018). UL has had a moderating role on alleviating the temperature extremes in the area (Delju et al., 2013). There, the mean annual air temperature and mean annual precipitation for around the recent 30 years (1988-2017) have been reported as 11.4 °C and 339 mm (Mirgol et al., 2021). Furthermore, the evapotranspiration from lake surface is about 900-1170 mm/y (Nikraftar et al., 2021). And, generally within the basin, the annual potential evaporation varies from 1050 mm in the northeast to 1550 mm in the southwest parts (MOE, 2012). In that geography, July is recognized as the warmest and January as the coldest months. Also, in the region the period of November to April/May accounts for the wet and humid period. Nevertheless, in general, from May to October precipitation is rare (Pengra, 2012).

The economy and income in the ULB mainly rely on agricultural and industrial sectors (Fazel et al., 2018). Alongside, the agricultural sector is the largest user of water which consumes around 95% of the total available water in the basin (MOE, 2013c). Following that, the Drinking and Industrial sectors with around 5% and 1% occupying the 2nd and 3rd ranks in water consumption (MOE, 2013c). Based on the political-jurisdictional partitioning of the region in 1958 (Chehabi, 1997)–subsequent to the partitioning in the year 1937-8–the basin is surrounded by the three East and West Azerbaijan and Kurdistan provinces (Figure 1.3.1).

As mentioned, in addition to the years 1966-1979 when the previous political regime tried to push the modernization and developmental approach which also gave rise to the agricultural practices, the significant development of reservoirs capacity and irrigation area was followed during 1990s. This endeavor coupled with the CC impacts and flamed adverse effects in the region such as the dramatic shrinkage of Urmia Lake (e.g. Shadkam, 2017; Ženko and Menga, 2019; Schmidt et al., 2021; Pouladi et al., 2021). Upon those circumstances, the lake experienced a sharp decline between the years 1995-2003 which was accompanied by a rather stable/convincing period around the year 2005 (2003-2007) and again got a fast-shrinking trend from 2008 due to the severe droughts (e.g. Danesh-Yazdi and Ataie-Ashtiani, 2019; Hosseini-Moghari et al., 2020; Sabbagh-Yazdi et al., 2020).

1.4 Environmental disaster of Urmia Lake vanishing

The lands of the ULB have been exploited for agricultural and animal husbandry courses for millenniums (Azizi and Rezalou, 2020). Indeed, socioecological systems tremendously rely on balancing mechanisms of their systems' dynamism. However, in developing areas, there is a controversial debate on how to balance the environmental and development needs (Dixon and Carrie, 2016). In such contexts, a sharp and early phase problem like financial supply for daily necessities can be more visible/influential than late coming consequences of environmental disasters. Relevantly in the ULB, the agricultural sector demands a large amount of water which creates an intervention for the Lake shrinkage. Nevertheless, eventually this issue affects the region adversely in a due time.

Based on studies, the diminishment of the lake will have significant effects on social, economic, health and environmental dimensions within the region (Schmidt et al., 2021). As an environmental disaster, Urmia Lake drying up prevails hot summers and dry winters (Delju et al., 2013). Furthermore, this issue rises the danger of saline dust extension with noticeable impacts on the health and livelihoods of inhabitants in the region (e.g. Maleki et al., 2018; Samadi et al., 2019, 2020; Dehghani et al., 2020; Mohammadi Hamidi et al., 2021; Feizizadeh et al., 2022). To this end, diseases such as cardiovascular, skin, and/or respiratory have already been addressed (Mohammadi et al., 2019). Even more, decline of soil quality for farming and livestock disease are also reported (Feizizadeh et al., 2021). In fact, such issues can also have side effects as escalation of immigration; workless/unemployed people; health/land treatment costs and so on, besides reduction of income; hope and living standards, etc. As a summary, 17 environmental consequences of UL water fluctuation have already been addressed as: increased temperature; extinction of wildlife; flood; changing the cultivation pattern; reducing pasture area; dust storm; soil and water salinity; groundwater decline and depletion; air pollution; plant species extinction; drought; destruction of surrounding agricultural lands; incidence of different types of diseases (respiratory, skin diseases, and various cancers); the food chain problems; disruption in ecosystem structure of the lake; desertification; decreased livability in surrounding cities (Hamidi et al., 2021). Among them decreased livability in surrounding cities was argued as the most dependent, and groundwater decline and depletion were outlined as the most significant and effective environmental consequences in the system (Hamidi et al., 2021). Furthermore, four of them: reducing pasture area, soil and water salinity, groundwater decline and depletion, and destruction of surrounding agricultural lands were stressed as driving factors which reveal a controlling role in the environmental changes in the region and any small change in these variables leads to fundamental changes in the entire system (Hamidi et al., 2021). Therefore, the survival of the lake is critical, and otherwise, the direct and indirect effects of its drying will threaten a population of 6.5 million in the area (Bakhshianlamouki et al., 2020). Thus, due to such disastrous consequences, it has been crucial to figure out appropriate solutions for mitigation of environmental complications as well as the local communities' support.

This alarming circumstance enforced Iran's government to provision a specific program for restoration of the lake (Saemian et al., 2020). To this aim, empowered by the Urmia Lake Restoration National Committee (ULRNC), an executive tool which was entitled the Urmia Lake Restoration Program (ULRP) started its mission since the year 2013 to support conservation of the lake (Salimi et al., 2019).

To manage the lake revival under facilitation of ULRP, the national and international organizations started to implement the provisioned restoration plans. For instance, the United Nations Development Program (UNDP) supported the introduction of the integrated and participatory ecosystem-based approaches for conservation of the lake. This program was systemized through the development and implementation of the wetlands integrated management plans through the Conservation of Iranian Wetlands Project (CIWP). Also, FAO through the fund of the Government of Japan and the mechanism of ULRP, introduced viable solutions for improving the farming practices and reducing agricultural water consumption (FAO. 2020).

Although, the proposed strategies have tried to overhaul the lake status, yet the lake is struggling to survive, and its fate can be determined by the interplay of global (CC) and regional factors (water governance and conservation).

1.5 Research objectives and methodologies

Recently the impact of CC on water resources and rise of environmental issues have pushed deeply the quintessence of CC adaptation and objective of conservation in the body of water governance. Whereas the fact is significant, its practical inclusion in the governance is controversial. To insert such a crucial but on the other hand tendentious goal among the previously commandeered targets particularly within aged governing regimes, a huge effort in political-institutional as well as individual levels is required. This alternation in objectives which tackles the environmental needs should be cared in both top-down (organizational) and bottom-up (individual) attempts to be sailed toward the tributary of success. Perceivably, **these ventures are intertwined with behaviors of systems (interlinked to their structures) and individuals (interlinked to their cognition) in line with their objectives/goals.**

To this end, not only the governmental instruments and regulations shall be adapted concerning the conservation plans but also the accompaniment of the users regarding such plans has to be greatly aroused. Upon this subject, the research tried to investigate the enterprise of both governmental systems and individual users in reviving UL. In this scope, the research objective encompassed the two folds associated with the administrative/institutional as well as individual entities. Correspondingly, relevant to the administrative/institutional domain, the fit of the water governing system structure to the ULB was assessed. Furthermore, in terms of individual acts, the governing factors of water conservation behavior among users within the major water consuming sector were identified. Through this approach, at macro/meso level, the structure of the contemporary governing system was modeled based on an innovative framework and it was compared with other system structures in relation to the horizontal and vertical reforms. Also, at micro level, the intention and behavior of the farmers (the major users of water) for water-saving in the ULB—as a requisite of UL restoration—was evaluated by means of environmental psychology models.

More specifically, in system level, to evaluate the fit of the structure of governing system (human-designed) to the hydrological system (natural) an inventive methodology was developed. In this domain, incorporating the Mathematical physics concepts, a specific framework was developed and used to detect the problems of fit in the basin. The methodology benefited from statistical mechanics approaches and in particular the mean-filed models to formulate a multipartite system of a water interactive-based societal case. Thus, through Hamiltonian formulation of water demand-supply governing system in the basin, the systems cost per its structure was estimated.

Such cost is a theoretical extent associated with the effect of various factors (external forces) and administrative/institutional interactions for operating water demand-supply process in the basin. Correspondingly, calculating the cost rates per the contemporary and feasible structures of the governing system based on the circumstances of the region, the comparison of cost fluctuations in association with different system forms was fulfilled and the results were discussed. Besides, in individual level, encountering the health, environmental, socioeconomic and other threats in the region due to the UL's condition, the methodology made use of pro-environmental behavior theories to assess the farmers' cognition and intention for taking up the water saving measures. This phase has been carried out by means of Protection Motivation Theory, Theory of Planned Behavior and Norm Activation Model to distinguish the determinates of farmers' water usage care and their intention to support conservation of the lake.

1.6 Thesis Outline

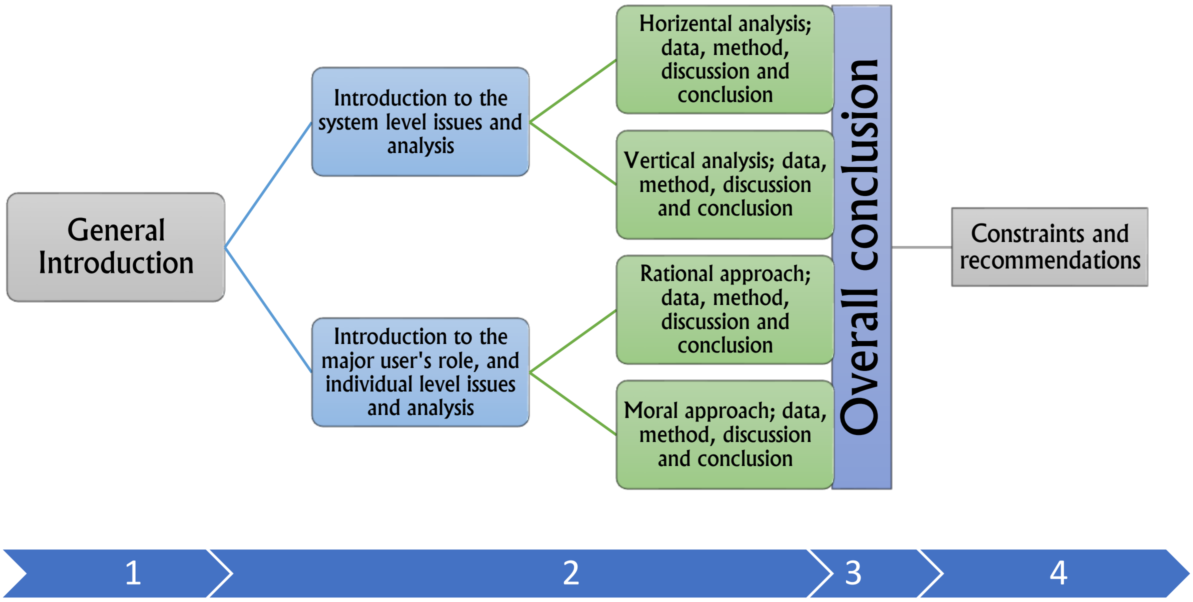
This Thesis reporting comprises four chapters as below:

Chapter 1 (i.e., the current one) includes a general introduction regarding the issue of water governance and conservation from global sight to local, case study region, environmental problems in the region and research objectives and methodologies.

Chapter 2 explains the research approach(s), data, the applied framework(s), and the analysis tools for investigating the problems and factors influencing water governance and conservation in the region. This chapter also discusses the conducted analyses results and discloses their related conclusions.

Chapter 3 summarizes the outputs of each approach and concludes the outcomes integratively.

Chapter 4 describes the constraints and releases the relevant recommendations.



Chapter 2

2 Analysis of water governance and conservation challenges in the ULB

2.1 Introduction

Nationally, the ULB is situated among three provinces where the issues of water quantity and quality have been addressed (Nabavi, 2017b). Furthermore, the region is occupied by different ethnics with various religions such as Turkic ethnic groups (e.g. Azerbaijanis), Kurdish, Persians, Assyrians, Armenians etc. which have diverse religions as Islam (Shia and Sunni), Christianity (Protestantism, Catholic, Orthodox and etc.), Judaism and others (e.g. Zoroastrian). Such diversity is associated with a range of beliefs and behaviors which may try to work on the governance of the region. On the other hand, internationally, the ULB is located close to the borders of Azerbaijan, Armenia, Turkey and Iraq which are dealing with various political, economic as well as environmental and natural resources issues. Hence, geopolitically the region is controversial and there are ongoing tensions around the basin. Thereupon, during the previous and current political constitutions in Iran the strategies has been to arrange the mechanisms for controlling the region under the rules of the central government. Hence, instituting obedience with the central government's rules and regulations has been the 1st priority in the level of public organizations. This circumstance has caused the dominancy of political and security terms for governing system of the region (Etaat and Nikzad, 2016). Hence, since the early phases of political-jurisdictional partitioning of the region during the 1930s and 1950s or later on 1980s and recent years, the pillars of such segmentation were founded majorly on political-security (military), besides economic and social objectives (Etaat and Nikzad, 2016; Nabavi, 2017). While political-security controls steadily have been present in such territory, the environmental threats and water stress stated their significance during the recent years (Hamidi et al., 2021). Upon the conflicts and problems exacerbation in the area which was connected with the UL's desperate state, the anxiety of facing with relating protests and oppositions was increased within the government's body. Thus, the water and environmental preservation rhetoric was diffused veritably within the security agenda of the region and could open a space for its presence among the privileged objectives of the governing regime. Although this modification could deliver some programs and projects to revive the lake, timewise, these implements were incorporated rather late when the severe decline of the lake had already been occurred (e.g. Alipour and Olya, 2015; Alizadeh-Choobari et al., 2016). Moreover, the practical support of the users in the major water consuming sector (agricultural) was inactive. Consequently, the outcome of such provisions has not been distinguished as efficient enough in restoring the lake (Danesh-Yazdi and Ataie-Ashtiani, 2019).

In addition to the consequences of the imprudence of the governing system in foreseeing of water and environmental complications particularly since 1990s respective to the huge expansion of agricultural practices and irrigated lands in presence of droughts, there are other influential factors that contribute to the state of water governance and conservation within the region. However, the roots of such factors are embedded within the attributes of the context where UL is positioned. To describe the water governance and conservation challenges in the ULB, I categorize the issue into two main levels. The basis of this classification is interlinked to the concepts of "determinacy" and "indeterminacy". Accordingly, the first level tackles the (political-administrative) system issues in line with the central government's main strategy which tries to implement a restrictive control on governing system's dynamism through the vertical and horizontal (re)arrangements. In this domain, the government's provisions aim to push the systemic (administrative/organizational) interactions toward the realm of determinacy. By means of this tactic, the government plans to safeguard the system's motion to achieve its objectives within the determined stream. Nevertheless, even though this scheme may well work as a top-down approach in a particular period of time, its success couldn't be guaranteed constantly unless a well consent bottom-up approach of the users be aligned with that (Alipour and Olya, 2015). Therefore, even if the objective of water and environmental protection is appropriately set out in the system level, its accomplishment is interconnected with the cooperation of the private entities and the individuals who use water. Hence, the second level get into grips with the individuals' actions and accompaniment of water and environmental conservation plans which sways in the realm of indeterminacy. Consequently, to arouse the indeterministic (re)actions toward a consent intention for following the water/environmental conservation programs, understanding the governing factors of users' (here farmers') water conservation behavior is essential. This declares the significance of micro level users' role in leading the water conservation and its governance to the arena of victory. Concludingly, both macro/meso level systems and micro level users jointly determine the water and environmental preservation accomplishment. Thereupon, both should be studied and analyzed for understanding the water conservation governance.

As a matter of fact, institutional workings are designed based on specific rules to deliver certain services by means of **structured interactions** (Ostrom, 2005). Therefore, such a situation is mainly affected by the presence or even absence of rules structuring the situation. **Rules are used**

for shaping the relationships among actors and they can be considered as the set of instructions incorporating in a particular environment to create an action situation for the given services (Ostrom, 2005). In the ULB as a politicized situation (Ketabchy, 2021) for water management, the major aim of water governance is to control and administer the water demand-supply service in a satisfactory range. This aims to prevent the probable oppositional movements against Iran’s government and constitution if users do not receive their expected/needed water. Thereupon, the basically politicized institutional-administrative rules for water demand-supply frame the routs for organizational interactions to deliver the water demand-supply service in a certain way. Such rules which are shaping the eligible administrative contacts among water governing (sub)systems inducing from the particular environment where the political constitution of the country with its dominant (ideological) objectives is grown. Thus, in such systems exogenous factors (e.g. security; economic; cultural) associated with system objectives resemble the external forces influencing the administrative interactions for water demand and supply. Indeed, system structure can vary in relation to system objectives manifesting changes in system behavior. If the objectives do not concern the biophysical requirements within a natural system, they can lead to unfit of the human-crafted system to the natural one (Moss and Newig, 2010). This fact is recognized as a certain challenge in water governance studies (Cash et al., 2006). The so-called problems of fit which is debated in the course of water governance, communicate the importance of the efficient designation of human-created systems to conserve the natural systems (Rogers and Hall, 2003). Relevantly, the ULB as a hydrological system requires a match institutional system for its administration. To investigate if the structure of the institutional-administrative mechanism for fulfilling the water service in the basin fits that, the structure of the water demand-supply governing system in the ULB is assessed based on the horizontal and vertical alternations. To this end, the horizontal alternations are associated with the spatial-political partitioning of the basin, and vertical modifications are relevant to inclusion of the environmental objective of Urmia Lake Restoration which deployed the vertical institutional rearrangements in governing system for water resources management. To realize which system structure fits better to the basin, the contemporary and feasible forms of the water (demand-supply) governing system was formulated through the mean-filed models in presence of Hamiltonian formula (section 2.2.1.4). Through this development, the behavior of the system could be distinguished based on the aim of the lower cost per given system forms. Comparing the costs per different system forms, the more fit structure of the governing system to the basin was appraised. In fact, the system structures producing less costs displayed more fit to the basin. Identifying the more fit structure(s) to the basin in respect to the region's circumstances, the recommendations for governing system adaptation to the basin were indicated.

Furthermore, in micro level associated with agricultural sector's users that consume the majority of available freshwater in the basin, the pro-environmental theories were incorporated for assessing the cognition of farmers about the water and environmental problems and their intention to adapt to water and environmental saving strategies.

To this aim, both rational and moral assessments were conducted (Valizadeh et al., 2018). In this chamber, in rational approach, encountering the environmental disaster of UL devastation which is associated with the rise of health, socioeconomic and other issues, the Protection Motivation Theory was utilized to distinguish the factors which influence the farmers' water-saving behavior (Keshavarz and Karami, 2016). Beside this rational socio-psychological model, due to the altruistic sentiments of humankind which are interlinked to their environment of living, emotions and place attachment, the Norm Activation Model was incorporated to evaluate if the moral factors can affect the water-saving intention of those farmers in spite of possible financial/economic complications for them (Savari et al., 2021).

As an outcome, in this research the investigation of the water governance and conservation in the ULB was set about the two main levels and through the specific evaluation tools based on their contexts as:

1. Macro/Meso: assessing the fit of the water (demand-supply) governing system (man-made) to the ULB as a hydrological/natural system according to the horizontal and vertical provisions.
2. Micro: investigating the governing factors of water conservation intention/behavior within the farmers' community based on the rational and moral factors.

2.2 Macro/Meso level issue: the structural fit of the governing system

According to administrative regulations associated with the political-jurisdictional segmentation of the region, the authority of water demand and supply in each province is exclusively pertinent within its jurisdictional boundaries.

In this scope, the local utilities in different areas of distinct provinces try to service the water needs of various sectors in their jurisdictional districts. To manage the water demand-supply initiatives, there, particular provincial level administrative mechanisms have been assigned resembling the headquarters of local entities. These focal organizations are positioned within the capital of each province. On that account, there are three disparate headquarters associated with the Drinking, Industrial and Agricultural sectors which manage the water demand-supply in their sectors via the coordination with Regional Water Company of the province. Based on administrative-jurisdictional rules and regulations, the local entities in a province, could almost never request water from each other or the entities of other provinces. Thereupon, in each sector, the interaction for water demand-supply has been eligible only between a local entity and its relevant headquarter in a certain province.

On the other hand, the quiddity of Urmia Lake Basin is a hydrological system and naturally water flows there based on biophysical rules. This issue should be deliberately considered in forming the water governing system in the region because the inconsideration of the biophysical necessities of the basin could produce environmental consequences. To this end, Moss and Newig (2010) have argued that due to the mismatch between a human-developed institutional system and a hydrological system, spatial spillovers and institutional inefficiencies can raise. Thus, understanding the fit of the administrative structure of water governing system to the basin which deals with the water service initiatives was recognized as essential. Upon this issue, the research tried to explore the structural fit of the water demand-supply administrative system to the ULB.

As a matter of fact, till this research for identifying and resolving the problems of fit, the majority of the proposed solutions have utilized the supranational environmental legislations (e.g. Moss, 2003 and 2012) or national and local institutional resources (e.g. Thiel and Egerton, 2011; Herrfahrdt-Pähle, 2014; Hack, 2015) in their courses of analysis. Although, the methodologies have been beneficial in recognizing the problems of fit in relevant scales/levels, they were not able to show several system states in one window placing the basis of comparison for detecting the most suitable system structure based on the status quo. The advantage of this methodology is to let the analyzer and decision-maker simultaneously and immediately capture the more fit system structure. Indeed, this asset sources from the possibility of the formulation of the system structure further with the measurable rate (cost) as the output of this formulation. To the best of my knowledge this is for the first time the appraisal of problems of fit in water governing systems has been investigated by means of statistical mechanics approaches.

2.2.1 Detecting horizontal fit problems

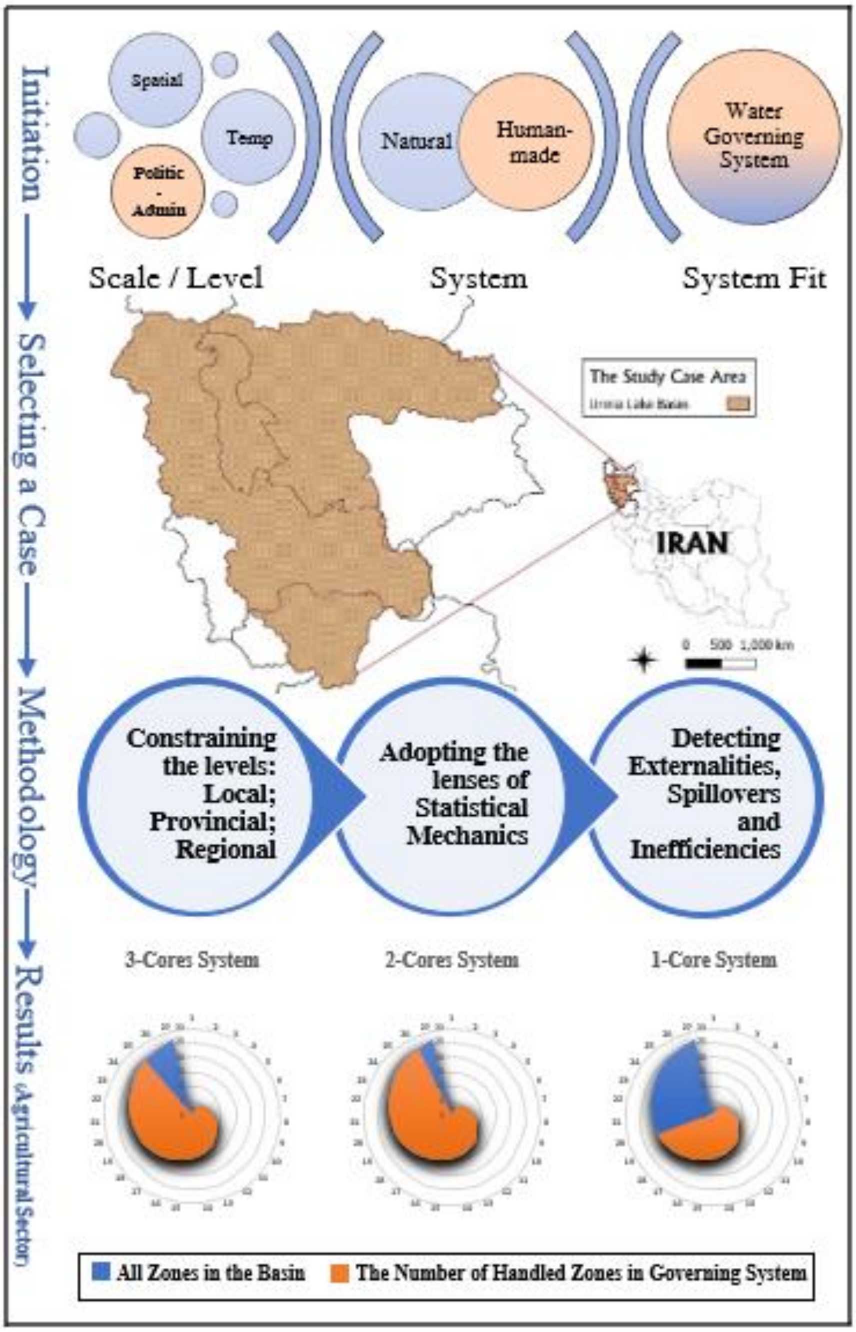
The sections 2.2.1.1-8 were published as:

Peyman Arjomandi A., Seyedalireza Seyedi, Ehsan Nabavi, Saeid Alikhani, **Exploring Water Governing System Fit Through a Statistical Mechanics Approach**, Water Research, Volume 215, 2022,118272, ISSN 0043-1354, https://doi.org/10.1016/j.watres.2022.118272.

Abstract

Water governing systems are twisted with complex interplays among levels and scales which embody their structures. Typically, the mismatch between human-generated and natural systems produces externalities and inefficiencies reflectable in spatial scales. The largely known problem of fit in water governance is investigated to detect the issues of fit between administrative/institutional scales and the hydrological one in a lake basin. To implement the idea, constraining the level of analysis interlinked to the concentrated levels of administration in spatial scales, the fit of the governing system was analyzed by means of statistical mechanics. Modeling the structure of water demand/supply governing system in a given region through the Curie-Weiss Mean Field approximation, the system cost in relation to its structure and fit was appraised and compared with two other conceptual structures in the Urmia Lake Basin in Iran. The methodology articulated an analysis framework for exploring the effectiveness of the formulated water demand/supply governing system and its fit to the relevant hydrological system. The findings of this study may help develop strategies to encourage adaptations, rescaling/reforms for effective watershed management.

For consistency with other parts of the thesis, within the sections 2.2.1.2-8, please consider the zones as the local utilities/entities and cores as the headquarters of local utilities



2.2.1.1 Introduction

Management of water resources and water governance confront with the challenge of inherent scales and levels playing an intricate role in their scope of steer. Due to the diversity of parameters affecting the water governing systems, the hydrological knowhow solely is not able to satisfy their proper formulation, and to increase the effectiveness of their mechanism the incorporation of knowledge of different disciplines is imperative. To address the complexity in such systems there is a need to pinpoint the scale and cross-scale dynamics (Cash et al., 2006).

Some authors (e.g. Gibson et al., 2000; Cash et al., 2006) have defined these scales as the spatial, temporal, jurisdictional, institutional, and other dimensions which are used to study or measure relevant phenomenon in their domain. Besides, levels communicate the units of analysis within the scope of scales. Also, authors have used the term scale when a graduated range of extent is dealt with, and levels are notified as non-continuous classes in the realm of scales (Daniell and Barreteau, 2014). For instance, time frames related to durations as days, months or years can be considered as levels of a temporal scale, or an administrative scale can encompass local, provincial, regional, national levels and so on. Although in categorial scope, scales are independent, they are combinable with each other. This aspect is well noted regarding the spatial and administrative scales where conventionally can be found both together. Such endowment is usual because various spatial levels are associated to jurisdictions respective to their administration levels.

According to Cash et al. (2006), a society may tackle with three common challenges within the scale's arena. The first one stems of scales/levels interactions which may fail to be recognized. The second one arises from mismatches between the scales of human-adjusted and natural systems, and the third, is generated by the heterogeneous values that disparate actors may assign to different scales/levels. Indeed, all the challenges are awkward. However, the second challenge is debated by many authors in socio-ecological and water governance subjects which can result in spatial externalities and inefficiencies (e.g. Young, 2002; Folke et al., 2007; Moss and Newig, 2010).

Water as a natural element with flowable characteristics in spatial scales has been under tenure tensions since millenniums. The physical flow of water has a tight relationship with political, economic, social and human flows (for more info please see Daniell and Barreteau, 2014). Therefore, hydrological (spatial) scales such as catchments, basins and so on, commonly face governance conflicts. Tackling with competing scales, typically the structure of water governance is determined by the political, economic, and administrative systems (Rogers and Hall, 2003). Majorly, in this area, water demand-supply and allocation plans are considered based on the need of users rather than the natural availability of water resource. Therefore, the system of governance is influenced by decisions at political/institutional scales and at the same time affects the flows of water and watershed scales. This issue generally creates conflicts due to misfits between the biophysical and human-tailored systems (Young, 2006). Since, conventionally, decisions are substantially oriented by the dominancy of human-determined objectives in comparison to environmental requirements, it leads to unfit of such administrative-political systems to hydrological basins.

The question may arise here is that how to tailor a more compatible water governance system in a given basin. In other words, how to design a more effective administrative/institutional system for a watershed management. Answering such question is controversial and deals with large complexity. It needs involvement of the opinions and achievements of many disciplines and deals with various dimensions. However, some arrangements can help observing the externalities or mismatches in focused levels of governing systems that can lead to diagnosing symptoms at relevant spatial/administrative scales and improving their structure. In line with that, constraining the levels of analysis, a particular lens should be adopted suitable to follow the relevant flows in certain levels of contributing scales (Gibson et al., 2000).

To detect the problems of fit, a deliberate equipment is needful rendering the (administrative/institutional) interactions, forces, and effects within the focused space of political-administrative and hydrological systems. Such apparatus should be able to transmit and map the spatial externalities (mismatched bonding of the spatial extent of an environmental resource to territorial administrative arrangements regulating its use) in meet of those systems. Hence, the research tried to embed a distinct evaluation in this regard. Accordingly, selecting a basin, the water management administration’s spatial externalities (for demand/supply) were investigated through a Statistical Mechanics device within the constrained political-administrative and spatiotemporal levels. Since the Statistical Mechanics tools can boost modeling complex phenomena in an easy to understand set up, they facilitate studying systems behavior. Such methods help portraying the effect of an adjusted configuration for (water demand/supply) interactions in given levels of an administrative scale via approximation by a single averaged effect able to lessen a many-body problem to a one-body problem. This supports conversion of a complex model to simpler one which its global behavior can be studied much easier (Seyedi, 2015). Since the problem of fit is mainly a system fit problem, the application of statistical mechanics models which consider scalar properties of motion signifying the system as a whole, is remarkably beneficial. Therefore, the research got the benefit of such instruments to explore the fit of water demand/supply governing system to the basin. As a matter of fact, till now for identifying and resolving the problems of fit, the majority of the proposed solutions have utilized the supranational environmental legislations (e.g. Moss, 2003 and 2012) or national and local institutional resources (e.g. Thiel and Egerton, 2011; Herrfahrdt-Pähle, 2014; Hack, 2015) in their courses of analysis. Keeping the importance of those provisions, taking advantage of the introduced method and concept in this work—yet to the best of authors' knowledge has not been explored/examined for appraisal of such problems in water governing systems— it is possible to recognize the system state via an immediate scan of its structure.

Indeed, Statistical Mechanics Methods (Gibbs, 1902) are considered as useful tools to study systems with uncertain knowledge[1] about their status in socioeconomic and natural science domains. Adopting atoms collective behavior in a magnetic field, it is explainable how a collection of interdependent behaviors of entities in a (social) system determines the system status (Durlauf, 1999). Such methods are incorporated to create frameworks for studying interactions-based socioeconomic models (Durlauf, 1996). Even more, they have been used in the study of the population-wide characteristics in human-created systems encompassing the aspects of social networks (Arthur et al., 1997; Mantegna and Stanley, 1999; Contucci and Ghirlanda, 2007; Castellano et al., 2009; Kusmartsev, 2011; Barra et al., 2014; Contucci et al., 2017; Agliari et al., 2018; and Contucci and Vernia, 2020), methodological management (Braha and Bar-Yam, 2007), and political issues (Meyer and Brown, 1998) as well as decision making (Ortega and Braun, 2013; Bensoussan et al., 2013). Of course, beside the advantages, there are also limitations concerning their application. For instance, they mainly go through with binary choices which limits their benefit for interaction environments with continuous choices, or the development of rational expectation forms in their domains face with difficulties (Durlauf, 1996).

Employing a statistical mechanics approach in presence of Hamiltonian formula, the system cost was calculated in relation to associated interactions and external forces in the system. Such cost is a theoretical estimate to evaluate the impact of contemporarily permitted (administrative) interactions, and the realizing forces for operating water demand-supply process in the basin. This scrutinizes to what extent the existing jurisdictional boundaries and biophysical boundaries are reasonably admitting each other for the created water supply-demand chain flow. In consonance

[1] Nonetheless, in less uncertain conditions (relevant to the context of this study), the method can strongly provide an operational measure of relative flexibility from initiates to future alternatives.

with this matter, beside the real-life setting in the study region, two other assumable governing structures in the region were analysed and compared.

Focusing on certain provincial/regional levels within the study area, the main aim of research was **to assess the fit of the structure of governing system of water demand and supply associated to given administrative levels with relevant territorial/jurisdictional boundaries to the hydrological system through calculation of system cost**. To this aim, the work tried to capture and project the spillovers, furthermore the state of systems' entities per different system structures. The objective of the research was to evaluate how the levels of administrative scale can sufficiently internalize the spatial externalities of water demand/supply process and to lessen system cost for more fit mapping (Breton, 1965) of the governing system to the basin.

2.2.1.2 Aim conceptualization

A governing system is recognized by its jurisdictional boundaries implicit in spatial scales. Its associated levels (e.g. local; provincial; national) can meet up wholly, partially or jointly with levels of hydrological scales such as catchment, river basin, or lake basin which nevertheless are types of spatial scales. Therefore, both human-generated and biophysical governing systems launch relevant levels on spatial scales respective to their pertinent boundaries. The jurisdictional boundaries are typically the borders of a politically/institutionally partitioned region (e.g. provincial borders). Such district may include several geographical zones such as urban or rural areas trying to obtain their water requirements through the routes created by administrative/institutional systems. A given task/service there, like as water demand/supply is operated through a mechanism in which the routes for requesting and delivering a service reveal the (administrative) structure for flows in associated levels. Hence, monitoring such routes the effectiveness of the devised administrative levels for water demand/supply is assessable in terms of a cost that the system bears per its structure to carry out water demand/supply service administration. That system cost is a measure of system fit connected to the spatial externalities between human-tailored and natural governing systems (Moss and Newig, 2010).

To explore the problems of fit, the "Urmia Lake Basin" in Iran was selected as a study case area (please see section 2.2.1.3). The research concentrated on three levels of administration associated to spatial scales, namely: local, provincial and regional (Figure 2.2.1). Positionally the basin is located inside three provinces each include relevant geographical zones (Figure 2.2.2 and Figure 2.2.3). The zones are administratively affiliated to the local level, and they are considerable as the entities demanding for water according to the needs of different users (here: Drinking, Agricultural and Industrial). In case of freedom in interactions for water demand and supply, different zones may interact based on their choices and decisions to make demands/supplies and therefore, the indeterminacy could accompany the related interactions. While this idea is majorly relevant to the efficacy of human choices at micro levels and individual users, at meso levels such as zones and provinces (concerning our case) the political-administrative arrangements try to control and orient the interactions into the ordered set-ups. This restrictive control desires to tend the interactions towards the ‘determinacy’ (almond and Genco, 1977). To implement a mechanism for such purpose, relevant to the case of this study, the governing system had incorporated particular entities responsible for responding the demands of the zones of distinct provinces where spatially located in the capital of each province. The aim was to vertically adjust focal entities institutionally armed with higher authority for dealing with demands/supplies. Administratively nailing those entities above zones, the governing system was largely able to constrain the interactions for water demand/supply to the channel between the zones with them and not with each other. Such entities which here we call them ‘core(s)’ were designed to cope with needs of disparate sectors. Thus, it is recognizable that each sector (e.g. drinking, agriculture) has its related core (responsible authority like provincial Agricultural Organization) to organize the required supplies in that sector. Since cores institutionally/administratively set out above the level of zones, they are affiliated to the provincial level at administrative scale. Furthermore, the regional level encompasses more than one province with their relevant zones and cores. Beside arranging cores, another strategy the governing system get benefit of that for restrictive control and increase of determinacy in interactions is the political-spatial partitioning of the region into separate provinces with distinct jurisdictional boundaries in line with the organization of the overarching governing system of the country. This provision limits the interactions of entities into their affiliated province and embeds horizontal restrictive control on interactions. Conclusively, exploiting such strategies, the governing system attempted to set-up a controllable and more deterministic administration operation. Such determinacy may be achievable in some levels at temporal scale based on the political-administrative conditions.

Having those notions, to observe the spatial fit of water demand and supply governing system to the basin in a given period of time, the administrative flows of demand and supply were derived in the region. Correspondingly, adopting a statistical mechanics approach through applying a mean filed model (see sections 2.2.1.4-5), the study tried to map the associated interactions for water demand and supply systemized through administrative/institutional arrangements. Indeed, that mechanism is inserted through the forces which are devised by political/institutional settings.

The interactions among cores and zones in this study were mapped according to the contemporary state at the time of analysis. The plans leading such interactions, nevertheless, are embedded at management scale which is linked to the national level of administrative scale. According to the constrained levels of administration in this study and spatial configuration of zones a cost function was formulated via mean filed models (sections 2.2.1.4-5) to measure the effectiveness of governing structure. Such cost function is a theoretical computational aid to measure the impact of the designed interactions, and forces for operating water demand-supply process. According to the extent of such cost the fit of the governing structure associated to relevant levels is identifiable at contributing scales.

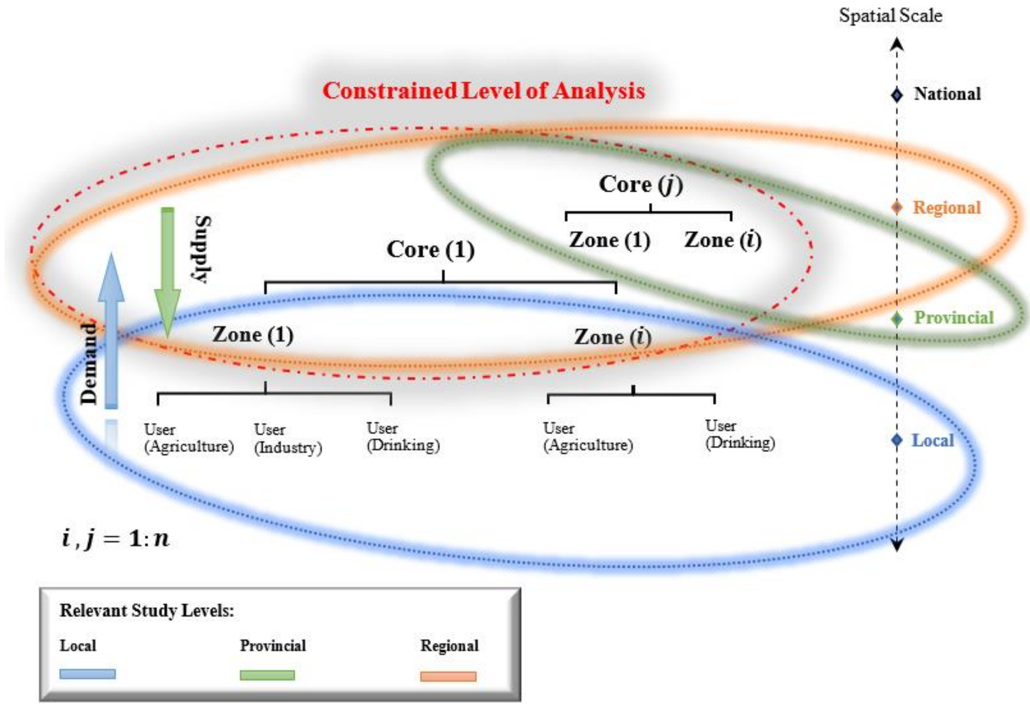


Figure 2.2.1 Schematic of the focused levels and scales relevant to the case study. A provincial level takes into account a core (associated to a particular sector) with its related zones and a regional level includes more than one core and their relevant zones.

2.2.1.3 Case study's political-administrative attributes

To exclude the information which are already disclosed about the case study in the previous parts, this section was adapted based on the political-administrative information of the region

Whereas the basin is surrounded by two provinces named according to their geographical position to the lake: West Azerbaijan, located on the west side of the lake, and East Azerbaijan, located on the east side of the lake, it also includes another province, Kurdistan, which involves to the basin via a small territorial contribution while shares a substantial extent of water (Figure 2.2.2). On the whole, there, water management organization is composed of the main ruler, Iran Ministry of Energy (MOE), which defines the policies and allocable water amounts from different sources, besides its provincial arms, the Regional Water Companies, which control and manage the water resources.

In addition, there are main distributers/suppliers such as Water and Wastewater companies responsible for drinking and sanitation aims; Agriculture organization responsible for irrigation and drainage initiatives; Industrial and Mines Organization which facilitates water supply for industrial zones; and department/organization of Environment takes care of pollution and ecosystem requirements. Those entities were following self-organizational objectives/targets until the year 2013 while started to take some shared responsibilities through the program of Urmia Lake Restoration. Generally, those organizations have their own representatives (local affairs) in main cities of the relevant province for water management, demand and supply initiatives.

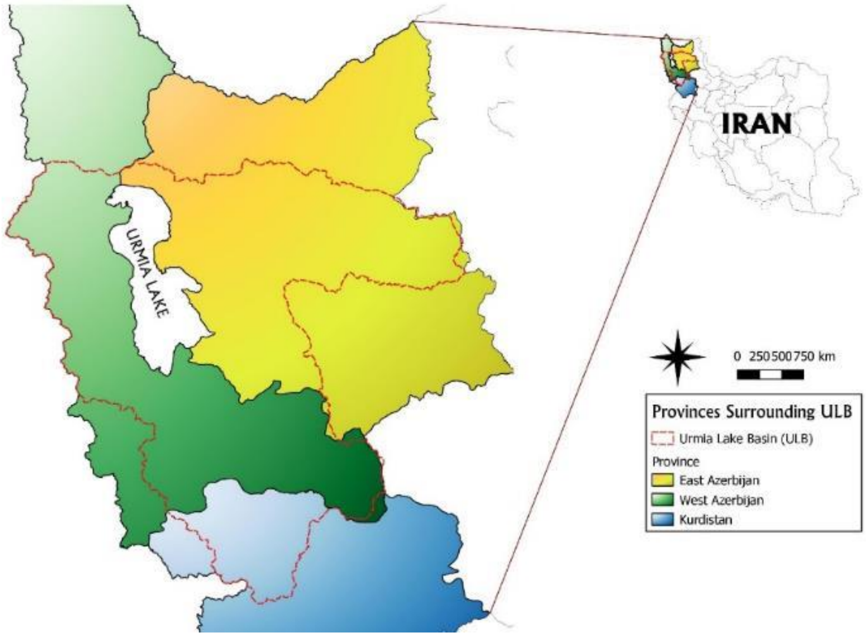


Figure 2.2.2 The provinces surrounding the Urmia Lake Basin, Iran.

According to the available data (MOE, 2012; 2013a; 2013b; 2013c; 2014; and 2015), three main sectors are using water in the basin, and therefore we consider the entities of Agricultural, Drinking, and Industrial sectors in 25 geographic zones (Figure 2.2.3) spread in 3 provinces[2] to tailor the analysis outlines. Each province has to manage the provincial issues inside its jurisdictional boundaries while may also communicate with another province for the transboundary issues through the highest administrative level of that province. This research is conducted based on the relevant data and existed administrative setting in the region until the year 2005, so, according to the official reference report (MOE, 2014) there hasn’t been any water transmission from/into the basin until then.

[2] The two zones (numbers:10 and 25) were divided into two separate ones in terms of administrative belongings to the West and East Azerbaijan provinces, even more the capital of Kurdistan province (although it is not located in the basin) is administratively contributed to the base model (3-cores).

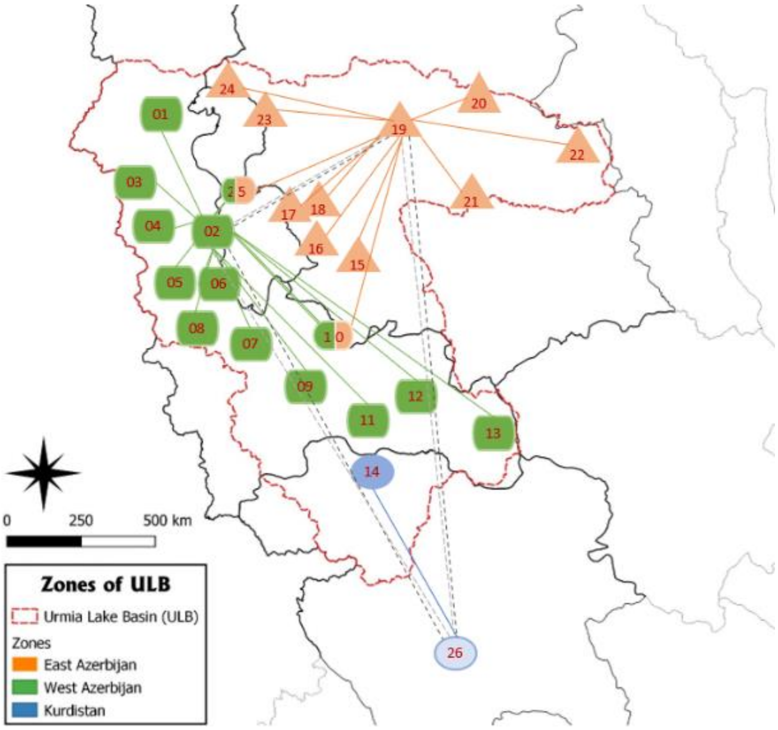


Figure 2.2.3 The main zones of three provinces located in the Urmia Lake Basin. Although, zone 26, geographically is not located in the basin, administratively is affiliated to there (please see also Footnote. 2).

2.2.1.4 Mean filed models

Within the scope of Statistical Mechanics, the Mean Field Models (MFMs) are among the largely exploited machines for studying socio-economic and political matters. MFMs apply explicit and exact computations so that the behavior of the complex systems can be studied easily. In other words, the method assists exploration of the macroscopic behavior of systems induced by microscopic interactions of their entities. Through the method it is possible to estimate the dynamics and connectivity distribution (patterns of interaction) of entities. The application of the concept in societal domains was originated based on the laws of thermodynamics capturing the behavior of atoms and molecules (Thompson, 1979; Durlauf, 1996). In this study, we apply one of the successfully examined MFMs in studying the social and economic systems. The applied Curie-Weiss Hamiltonian model (subsections 2.2.1.4.1-2) containing the high-occurrence-likelihood of interactions amongst some particles with opposite spin may play a prominent role as a suitable instrument for observing systems' semideterministic state very close to the boundaries of indeterminacy. Correspondingly, through Hamiltonian formulation of the governing system of water demand/supply, we aim to evaluate the extent of system's fit at the basin scale.

2.2.1.4.1 The Curie-Weiss model

The idea of mitigating a multipartite system to a one-population problem (Mean-Field Theory) by replacement of all interactions to any one population with an average/effective interaction (Molecular Field) was appeared initially in the work of Pierre Curie and Pierre Weiss when they tried to explain a simple classical system that exhibits phase transition (Curie, 1895; Weiss, 1907). Among several MFMs, the Curie-Weiss Approximation is one of the frequently applied models in studying social, economic and political issues (e.g. Barra et al., 2014; Contucci et al., 2017) in which an interacting system of N particles (entities) is generally Hamiltonized with uniformly binary random spins (σ_i) as:

$$H_N(\sigma) = -\frac{J}{2N}\sum_{i,j=1}^{N}\sigma_i\sigma_j - h\sum_{i=1}^{N}\sigma_i, \qquad (1)$$

where the magnetization of the binary configuration, is defined by $m_N(\sigma) = \frac{1}{N}\sum_{i=1}^{N}\sigma_i$ along with the value of the external force: h, as well as the interacting positive constant: J. This means that the interested multispecies Hamiltonian of the Curie-Weiss machine may be characterized by

$$H_N(\sigma) = -N\left(\frac{1}{2}\sum_{i,j=1}^{N}\sum_{i,j=1}^{N}\alpha_i\alpha_j J_{ij}m_i m_j + \sum_{i=1}^{N}\alpha_i h_i m_i\right) \qquad (2)$$

with assumptions of the relevant magnetizations:

$$m_k(\sigma) = \frac{1}{N_k}\sum_{i=N_{k-1}+1}^{N_k}\sigma_i\,;\ k = 1,\dots,\mathcal{T};\, i = 1,\dots,N;\ N_0 = 0 \qquad (3)$$

along with their proportional subsets' size, $\alpha_k = \frac{N_k}{N}$ (k is the number of sets) where the first binary choices selected from $\{\sigma_i |\ i = 1,\dots,N_1\}$ when the last alternatives are: $\{\sigma_j |\ j = N_{k-1} + 1,\dots,N_k; k = 2,\dots,\mathcal{T};\ \mathcal{T}\ is\ the\ total\ number\ of\ partitions\}$ with the fixed term $N_1 + \cdots + N_k = N$. Such that, the relevant vector field h_i is assigned by the k magnetic fields: $\begin{bmatrix} h_1 \\ \vdots \\ h_k \end{bmatrix}$, while J_{ij} tunes the mutual interaction among those particles with respect to the following adjusted matrix:

$$\begin{bmatrix} J_{11} & \cdots & J_{1k} \\ \vdots & \ddots & \vdots \\ J_{k1} & \cdots & J_{kk} \end{bmatrix}$$

in which the positive blocks J_{ij} reveal the interaction among the particles belonging to the same/different subsets (Contucci et al., 2008; Fedele et al., 2013). In other words, the concept communicates that through maximization of the pressure, the output of self-consistent equation of a multi-species system pictures the total energy exchange in the system. Furthermore, it transmits that the relevant magnetic critical/threshold exponents are discernible as a function of an effective mean-field (Contucci and Ghirlanda, 2007).

2.2.1.4.2 Meaning of parameters in the case

In a set (province), to see for a moment the behavior of an semideterministic system which its determinacy is provisioned through political-administrative arrangements (sections 2.2.1.2 and 2.2.1.6), we consider some almost surely interaction events J_{ij} (holds amount of water demand/supply) between entities (e.g. zone i and core j, and vice versa) with opposite paired 'spins' or administratively we call 'orientations', (σ_i, σ_j), which may occur under the influence of the diffused institutional/administrative rules of interaction (see section 2.2.1.6). Such orientations resemble the arranged 'trait values' for the entities in a demand/supply chain process based on the discussed instructions.

Within tending realms towards determinacy, in a system composed of subsystems/sets, according to the network analogy of Gauss's law that relates a measure of flux through a set's boundary to the connectivity among the set's nodes (Sinha et al., 2018), each entity is surrounded with a magnetization (connectivity flux) rate (m) relevant to its belonging set. Through this notion and in line with the principals of MFM, the magnetization in a set is achievable by averaging all entities' signs in that set: $m_\sigma = \frac{1}{N}\sum_i \sigma_i$. This let the reflection of that magnetization, 'm_σ', as 'a group (provincial) trait value' per a certain set which can be allotted to all entities of that set characterizing the set as a community with appropriate flux through its boundary. Correspondingly, the proportionate 'subset sizes', 'α_k', are calculable dividing the number of entities in a set (province) over the number of all entities in the system (basin). Like as the magnetization each subset size is equally allottable to all entities of the relevant set.

As a result, the total cost function in multi-populations can be expressed as Eq.2 when the relevant mutual interactions and the associated provincial trait values (m_σ) are expected by the collection of possible configurations (jurisdictional/administrative in our case) in a system. As conceivable, provincial trait values and their relevant subset sizes in the basin are linked to the governing system structure. They stand beside the extent of demand/supply (can be seen in Eq. 2) to formulate the interaction rates of entities in a certain set. Therefore, those variables are nominated as control variables could be used in appropriate structuring of a system to improve the match between administrative and biophysical systems. However, they also reveal that how a system could be exposed to influences by political-administrative provisions. Apart from the discussed parameters and variables contributing to Hamiltonian formulation of the system, we go through with the external forces (h) which have hidden (implicit) attributes. Those forces result from the combination of rules formatting the context in which the interactions for water demand and supply take place. In the environment we assess the interactions, such forces are noticed as effects associated with the set of instructions structuring the administration mechanism. Therefore, they can be intuited as a sort of institutional forces trying to sustain the system dynamism while orienting the interactions. Such forces are perceptible as pre-existing ones if we refer to them at the time of analysis. However, they may change in time according to the changes in the system composition by the decisions in pertinent levels of administration. The abstract of those forces could be well quantified by inverting the abovementioned many-body approximation (Eq.2), (for further information please see Fedele et al., 2013):

$$h_i = \tanh^{-1}(m_i) - \sum_{j=1}^{N} \alpha_j (J_{ij}) m_j \qquad (4)$$

The Hamiltonian cost (H) is a cost a system bears per its structure. It resembles the total cost a system carries for administration of all interactions in the system. In fact, the costs related to a given entity in a particular set are symbols of state parameters that show how a system and/or an entity is affected by the existed structure. Another parameter beside the cost which supports the estimation of the state of a system, is the Pressure (P) which is determined by the logarithmic format of the exponential formulation of the symmetric position for this Hamiltonian (for further information please see Seyedi, 2015):

$$P_N = \frac{1}{N} \log \left(\sum_{\sigma} exp \left(-H_N(\sigma) \right) \right) \qquad (5)$$

This parameter is tightly connected to the cost. It reflects the measure of "return" a system receives per the cost it bears. Whether a system can better preserve its energy via lessening its cost, its pressure or return will grow higher. P for the system is discernible as a type of return, interlinked to system's (dis)organization. Whereas, for the entities of the system, it denotes a sort of gain affected by the cost intertwined with the system structure. It reveals to what extent a zone sustains energy (encountering less cost) in relation to system structure. The more sustainment the better gain, and privilege of the zone in the system which may be equated as a profit or benefit for that. To transmit this apprehension, the values of P were projected in radar charts resembling the gain of a zone as an inflation. As later will be discussed further in this paper, the parameters H and P, are the outputs of the designed machine and the analyst diagnoses the system status per different structures via such state parameters. Having those notions, the model development is further discussed in the next part.

2.2.1.5 Tailoring the concept to the case

As indicated in section 2.2.1.2, the zones are considered as demand entities in local level which themselves include the water requirements of three sectors according to the MOE report (2014). Each sector (Agricultural, Industrial and Drinking) requests for its demand from the responsible entity (core) in that sector (section 2.2.1.2). The core is administratively above the level of zone. Cores resembling the provincial level entities that can surely interact with the zones of their province and may interact with each other for information exchange. However, according to the administrative restraints the zones almost never can directly interact with each other for their requirements. Hence, the structure of water demand/supply governing system for a given sector in the year 2005 at the Urmia Lake Basin concluded in three cores associated to three provinces responding the demands of their zones (Figure 2.2.4a). Furthermore, due to the distinct scalar dimensions of the water demand/supply volumes of each sector and the sectors' administrative disconnection of water demand/supply process, the related interactions of one sector are assumed to be valid for that sector only, and accordingly the interaction rates of disparate sectors should not be compared with each other. Beside the existed assembly of governing structure (3-cores) defined based on jurisdictional boundaries of the three provinces, we evaluated the two other forms (Figure 2.2.4b and 4c). Those forms represent the state in which all zones may interact with one hub for their demands (1-core) as well as the state that the only contributing zone of Kurdistan province (the zone 14) could be included in West Azerbaijan's team and the basin administration could be shared between the two, west and east Azerbaijan provinces (2-cores). Through such appropriable rearrangements, the magnetization rates (m) and their proportionate subset sizes (α) can vary in the assumed formations (subsection 2.2.1.4.2). Subsequently, the system cost shall alter in relation to those changes which embeds the basis of comparison for the analyst. Placing these postulations in addition to the practical experience of the main author in the region[3] , we analyzed the system per the three constitutions through the application of the Curie-Weiss Model.

[3] Technical Expert at West Azerbaijan Province Water and Wastewater Company (Shirzad et al., 2011)

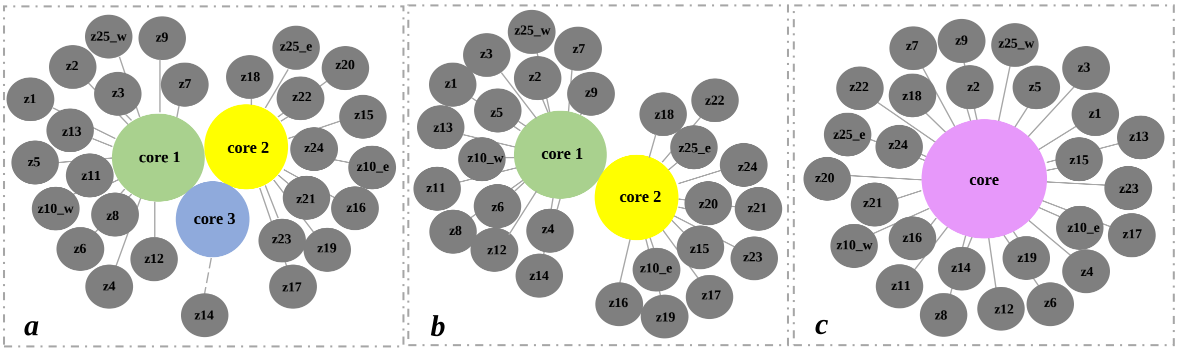


Figure 2.2.4 The partitioning of entities in 3 modeled system forms: (a) 3-cores (left), (b) 2-cores (middle) and (c) 1-core (right).

2.2.1.6 Modeling the governing system

According to Durlauf (1996), the collective interdependent behavior of entities in a socio-economic system can be adopted from collective behavior of atoms in a magnetic field. Furthermore, Sinha et al. (2018) proved that the Gauss's law (Gauss's flux theorem) is also applicable for social systems and the connectivity flux in a social network is the implication of electric flux in a magnetic field. Therefore, the concept of electric charge was let to determine the probabilistic connectivity distribution among contributing entities according to the administrative/institutional connectivity rules: i) zones can almost never interact with each other; ii) in a certain province each zone can almost always interact with its relevant core; iii) cores may contact each other for information; iv) sectors should be treated separately. Correspondingly, each zone of distinct province was most likely connected to its core appointing an opposite paired binary connectivity (charge) sign, (σ_i, σ_j) to them (the ratified trait values which let the demand/supply flow be defined according to the routes instructed by administrative provisions under given political-administrative conditions).

Administratively characterized in our example case, the zones interact for water demand with the extent of demand J_{ij}[4]. Such extent is the volume of water solicited by a zone which is rescaled in our case separately for distinct sectors respective to their max-min demand amounts based on Feature Scaling method to place pertinent and rational values incorporable in the evaluation device (Figure 2.2.5). Therefore, the rescaled demand/supply amounts of a particular sector (J)

[4] J_{ij} is a number that summarizes the nature of the interaction between i and j, for instance, if i is a solicitor entity, it interacts with the extent of its demand as the value of J_{ij} for its interaction.

are only comparable within that specific sector and not among the sectors. Similarly, the cores interact to respond the zones via the extent of supplies (J_{ji}) which are rescaled based on the same method.

In obedience to that inception, at the first stage, we let the interactions be shaped through a predefined concept of magnetization based on adaptation of Gauss's law for networks to the existed administrative structure in the basin. According to the governing structure, the contributing entities partitioned in three sets respective to the present provincial boundaries in the basin. Each set includes a core, besides its zones forming the total number of contributing entities positioned in that set (N_{i}). The total number of entities (N) contributing to the basin's water demand and supply initiatives is considered as the sum of all entities in the sets participating in interaction process ($N_1 + N_2 + N_3 = N$). Mapping the entities' configuration, each entity was featured by a trait value (σ_i) based on the rational of attraction (connection) due to opposite signs (trait values) between the core and its zones to place the interaction scheme at the time of analysis. However, in relation to the Kurdistan province since its core spatially does not belong to the basin area, it is assumed as an electric pole with no particular sign (neutral) supporting the administrative linkage of its only zone in the basin to the system. Above all, the overall order of the signs (orientations/trait values) of all contributing entities endorsed the connectivity in the system. Subsequently, the provincial trait values (m_σ) as well as their proportional subset sizes ($\alpha_k = \frac{N_k}{N}, k = 1,2,3$) were calculated for each set (province). Tuning the 'interaction rates' (αJm) via the demand and supply (rescaled) volumes (J_{ij})[5], respective to the objectives of the entities in our example case, the external forces were determined according to the Eq.4. Furthermore, portraying the administrative interaction episodes in presence of interaction rates (αJm), external forces (h), and the participant zones of each set (Figure 2.2.7), the effectiveness of the governing structure for water demand and supply interactions was noticed.

[5] The volumes of demand and supply (MOE, 2014) are rescaled for each sector separately respective to the distinct sector's max-min amounts based on Feature Scaling method to place pertinent and rational values incorporable in the evaluation device. Therefore, a particular sector's rates are only comparable within that specific sector.

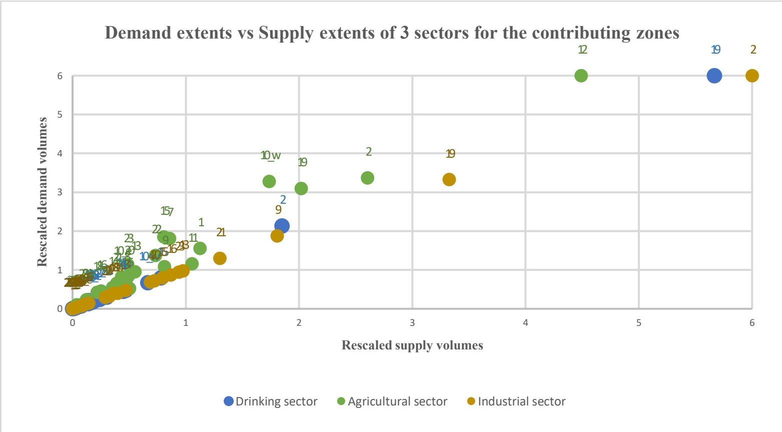


Figure 2.2.5 The rescaled rates of water demand and supply volumes (MCM) of three different sectors for the zones of the Urmia Lake Basin (MOE, 2014). Those rates manifest the biophysical scalar organization in an administrative mutual interaction plane (for demand and supply). The zones are pinpointed through their relevant numbers (above dots) for different sectors.

In the second stage, the relevant costs (H) of each sector per different system structures were determined through the Eq.2 (Figure 2.2.8). Lastly, in the third stage, the system and zones pressures (P) were measured via the Eq.5. As mentioned, the pressure for zones were discerned as the quintessence of gain (Figure 2.2.9).

According to the induction in section 2.2.1.5, the model basically was designed for the 3-cores structure respective to the contemporary governing system in the basin. However, to analogize the existed system with some other relevant structures, the model was customized for the two hypothetical forms, namely the 1-core, and 2-cores. In the 1-core setting, the jurisdictional/provincial boundaries are neglected, and the zones are interacting with only one core (for each sector). While, in the 2-cores setting, the only located zone of Kurdistan province (14) in the basin is assumed to be an entity of West Azerbaijan province.

2.2.1.7 Results and discussion

To get the picture of interactions, effects, and outcomes per different system settings in our case, we split the analysis in three clusters. Duly, the first cluster goes through with the type of control elements in rule-structured environments which are created through instructions for administrative interactions in the Basin. In this cluster, the ensemble of administrative interaction episodes is projected (Figure 2.2.7). The aim of this projection is to show how system composition launches an area corresponded to the interactions and forces in which the entities of a certain set are configured according to their rates of interaction alongside the forces (Figure 2.2.6). The more sited interactions inside their relevant area, the effective the system structure, since it has handled more interactions. Indeed, the interaction of each zone of a set which is not sited in such an affiliated area, is not handled by the designed structure of the system. Therefore, the analyst can detect how the control or handling capacity of a system (to deal with its zones' interaction rates) varies by its structure. Displaying the results of this cluster in Figure 2.2.7, we narrate the outputs correspondingly.

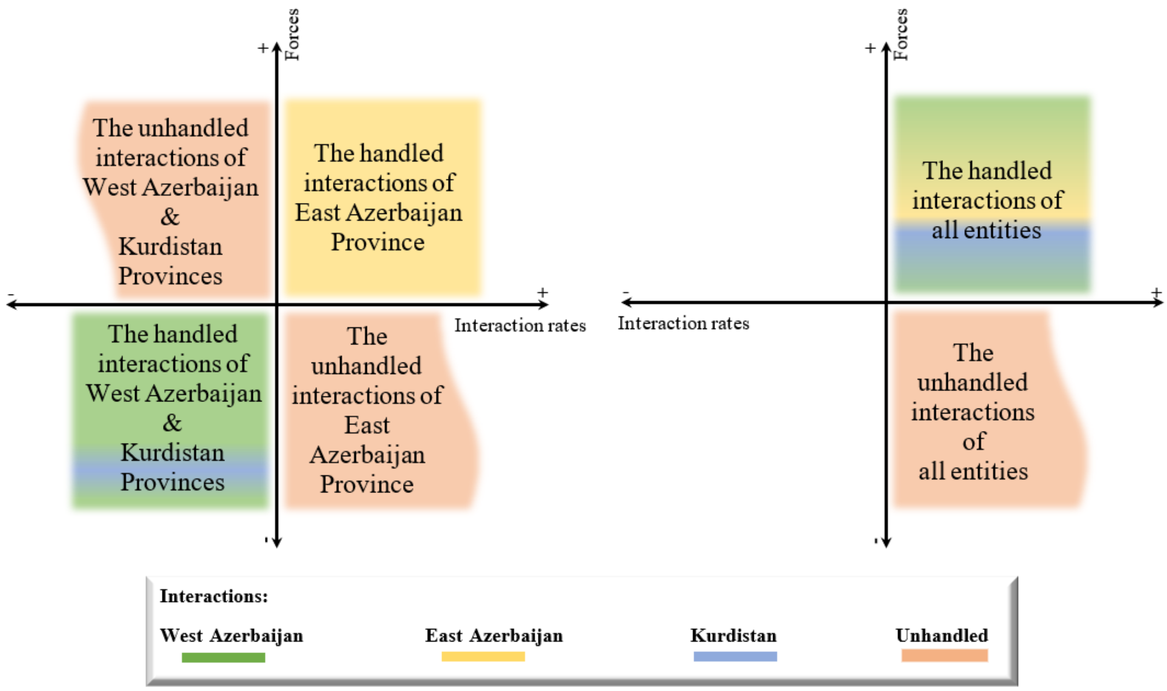


Figure 2.2.6 The launched areas by the system composition for interactions of different sets per the 3 formations; right: the 1-core and left: the 3-cores (also 2-cores).

To give a clear-cut induction on the results of the first analysis cluster, we emphasize on an affiliated area to the defined set of entities in different configurations. According to this knowledge, in the 1-core system, there is only one associated area (Figure 2.2.6) to all interacting zones in which both interaction rates and external forces have the same sign (positive). Whenever a zone's interaction rate surpasses a critical value (the first compartment of equation 4), it outstrips the appurtenant area and stands beyond there. This means that the proportionate handling capacity of that system determined by its structure is not effective for administering such zone's interaction rate. This issue is well detectable regarding the interactions perched on the below part of the horizontal axis of the 1-core setting. Another principal is that the values of forces in such cases have the reverse alignment with the zones' trait values (σ) meaning that those forces are struggling to orient such interactions toward their pertinent sphere, and this causes the force direction to be altered to the opposite one which is associated with an additional cost infliction to the system. Identically, in the 2-cores and 3-cores settings, the handled interactions of entities are configured in top-right and bottom-left portions where both interaction rates and external forces have the same sign. They are the pertinent launched areas for interactions in those systems. Like as the 1-core's state if an interaction placed in an area that is not affiliated to, it represents a sort of problem which arises due to the system's structural fit in handling the zone's interaction rate in that configuration.

Through this illustration and adopting a sectoral approach for the comparisons, we assessed the outputs of this cluster. The results (Figure 2.2.7) indicate that once there is a 1-core system responding to the demands of all entities, the system is apparently impotent in handling the interactions of several zones, particularly in agricultural sector. More indicatively, the interactions of zones: 1, 2, 7, 10_w, 12, 15, 19 are perching beyond their assigned area. Whereas, only, one interaction in 2-cores, and two interactions in 3-cores settings are unhandled. Apart from agricultural sector, indeed the unfit of the 1-core system is realizable in other sectors. While the judgment comes to the 2- & 3-cores settings, the competition is tight. It is transparent that not only regarding the number of the interactions settled in the belonging areas, the 2-cores setting shows better fit, but this structure also handles its zones' interactions with more satisfactory rates. For instance, to handle the interaction of zone 12, in the 2-cores set up, the related force is smaller than the 3-cores set up. In addition, the interaction of zone 10_w is hardly being handled in the 3-cores setting but is well handled in 2-cores one. Correspondingly, a message that may stem from comparisons is that the predefined (political/jurisdictional) boundaries used for administration of water demand/supply (in 3-cores system) may not fit as the 2-cores system in the basin. This shall propose a slight reconfiguration/rescaling (Moss and Newig, 2010) and adaptation in administrative structure to benefit the system.

Figure 2.2.7 The interaction episodes, interaction rates, and forces. Although we modeled the example case based on demand and supply interactions, to prevent confusions, we only displayed the attributes of demand interactions in the graphs. Even more, the demand rates are greater than the supply ones (in our case) which notify that if a demand interaction of a zone is settled in the affiliated area, its relevant supply interaction is already settled there due to its smaller rate. Each dot shows the interaction of a zone which is displayed by its number (above dot).

To further endorse the disclosures of the first analysis cluster, we deploy the results of the second cluster which compares the extents of costs per different system structures (Eq.2). According to the computed values, the system with 2-cores in all sectors dominantly takes care of its costs. In other words, the system has the smallest cost rates in different sectors for administration of the interactions comparing to the others (Figure 2.2.8). As a matter of fact, the Hamiltonian could be a benchmark for the system fit. It communicates that the two compartments of Eq. 2. shall be harmonized in a way enlarging the rate of the function as a whole to lessen the cost due to the invert sign in the equation. The higher the rate the lesser the cost, the better the system fit. To achieve this aim, the system structure shall be formulated in a way that the interactions could be handled properly. Verily, the results of this cluster further revitalized the outputs of the first cluster by admiring the conduct of 2-cores system.

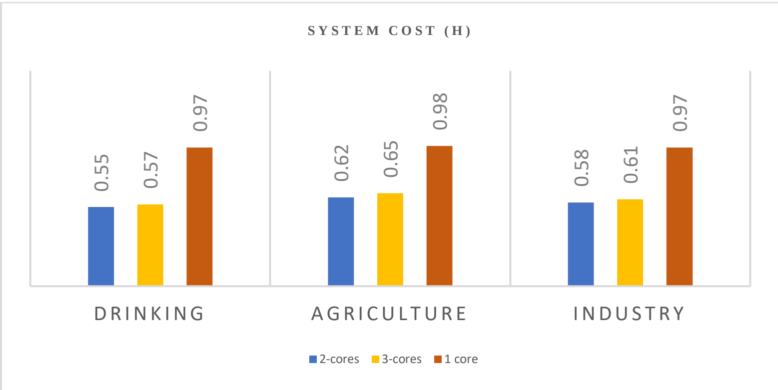


Figure 2.2.8 The normalized rates of (H)s.

Finally, the third cluster of analysis tackled with the consequence of various structures and their costs on the state of the systems and their entities. The outputs of the third cluster (Figure 2.2.9) revealed that how the zones gain valuation in different system settings. Such values resemble 'gains' from system's composition. In this cluster, although the pressure (return) of the systems didn't change greatly, specifically for some sectors (e.g. Agriculture), but the entities pressure (gain) vary significantly in different settings. Indeed, the system pressure per disparate sectors in distinct structures was resulted as a function of summary measure of cost values to all the entities in the system. In other words, it is a cumulative score of the range of all costs stemming from system composition. Hence, in 1-core set for instance, the core held the large extent of pressure and the zones become less gained ones. Whereas, in 2-cores and 3-cores the gain is moderately diffused to the zones. This denouement rendered that in 1-core set it is the core's gain that mainly determines the system pressure as it possesses the mastery role, and zones are experiencing little gain, while in 2-cores and 3-cores settings this effect is unlikely. In detail, recognizing the results, the values of 2-cores system disseminated that again this formation deploys satisfactory gain rates comparing to the others.

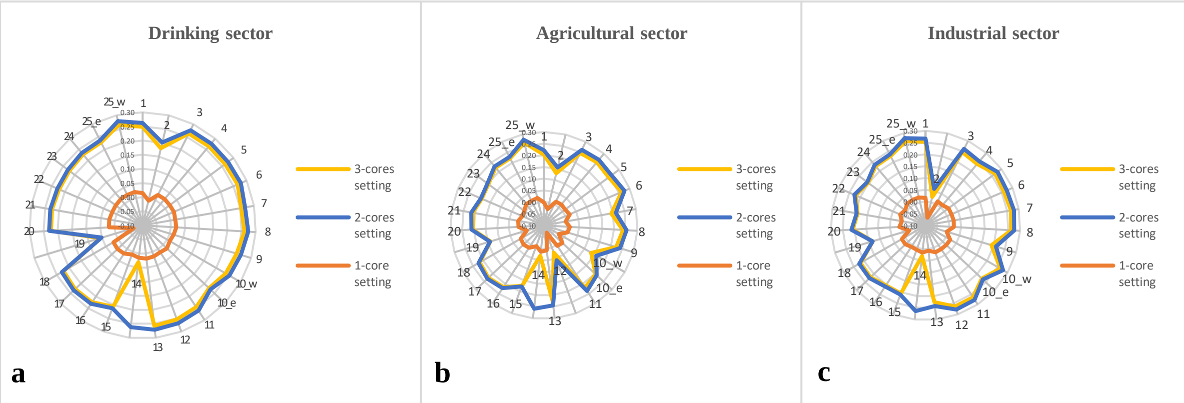


Figure 2.2.9 Normalized rates of the pressure of zones (P) per different formations in three sectors: (a) Drinking, (b) Agricultural and (c) Industrial.

Transparently, apart from the apparent supremacy of the 2-cores setting to the 1-core, remarkably, in the zone 14, there is a huge revamp in gain comparing to the 3-cores system. This confirms that in spite of the existed structure (3-cores) in the basin, the zone 14 could be benefited if it was coupled with West Azerbaijan's group. This issue may further support boundary revisions usefulness in the basin.

Other than the aspects discussed in different clusters of analysis, another point worth mentioning, is the importance of the extent of demand (J) in different sectors which may lead to improvements in policies and decisions. In this regard, it is clear that the Industrial and Drinking sectors are satisfied predominantly while agricultural sector strives to reach by its supply targets. Although, Drinking and Industrial sectors got higher priority in receiving their demands, it is the agricultural sector that determines the overall status of the system due to the greater amount of water demanded in this sector. Therefore, a particular attention on this sector is necessary.

Another substantial fact is that the interactions of some zones cannot be handled through any of the structures. For instance, in Drinking sector the interaction of zone 19, or in agricultural sector the interaction of zone 12 are not handled through the featured settings. Else, in Industrial sector the status of zone 2, not only exposes the same characteristics of the two beforementioned zones but it also subjects to delicate situations in agricultural and slightly inferior in Drinking sectors. This may trigger an idea that there might be no best solution of partitioning to form the systems (horizontal arrangements) but there could be several good ones. Nevertheless, the vertical modifications in administration system may boost the fit of the governing system which their assessment overwhelms the content of this paper, and another extensive research is necessary to investigate their impacts.

2.2.1.8 The outcome and conclusion

Extending a pragmatic and analytical approach, three different systems for administration of water demand/supply interactions were investigated through the unified language of mathematics based on a physical principle. For an inspiring evaluation, the methodology is applied to an example case tuned by related political-administrative arrangements to restrict the indeterministic interactions. Exhaustively, through the probabilistic Hamiltonian mechanics' formation of a multipartite system, a water interactive-based societal case is prescriptively analyzed in order to assess the fit of a governing system for water demand/supply to the relevant basin. The research aimed to avail a unique window for the observers to follow the system fit per the interaction rates for water demand/supply along with the generated forces due to different circumstances in the region during the given period of time. In fact, the model enabled us to put together the semideterministic interactions per units of water resource in administrative-political settings with the product of exogenous factors in the form of forces under the relevant conditions. Furthermore, it supported the comparison of the existed system with two other imaginable ones. This uncovered that how the modus operandi of those interactions is affected by the system structure within distinct sectors.

Through the comparison of the three studied systems, it is revealed that even though the 3-cores system (contemporary) is moderately fit to the basin, it is not as proper as the 2-cores system in respect to the number of privileged zones and system cost. Even more, in 2-cores setting the interactions are better handled. Indeed, the 1-core set showed unmatched characteristics in all the sectors. This outcome highlighted that either the political/jurisdictional boundaries (Nabavi et al., 2017) or basin approach may be revised for fitter water demand/supply administration systems in the basin. On the other hand, the study shows that whether, the governing structures are deformable entirely or partially, the system can be enhanced accordingly. Therefore, during restructurings, it is recommendable to evaluate the configurations producing less costs as well as more benefits for the zones.

Results of the study may also divulge some additional intimations regarding systems' fit. Those revealed that in a system without perfectly fit structure for governance, the gain (pressure of the system) settles only in the cores but not reasonably in other components (e.g. 1-core setting). This issue would lead to malfunction of the system and/or deficiency while if the gain could be rationally diffused to other components, system hits rewarding results.

A notification may appear here, is that the number of cores has to be determined according to the system requirements and more cores doesn't exactly mean more fit. Of course, structuring a system for a particular objective such as water demand/supply will be more admirable if both vertical administrative arrangements and horizontal spatial provisions could be balanced jointly. Even more, the perfect fit shall respect to the objectives of the other systems (e.g. energy and food) in which the same entities may interact. Therefore, before any action in the imposition of a new system, the mutable and affecting circumstances shall be assessed rigorously embodying a sophisticated approach to restrain the eventual affections.

Openly, this paper discussed an example for a simple application of MFMs on a political-administrative structure of water demand/supply governing system during the year 2005 in the Urmia Lake Basin. This paper tried to show how such machine can assist exploration of more match structure for administration of the water demand/supply in the basin. Indeed, a comprehensive study may be necessary combining diverse objectives deemed for a given territory to appropriately formulate the levels on administrative scale, beside the hydrological one.

2.2.2 Assessing vertical system fit

In addition to evaluation of the horizontal fit of the water governing system, its vertical fit was assessed in relation to an institutional (re)arrangement in the basin. To do so, incorporating the same methodology, the system cost was estimated for the two system states relating to the institutional structures of the system before and after the inclusion of the ULRP. Upon this evaluation, the effect of ULRP's incorporation on the status of the system structure and cost was distinguished.

2.2.2.1 Urmia Lake Restoration Program

As mentioned in section 1.4, the alarming circumstance of UL evoked Iran's government to provision a specific implementation for the restoration of the lake (Saemian et al., 2020). To this aim, "Urmia Lake Restoration program (ULRP)" was set up by the government in 2013 to enhance the coordination of organizations dealing with water demand-supply in different sectors. Furthermore, the ultimate aim of such devising was to implement an integrated and sustainable solution for alleviating the recent CC and human caused pressures on UL.

Nikraftar et al. (2021) indicate that ULRP was designed to be impounded within 10 years (2013-2023/2024) and in three main stages as:

i) Stabilization: from the year 2014 to 2016: to preserve UL's ecological life associated with the health threshold water level of 1271.72m a.m.s.l. This phase provisioned to decline the expected biophysical adverse effects arising by shrinkage of the lake (e.g. dust storms);

ii) Restoration: from the year 2016 to 2023: to rise the UL water level to 1273.7m a.m.s.l by supplying its entire water demand, and;

iii) final restoration: from the year 2023 to 2024: to stabilize the UL water level at the ecological level of 1274.1m a.m.s.l as the estimated optimal water level for sustaining the ecosystem integrity and stability further with protecting biodiversity and improving the environmental quality

As a matter of fact, the ecological revival of the lake through the accomplishment of integrated water management with a strong emphasize on sustainable agricultural in the basin was considered as the key sight of this program (Bakhshianlamouki et al., 2020). There are six major approaches within the road map of ULRP (ULRP, 2015) which could be summarized as:

i. Decreasing the water consumption in agricultural sector and reducing water allocation in this sector by a certain level of 40% over a five-year period which has to be accompanied with 60% increase in agricultural productivity by means of the development of new agricultural techniques and the application of the modern technologies;

ii. Conducting preventive measures for mitigating the illegal water abstractions and water theft, besides expanding the technological measurement basis (e.g. smart water meters) for gauging the ground water abstractions and banning the development of damming projects to control and assist the surface water delivery to the lake instead of agricultural extensions in the basin;

iii. Environmental impacts control through identifying and restraining the dust creation zones, implementing ecological management and fauna protection programs, assisting water flow in streams and conducting river cleaning projects;

iv. Promoting stakeholder awareness and capacity building with the eventual goal of the development of decision-support systems;

v. Improving inter-basin water transfer to increase the rivers inflow into the lake;

vi. Conveying the recycled water and wastewater to the lake and developing new water feeding sources to the lake.

Distinguishingly, instituting ULRP revealed the recognition of a concern by the government regarding an environmental risk with various socio-economic, political, health and other consequences (e.g. Schmidt et al., 2021; Zucca et al., 2021). This reform in the water governance platform, transmitted the force of water and environmental risks besides the earlier considered ones like political-economic and/or political-security/military in structuring the governing systems of the region.

ULRP institutionally was incorporated above the provincial level entities with higher authority (Salimi et al., 2019) for controlling the water allocation specifically for the ecological needs of UL, and water demand of disparate sectors. Hence, the headquarters (cores) of various sectors which were handling the water demand-supply requirements underwent a service supervision by the monitoring and evaluation device of the ULRP. This matter communicates the moderating role of ULRP on water demand-supply interactions. Of course, based on the administrative hierarchy, only the headquarters (cores) were allowed to directly interact with ULRP and not the local utilities. ULRP had two main representatives which were situated in the capital of West and East Azerbaijan provinces and here we call them respectively as ULRP-W and ULRP-E. So, there were two ULRP units interacting with the headquarters of disparate sectors. Thence, after the constitution of ULRP, the antecedent structure of the water governing system within the basin was transformed by the inclusion of the two additional entities above the institutional-vertical level of provincial organizations (headquarters), besides their main authority (ULRP) above all.

2.2.2.2 Application of the framework in vertical dimension

This section is ready for submission (2023) as

Investigating Vertical Reforms' Effect on Water Governing System Fit

Peyman Arjomandi A., Seyedalireza Seyedi, Nadejda Komendantova, Ebrahim Vahdani H.

As a matter of fact, ULRP was a vertical arrangement on institutional scale enforced by a national-level committee to supervise the water requirements at the regional level. This authorization was tailored to control water demand-supply initiatives in the provinces surrounding the UL. To this scope, a basin-level authority for water management within the institutional scale was deemed above the provincial level to control the given instructions.

This variation in the institutional realm was deployed to help the water (demand-supply) governing system achieve the freshly seeded environmental objective of the lake restoration. Whereas the success of such a movement can depend on various factors as the timely incorporation of that, its function was expected to have improvements in system state and efficiency. Hence, to assess the effect of such a vertical arrangement in the water (demand-supply) governing system, benchmarking the UL basin as the given spatial level on the hydrological scale, the study was further developed. To this aim, a certain period for the evaluation was considered as the temporal scale level of the study. In this scope, the year 2005 was considered as the time of analysis. Verily, besides the availability of the related data (MOE, 2012; 2013a; 2013b; 2013c; 2014; and 2015), this year has been stressed as a critical milestone in the four distinguished stages of water resources development in the region (Shadkam, 2017). As mentioned, the significant development of reservoirs capacity and irrigation area in the region had started around a decade before the year 2005 which their probable adverse effects coupled with the growing evaporation loss and led to the explicit defacing of the lake after the year 2004 (Shadkam, 2017). Therefore, even if ULRP was established in the year 2013, the research aimed to explore the effect of such institutional implementation if it could be instrumented in the year 2005 when the shrinkage of UL was slight (Figure 2.2.10) and gradually increased since then (Hosseini-Moghari et al., 2020). Nevertheless, to capture the effect of ULRP policy in agricultural sector associating with a 40% water consumption reduction, a hypothetical circumstance was deemed, and the system state was analyzed accordingly. To this end, it was assumed that the ULRP policy could sufficiently decrease the water demand-supply rates by 40%. Thereupon, the costs of entities and system were assessed based on the 40% less water demand-supply in the agricultural sector.

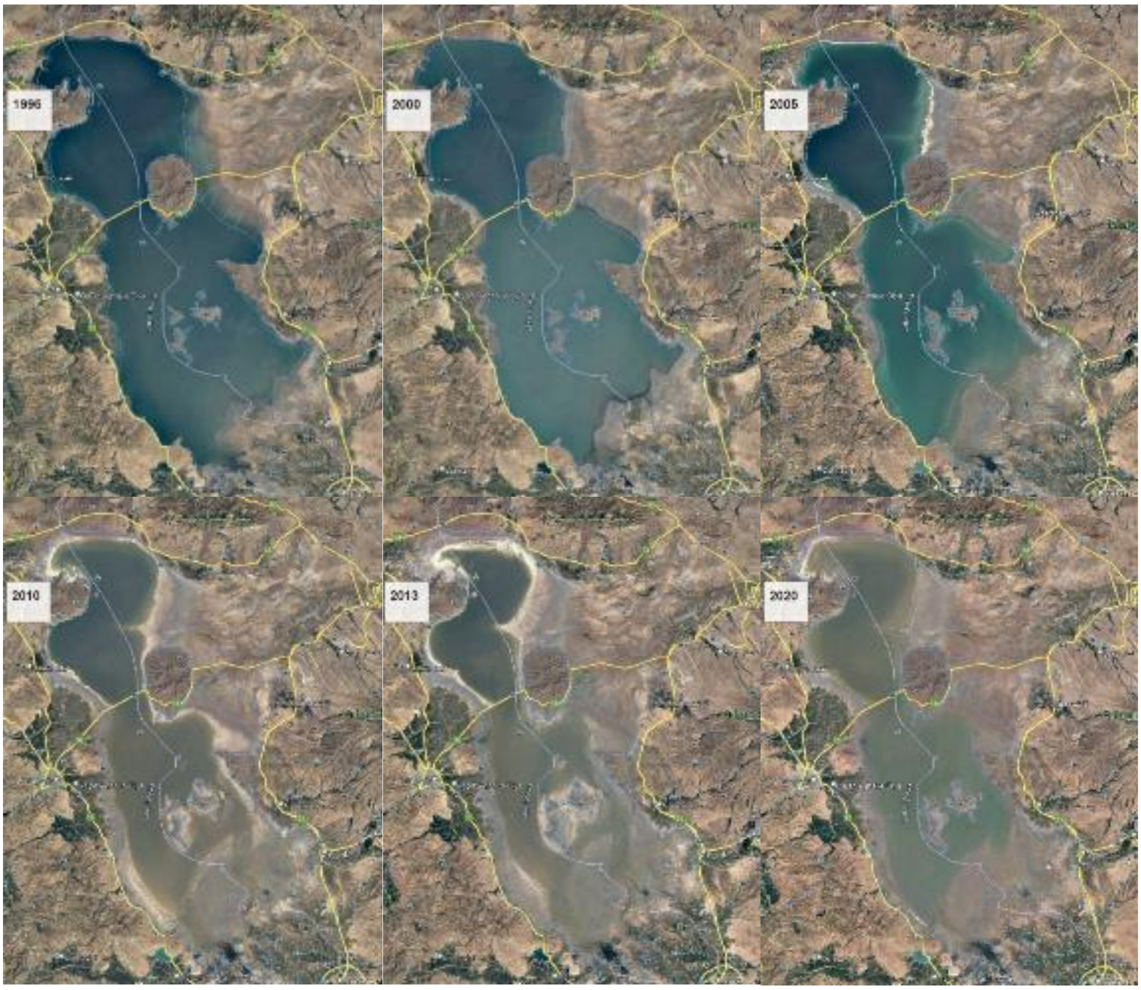


Figure 2.2.10 Urmia Lake state since 1995, Landsat (Google Earth Pro)

Accordingly, the influence of the constitution of the ULRP on the structural fit of the governing system to the UL basin in the year 2005, as well as its agricultural water policy's effect on system was measured by means of the Hamiltonian system cost explained in the section 2.2.1.

To do so, obeying the rules of interaction (section 2.2.1.6): i) the local entities can almost never interact with each other; ii) in a certain province each local entity can almost always interact with its relevant headquarter; iii) headquarters may contact each other for information; iv) sectors should be treated separately, the system formulation started shaping.

Three scenarios were concepted to evaluate the effects of ULRP's settlement on the water (demand-supply) governing system. In the first one, the administrative interactions were mapped in two provincial sets of local water utilities and their headquarter authorities associated with the two East and West Azerbaijan entities. This attribute was in line with the better fit of the 2-cores system (Arjomandi A. et al., 2022) in the spatial/horizontal scale. Thereupon, to exclude the problem of horizontal fit in the same spatiotemporal scale level, the only entity of Kurdistan province in the ULB was reasonably contributed with the team of West Azerbaijan province in the model. Followingly, in the second scenario, in addition to the two mentioned populations, a set of vertically top-adjusted entities of ULRP was added to the system structure. To this end, the two of them, ULRP-W and ULRP-E, as the West and East Azerbaijan ULRP representatives operate closely with the provincial headquarters of the previous two sets under the supervision of their central entity (ULRP). Meaning that the headquarters can interact with their relevant ULRP representatives and those ULRP branches interact with their central unit (Figure 2.2.11). Besides, these two structural scenarios, an additional scenario was concepted and evaluated in association with the system structure subsequent to the constitution of the ULRP and a 40% water demand-supply decrease via enforcing the ULRP policy in the agricultural sector.

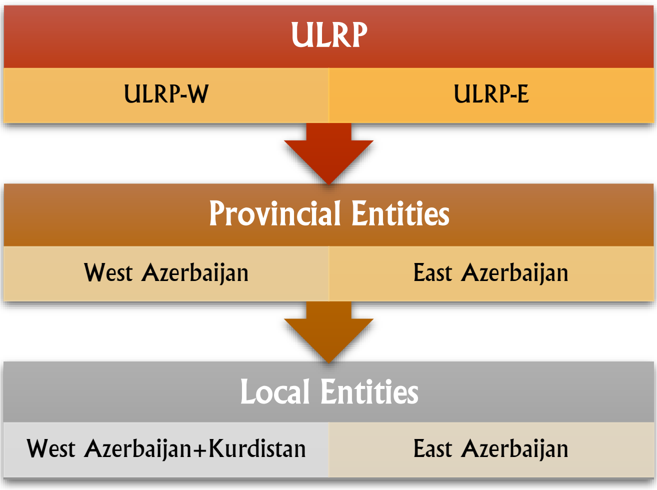


Figure 2.2.11 the hypothetical hierarchy of the water governing system after inclusion of the ULRP

Corresponding to set of interaction ordinance, through the process which is explained in section 2.2.1.6, the governing system structure was formulated and tuned by the same data. Accordingly, the entities' cost, and the eventual cost of the system were estimated in three states. As mentioned, the cost mirrors a joint effect of the forces of (i) administrative/institutional interactions (kinetic) and (ii) exogenous political, economic, biophysical etc. factors (potential) which influence the interactions. Then, the cost function resembles a theoretical calculation tool to track the system state with respect to formable structures based on the region's context. Using this advantage, in my work, I have tried to display how the water (demand-supply) governing system cost changes by (vertically) reforming the system structure, besides 40% reducing of the water demand-supply rates according to the ULRP policy in agricultural sector. Notwithstanding, such reform induced from the impact of a political-environmental[6] factor's force on interactions within the basin leading them to restructure the water governing system for embracing more fit to the basin.

2.2.2.2.1 Results and discussion

As detected in the region (section 2.2.1.7), the agricultural sector has projected the most significant unfit rate in horizontal scope among various sectors. On the other hand, the drinking and industrial sectors consume a very small proportion of the available water (around 6%) within the region (MOE, 2013c). Also, they have priority of supply based on the governance decisions. Thus, here the outputs of the assessment have been disclosed only for the agricultural sector which struggles to receive the appropriate institutional fit with respect to its water demand. Subsequently, to display a transparent picture of the ULRP's impact as the expected vertical enhancer of water governing system structure specifically in the agricultural sector, the results are exhibited in 3 domains. To this aim, at first the local entities' status is disclosed in Figure 2.2.12, and followingly the provincial entities' circumstance is presented in Figure 2.2.13, after all, the system state is demonstrated in Figure 2.2.14.

Corresponding to the inclusion of ULRP, as diagnosable from Figure 2.2.12, the local entities' costs tend to decline. As a matter of fact, the extent of cost reduction varies per player. However, the cost of entities with greater water demands in comparison to the others, was reduced more exceptionally. For instance, the costs of local utilities: 2, 12, 19 and 10_w[7] were decreased by 46, 29, 17 and 21 percent, respectively. Such attribute in the wane of local entities' costs revealed

[6] Reviving Urmia Lake was a political vow for the 2013 presidential election in Iran.
[7] Please see section 2.2.1.3.

the effective role of vertical reform in subsidizing their costs. Nevertheless, those costs were associated with the magnitude of the interactions of such entities along with the extent of external forces realizing the interactions. Indeed, the interaction rates were connected with the water demand-supply volumes (J) and the effect of system composition on them (αm). Thus, the system structure subsequent to the incorporation of the ULRP has been more appropriate for subsisting the water demand-supply interactions within the system further with the function of external forces. To this end, the external forces try to administer the entities' interactions within the system in line with system objective(s).

While this improvement in the status of local entities after the inclusion of ULRP is admirable, still it is recognizable that the local utility 12, is disinclined to the direction of local entities' costs. This means that its interaction rate associated with the demand of this entity is not handled by any of the system formations. In such circumstances, the external forces struggle to administer the interaction of such entities, and this hurdle causes the alternation of the force direction to the opposite one which imposes an additional cost to the system (see section 2.2.1.7). Therefore, the situation expressed the space for further improvements in the system structure or water demand rates. Whereas this affair is important, it is subjective to the case condition. In this scope, for governing systems based on the circumstances, there may not be the best achievable structure but several good attainable ones.

Despite, the interaction of the entity 12 which is interlinked to its demand-supply (J) rates is not handled by none of the structures (after/before the ULRP), as soon as the ULRP policy yields the 40% less water demand-supply, its interaction becomes handled. This attribute transpires that the system structure including the affiliated entities fits the interaction rates associated with a 40% less water demand-supply volumes. Such policy could lead to the decline of the cost of entity 12 by 1.43 times relative to the cost prior to the inclusion of ULRP. This rate is around 5 times more than the cost reduction solely by structural change after the ULRP (which was 29 percent). Similarly, fulfilling such a policy, the costs of local utilities: 2 and 10_w, could respectively reduce by 2.28 and 1.06 times relative to the era before ULRP, and the entity 19 could seize an 83 percent diminution in its cost.

Hence, the evaluation device transparently uncovers that not only by structural reforming of the water governing system through the constitution of the ULRP, but also particularly via fulfilling its policy, the system and its entities can experience superior conditions. This issue reveals the function of political derivers on system state which are mediated by security (i.e. interaction rules;

regional divisions that affect $i, m \; and \; \alpha$), economic (i.e. agricultural expansion that increases J) and environmental (revival of UL that decreases J) factors.

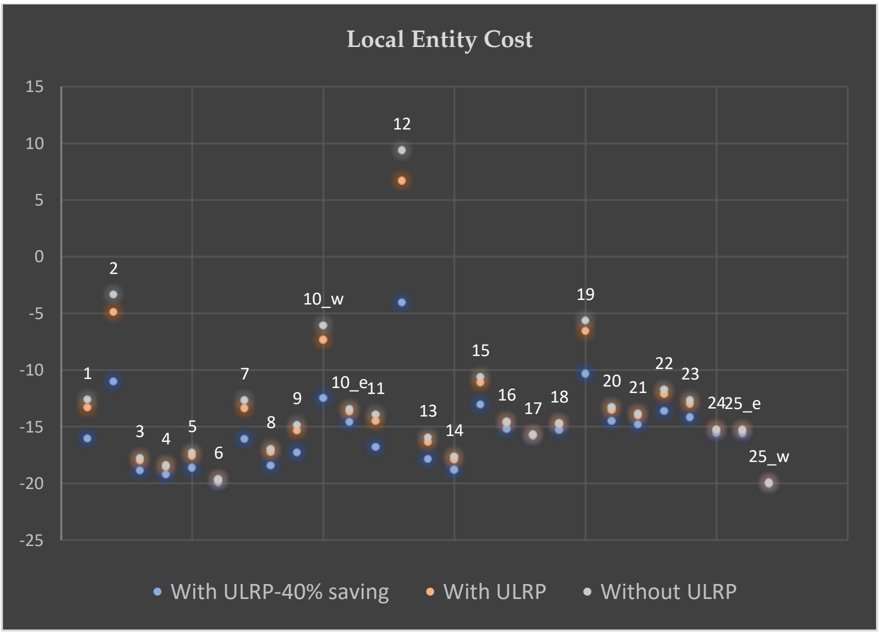


Figure 2.2.12 The local entities' cost rates: gray dots represent the rates before constitution of the ULRP; orange dots display the rates after incorporation of the ULRP and the blue dots manifest the rates subsequent to ULRP along with accomplishment of its water-saving policy, the entities are demonstrated by their relevant numbers (MOE, 2014) above dots.

As a spectacle, the status of the headquarters further endorsed the mode of local entities. Verily, their position got the same stream in the alleviation of their costs by the involvement of ULRP. To this end, the headquarters of West and East Azerbaijan provinces (2* and 19*), respectively, displayed a 31% and 70% decline in their costs after the inclusion of ULRP in the system. This enhancement was remarkable and reflected the significant effect of such modification on provincial level entities which interact with several lower (local) and upper (ULRP) level entities. Moreover, through the policy of 40% water-saving, it's recognizable that the headquarters can realize additional cost reduction. In this scope, the headquarter of West Azerbaijan exhibited a 68 percent and East Azerbaijan 1.16 times (relative to prior to the ULRP) deteriorations in their costs by fulfilling that policy along with the inclusion of ULRP in the system. These cost drop rates are respectively 2.18 and 1.64 times more than the situation which was placed solely by the vertical structural reform.

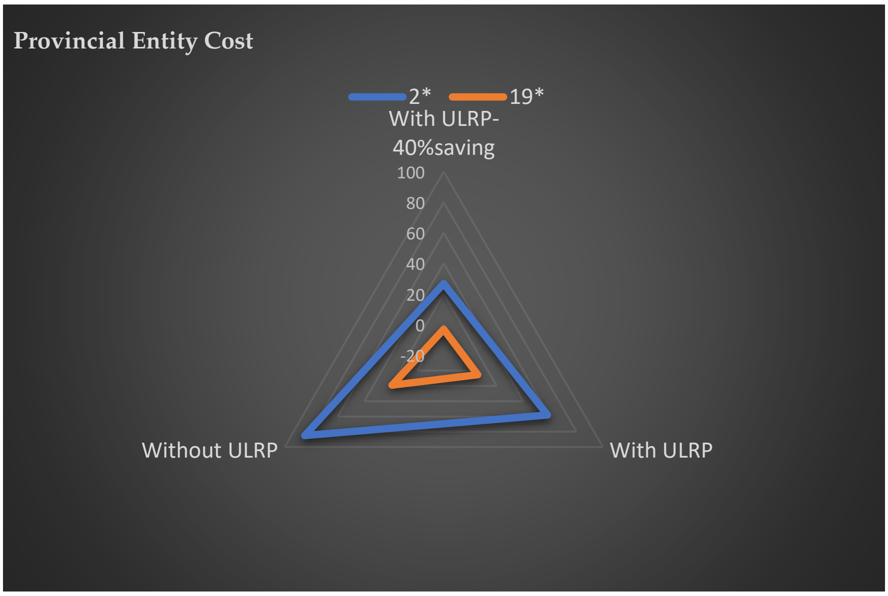


Figure 2.2.13 The provincial entities' cost rates: the blue color represents the values of the headquarter of West Azerbaijan and the orange color displays the relevant extents of the headquarter of East Azerbaijan based on various scenarios

Eventually, the system cost transmitted a perceivable refinement of around 25 percent by means of such vertical (re)arrangement. This rate could further be improved by means of the ULRP water-saving policy. Accordingly, the system cost was reduced by 59 percent through completion of such policy which is 2.39 times more than the pure structural reform effect on system state.

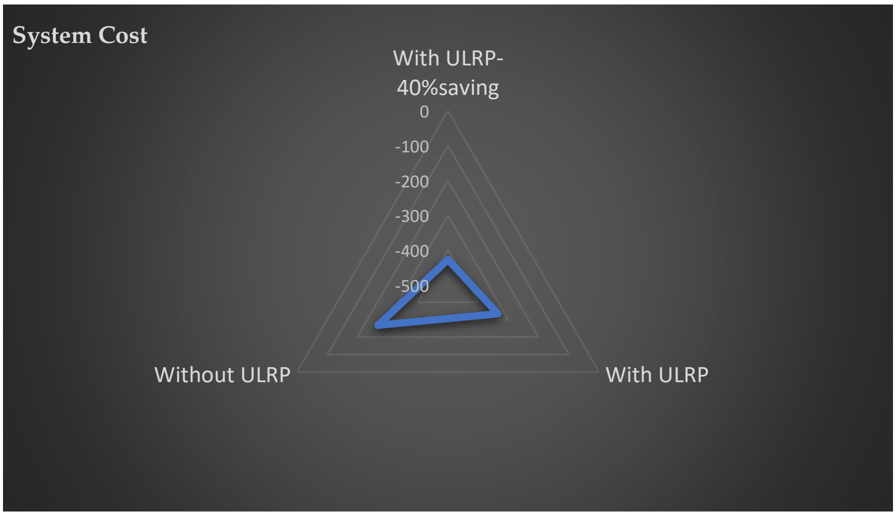


Figure 2.2.14 The system cost rate based on the concepted scenarios

As reflected, due to such structural modification in the water governing system, there was a revamp in all levels of the water demand-supply administration. Particularly, the provincial level entities which were dealing with the local utilities' interactions, benefited significantly through the reform. Also, some local entities that their interaction rates were proportionately larger than the others, could experience a noticeable decrease in their costs. This constructive effect is encouraging in system reform. In addition, a 40% water demand-supply decrease together with such a structural enhancement, could embed remarkable development in system fit conveying the unhandled interaction of the entity 12 to the handled arena. This means that by 40% reducing the water demand-supply volumes, these amounts enter to a criterion which is handleable by the system structure. Notwithstanding, regarding the success of the lake revival program, other political-administrative factors besides the timely and dedicatedly execution of the enforced environmental instructions may influence the Urmia Lake Restoration goal achievement (Pouladi et al., 2021) which are not the focus of this thesis.

2.2.2.2.2 Conclusion and outcome

By means of the introduced framework (Arjomandi A. et al., 2022), the effect of a vertical structural (re)arrangement on the state of the water (demand-supply) governing system in the ULB was evaluated. To this end, the Hamiltonian system cost was estimated in three states relevant to the preceding and following the incorporation of ULRP, also fulfillment of its water-saving policy. The system structures were shaped with respect to the interaction rules. The rules were instructed by political-administrative mechanisms associated with the previous and recent objectives of systems' (re)formation. In this scope, the objective of Urmia Lake Restoration as an environmental mandate was adjusted beside the primary goal of (military/political/economic) security. Driving the interaction frame by means of the rules of interaction, the structure of the governing system was tuned by the (rescaled) water demand-supply volumes (section 2.2.1.6). Correspondingly, the forces of interactions and external forces together mirrored the costs of entities and the system. **The outputs indicated that the vertical adjustment in the structure of the antecedent water governing system in the ULB in the year 2005, could have been advantageous**. In this domain, the provincial level entities in particular, and the local entities with larger water demands, manifested a considerable shrinkage in their costs through inclusion of the ULRP in the system. Indeed, such a declining feature was seized also regarding the system cost. This transpired the properness of the insertion of ULRP for improving the structure of the water governing system. Along with such structural improvement, the evaluation based on the 40% water demand-supply reduction in agricultural sector was further approved the betterment of system fit by fulfilling the ULRP policy. Indeed, by means of the accomplishment of this policy, all the interactions of entities were handled by the system structure, also, the entities could encounter more wane in their costs. As a significant achievement of the joint effect of the vertical structural reform following the constitution of the ULRP and its policy's feat in agricultural sector, the system cost decline reached to more than twice in comparison to the cost deterioration purely by the structural reform.

The outputs of the analysis also communicated the methodology's usefulness for assessing the effect of such a vertical reform. While the results acknowledged the variation of the fit of the human-generated system to the hydrological system with vertical (re)arrangements, they also stated the cruciality of the water-saving policy in agricultural sector which improves the system state and its fit.

Indeed, the analysis was focused on the structural fit of the water governing system to the UL basin through ULRP's incorporation and its agricultural water-saving policy's effect on system state. This doesn't exactly mean that the eventual outcome of the restoration of the lake has been satisfying on reviving the lake. Mainly, the aim of the study was to simply show the application of the developed framework in formulating the structure of the water governing body based on the vertical reforms. Truthfully, the success of such a program is connected with other determinant factors which their identification would need another comprehensive study. The findings of this study can expectedly convey a sort of utilitarian information for designing fitter water governing systems to the basin. Besides, they can help set fruitful policies for accomplishing such an aim in line with climate change adaptation and environmental conservation.

2.3 Micro level issues:

2.3.1 Agricultural sector's role on Urmia Lake's circumstances

In the ULB the economy and income mainly rely on agricultural and industrial sectors (Fazel et al., 2018). However, the agricultural sector consumes around 95% of the total available water in the basin (MOE, 2013c) to share its economic yield in the region.

As mentioned in section 1.2, beside the early agricultural development plans (1966-1979) in the era of the former political regime in Iran, during the 1990s in the new political constitution, the contemporary president of the country tried to foster the water resources development for agricultural expansion. This attitude was more reinforced by the plan of the privatization of the development during 1989-1997 which was prescribed as a solution to get the International Monetary Funds (Hoogland, 2009). Hence, the development of agriculture and respectively the allocation of water for agricultural plans were positioned at the heart of the government's program.

On the other hand, that period got associated with the time of increasing temperatures, further with decrease in snowfall within the basin triggering noticeable drought events since 1995 (Habibi et al., 2021). Also, Abbasi et al. (2019) pinpointed the 1998-2009 as one of the long periods of droughts in the region during the statistical period. Evidently, the agricultural water consumption has increased considerably between 1995 and 2010 (Taheri et al., 2019). Even more, Taheri et al. (2019) argued that one of the most important anthropogenic factors in elevating water consumption was the rise of the cultivation of water-based crops in the area during this period. Accordingly, it is understandable that besides the CC effect on the lake, its circumstance could have been influenced by the overexploitation of water resources for compensation of the deficiency of precipitation and/or excessive temperatures for farming. Shadkam et al. (2016) emphasized that climate and irrigation respectively have an impact of 60% and 40% on the lake inflow's decline. As well, it is stated that the irrigation water demand growth results from prolongation of droughts and their intensity which established a direct correlation between the growing agricultural water demand and climatic change (Fathian et al., 2015, Shadkam et al., 2016). Moreover, Alizade Govarchin Ghale et al. (2018) comparing the water balance of the lake with agricultural water use concluded that a human-made cause had determined around 80% of the lake shrinkage between the years 1998 to 2010. Likewise, Chaudhari et al. (2018) stated that man-caused influences during 1995 to 2010 had leaded to 86% of the lake decline. Prior to them, applying a system dynamics model, Hassanzadeh et al. (2012) identified that the alternation of the rate of direct precipitation on the lake, and the inflow decrease because of overexploitation of surface water, respectively, determined 10% and 65% of the lake volume loss. They also advocated the effect of the reservoirs (at a storage volume of roughly 1 km^3) around 25% on UL shrinkage. As recognizable, in common, the scholars have nominated both CC and agricultural water consumption as major reasons of UL drying up.

To get the overview of the recent trend of water resources and lands development for agricultural expansion in the region, besides demonstrating the probable changes in the lake volume based on provisioned agricultural policies, a sort of hydrological models was regenerated utilizing researchers experiments. To do so, inspired by the work of Schulz et al. (2020), the temporal extension of irrigated lands, water consumption and the reservoirs development were reproduced in MATLAB version R2020b (Figure 2.3.1). Indeed, the aim of this work was to help visualize the effect of politically deemed objectives and water allocation policies on Urmia Lake, and not to investigate the hydrological and climatic determinants of the lake state which overwhelms the scope of this thesis. Making use of other authors' studies in this part, I aimed to present a hydrological synopsis for the readers to perceive the issue more clearly.

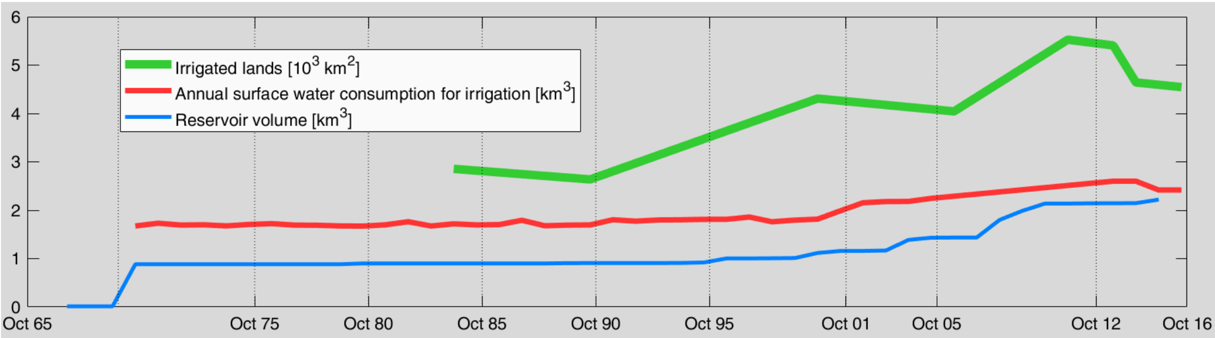


Figure 2.3.1 The temporal trend of the extension of irrigated lands and surface water consumption, also the reservoirs development in the ULB (inspired by the work of Schulz et al., 2020, plots were reproduced using MATLAB R2020b, for the requirements of this part)

As realizable from Figure 2.3.1, the evolution of land and water resources development for agricultural practices is in line with the discussed/addressed trend by the scholars. Respectively, since 1990 the irrigated agricultural lands have been remarkably grown. Particularly, by the end of that decade, reservoirs' capacity and surface water consumption were increased considerably. According to Schulz et al. (2020), in total, surface water consumption rates are high and often (notably in the recent years) surpassing the remaining inflow into the lake. Hence, based on this insight and other outputs of their study, **they came in conclusion that even if the huge**

withdrawal of surface water may not directly cause the significant failure in the lake level over the last two decades, it has seriously attenuated the lake resilience, making it vulnerable to climate change. Therefore, whereas our ability to mitigate climatic change effects, seems to be not sufficient in a short period of time, at least an urgent water-savings through the optimization of agricultural practices can alleviate a significant influence on the lake resilience.

Correspondingly, when the issue transited from the climatic (natural) boundary to the agricultural (human-made) realm, the mechanism of coping with the issue tackled (local/regional) management issues in the basin. In this domain, I tried to forward-simulate the state of the lake based on its recent circumstance, and the effect of two main policies on that. To this end, inspired by the work of Schulz et al. (2020), I forecasted the lake state within ten years (based on status quo) for the two documented and one hypothetical plans. The status quo state considers the mean of the period from October 2012 to October 2017 (based on the most recent available data) when the lake volume has been quite stable (Schulz et al., 2020). The basis of this forecast was founded on the climatic boundary conditions as follow (Schulz et al., 2020):

(i) Precipitation 303 mma^{-1};

(ii) Potential evaporation 1776 mma^{-1} , and;

(iii) Inflow 1.3 km^3a^{-1}

The forecasts were developed according to:

1) the newly enforced policy of 40% water-saving in agricultural sector by ULRP;
2) the previously development plan of the region which was associated with 25% increase in water allocation for agricultural expansion (Shadkam, 2017), and;
3) the vice versa of the extension policy which instead of 25% increase there could be a 25% decrease in water consumption of agricultural sector.

In a glance, the results indicated that assuming the climatic conditions remain almost as status quo for about 5 years, the 40% water-saving based on the ULRP strategy can lead to 36% increase in the lake volume within 5 years. However, if the previous plan of agricultural development be followed which is associated with 25% additional water consumption, the lake can lose around 40% of its current volume within 3 years. Nevertheless, if instead of increase, the water consumption could be decreased by 25%, the lake becomes more stable in 2 years keeping its volume about 5% above the status quo state (Figure 2.3.2 and Table 1).

Table 1 The changes in the lake volume (km³) based on different policies

Year	40% water saving	25% extra use	25% water saving
0	2.299	2.299	2.299
1	2.721	1.450	2.381
2	2.925	1.317	***2.402***
3	3.043	***1.359***	2.422
4	3.091	1.348	2.422
5	***3.116***	1.359	2.422

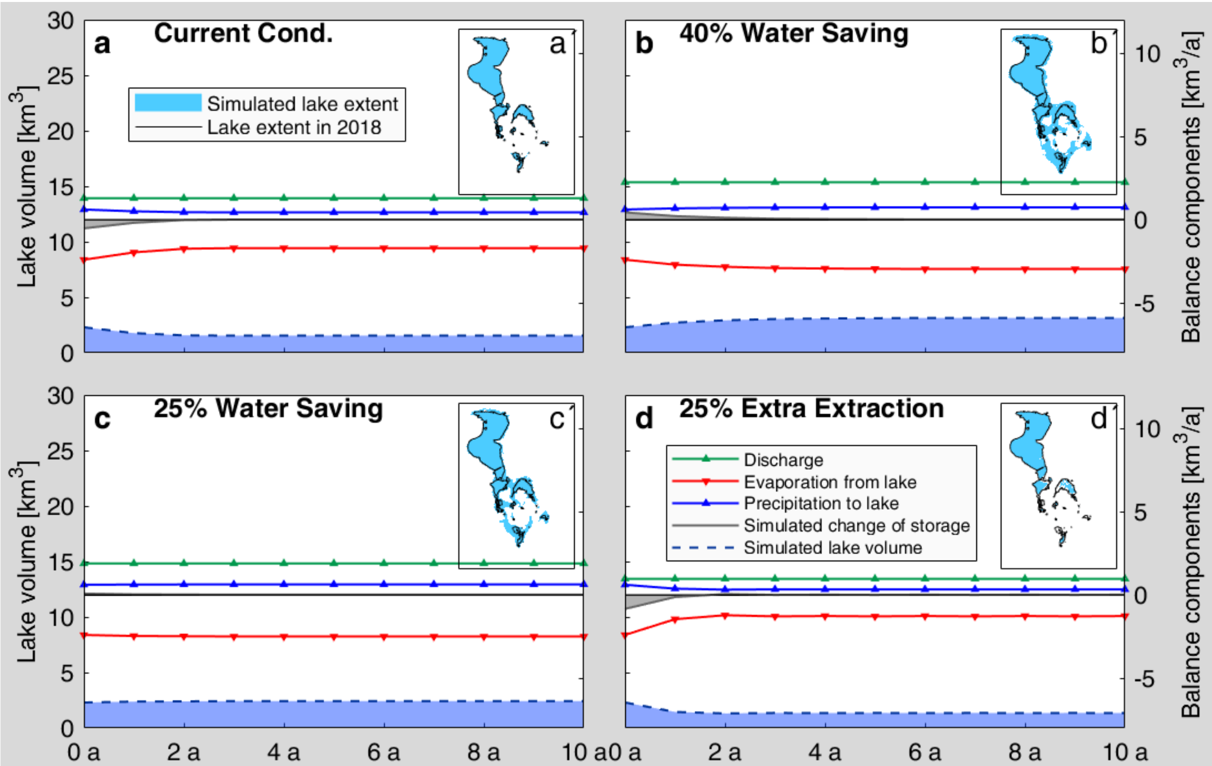


Figure 2.3.2 Urmia Lake status per various agricultural water consumption rates in line with the previous and recent water policies, besides a hypothetical policy of 25% water-saving (inspired by the work of Schulz et al., 2020, plots and maps are reproduced using MATLAB R2020b for the requirements of this study)

Institutionally, the purpose of agricultural water consumption reduction was a pioneer in the road map of ULRP (ULRP, 2015). However, such top-down strategy, eventually, faces the farmers' decisions as the main water consumers. Thus, farmers' bottom-up perceptions and compliance with the top-down implements can affect the policies success. To encourage and rationalize related water savings, the individuals' cooperation is key. Therefore, to explore the governing factors of water-saving behavior and disclose specific information in this regard the study approached to the realm of psychology and social sciences to investigate the pro-environmental behaviors of farmers in the ULB.

2.3.2 Exploring pro-environmental behavior and water conservation intention among the farmers in the ULB

Essentially, in arid and semi-arid regions (e.g. many parts of the Middle East) either droughts or political-economic circumstances have adversely affected the water and environmental states (e.g. Sowers et al., 2011; Distefano, 2021). There, water demand management is controversial (e.g. Postel, 2014; Banihabib and Shabestari, 2017). The supply-side policies often rely on predetermined decisions by the government respecting the development plans, and local factors like water resources availability. Whereas the top-down arrangements through the relevant authorities try to resolve the water supply initiatives in such contexts, the unmatched bottom-up outlooks on the demand-side, affect their goal achievements (e.g. Dettori et al., 2019; Mirdashtvan et al., 2021). Hence, the level of acceptance and agreement with top-down policies varies with undetermined bottom-up intentions perturbing the success of those programs (Boazar et al., 2019). Thus, demand-side management is crucial and water consumption reduction appears as a top priority in such contexts (e.g. Fernandes et al., 2011; Zekri, 2020). To this end, the impact of the main water consumers is critical.

In association with such circumstances, Iran is recognized as a water-scarce territory (Nazari et al., 2018) where the agricultural sector is known as the major consumer of water resources (Madani et al., 2016). Based on research, the problem of irresponsible usage or overexploitation in agricultural sector is predominantly apparent in various regions of the country (e.g. Hassanzadeh et al., 2012; Edalat and Abdi, 2018). Nevertheless, despite the seriousness of the issue and the extreme demand for water consumption reduction in the sector, operationally, it is reported as a “logy task” among Iranian farmers (e.g. Yazdanpanah et al., 2014; Yazdanpanah et al., 2015). Then, whilst the optimization of the agricultural practices can deliver a great potential for assisting water resources resilience (Mostafa et al., 2018), the challenge is how to initiate it within the farmers’ community.

Generally speaking, there are two categories of demand-led workings subsiding water consumption (e.g. Pearce et al., 2007; Raheli et al., 2020; Tajeri Moghadam et al., 2020). The first one is commonly deployed by governmental instruments such as price controls (e.g. Varela-Ortega et al., 1998; Soto Rios et al., 2018), water allocation and use restrictions, etc. and the second one flows by the voluntarily modulating actions of the users (e.g. Lee, 1981; Fielding et al., 2013) like as improvements in irrigation methods, cultivation of less water consuming crops and so on. Of course, both approaches seek water conservation and saving aims. While the regulatory interventions by the government can lead to fast but undesirable or impermanent reactions (Fielding et al., 2013), the voluntary operations are more admitting the sustainable water-saving behavior (e.g. Geller, 2002; Tortajada et al., 2019). However, voluntary exertions themselves may increase in association with the rise of awareness (e.g. Schwarz and Megdal, 2008; Tortajada et al., 2019). Environmental awareness can increase the value associated with the conservation of nature and natural resources (e.g. water) growing users' risk perception interlinked to the resource diminishment (e.g. Slimak and Dietz, 2006; Shahangian et al., 2022). To this aim, understanding the farmers' perception and knowledge about the influencing factors of the resource state and their willingness to come along with the resource saving strategies is essential. This realization can place a legitimate source of information in developing appropriate conservational policies.

To help create a concrete source of information for reinforcing water and environmental conservation, an empirical study was conducted within the case study region. To this aim, the research went through behavioral theories and the realm of environmental psychology to explain the farmers' water conservation intentions/behaviors.

According to Schultz (2000), commonly, there are two main streams in the scope of pro-environmental behaviors such as water conservation. One tackles the rational human approach, which is compatible with the traditional economic approach, and the other one meets the moral attributes (Figure 2.3.3). The rational human approach contemplates human behavior as a state of rational choice. To this end, for instance, the Protection Motivation Theory (Rogers, 1975; Rogers and Prentice-Dunn, 1997) or the Theory of Planned Behavior (Ajzen, 1991) are the introduced concepts based on this approach. On the other hand, the Norm Activation Theory (Schwartz, 1977) or the Value-Belief-Norm Theory (Stern, 2000) resemble moral approach models. Upon the rational approach, the farmers behave consciously to deploy actions returning them the maximum benefit within a particular condition by means of water conservation. Unlikely, in moral approach, farmers try to conserve water to benefit others and environment than taking into account their profits or benefits.

Indeed, the selection of an appropriate methodology to assess the individuals' behavior affecting the natural resources is essential for a credible analysis. This helps realize the intentions/behaviors and develop the requisite of behavioral changes (Steg and Vlek, 2009). Hence, a comprehensive study was carried out on different models of pro-environmental theories in association with the ULB's context. Furthermore, a thorough discussion and consultation in this regard was fulfilled with the experts at International Institute for Applied Systems Analysis (IIASA), Leibniz-Centre for Agricultural Landscape Research (ZALF) and the local academic and professional entities, besides some of the farmers in the relevant catchments of the study area. The outcome of this process led to make use of three main environmental psychology theories which were further enriched by additional proper factors.

Thereupon, the farmers' water-saving intention and behavior in the ULB was evidently assessed by means of the Protection Motivation Theory (PMT) and the Theory of Planned Behavior (TPB) as appropriate rational models in respect to the alarming consequences of UL vanishing. Also, the Norm Activation Model (NAM) as an appropriate device to evaluate those farmers' water-saving intention/behavior based on their feelings about their endangered environment (Figure 2.3.3).

Above all, it should be notified that the water-saving behavior study in the region was conducted in accordance with **the Declaration of Helsinki**, and approved by the Institutional Review Board of Urmia University of Technology (protocol code UUT/JAGR_AGR_009, 20 January 2022).

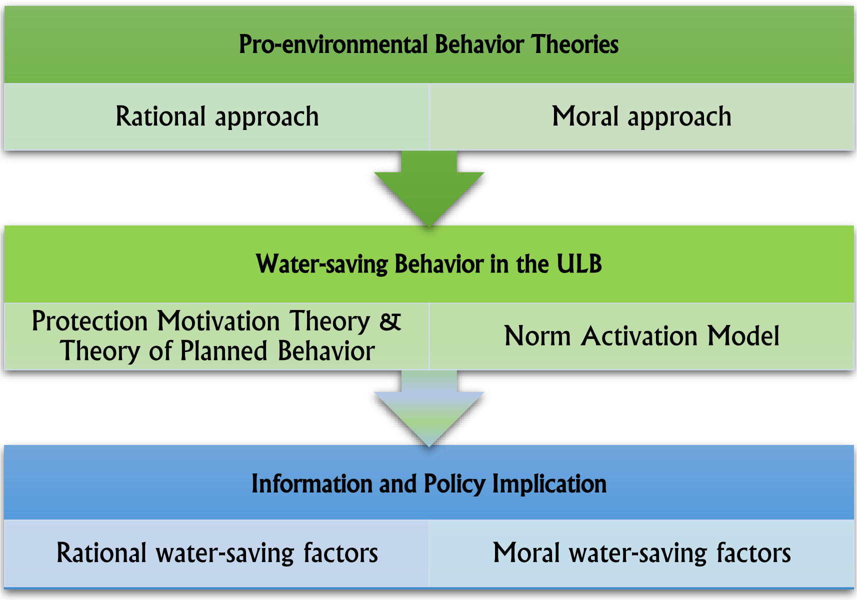


Figure 2.3.3 the main approaches of pro-environmental behavior

2.3.2.1 *Application of the Protection Motivation Theory and the role of Institutional Trust*

The sections 2.3.2.1.1-6 were published as:

Arjomandi A., P.; Yazdanpanah, M.; Shirzad, A.; Komendantova, N.; Kameli, E.; Hosseinzadeh, M.; Razavi, E. **Institutional Trust and Cognitive Motivation toward Water Conservation in the Face of an Environmental Disaster**. Sustainability 2023, 15, 900. https://doi.org/10.3390/su15020900

Abstract: The agricultural sector, in general, and in Iran in particular, is a major consumer of water and now finds itself under significant pressure due to water deficiency. This study used the Protection Motivation Theory to detect reasons for the imprudent consumption of water in Iran and to further its conservation. The Theory was extended for particular application to a seriously affected water basin, the Urmia Lake Basin in Northwest Iran. The factors governing water-saving intention among farmers in the Basin were investigated. Three hundred farmers were selected through a multi-stage, clustered, random sampling method. The results of structural equation modeling illustrated that while the original model variables accounted for 58% of the variance in water-saving intention, this rate increased to 63% in the extended model when institutional trust was used as a variable. Whereas response efficacy showed itself to be the strongest determinant of water-saving intention, all factors except perceived severity were significant in both models. Furthermore, the results of a multi-group analysis revealed that the intention to adopt water conservation measures is commensurate with the distance from the water resource and proximity to the (drying) lake. The findings of the study are expected to provide important information for policymakers looking to tailor policies to work in extreme water deficiency cases like the Urmia Lake Basin.

2.3.2.1.1 Introduction

> **To prevent repetition, the introduction section (2.3.2.1.1) was adapted to the PMT's requirements without discussing the case study information.**

If the water in Urmia Lake were to disappear completely, it would be a disaster for all concerned, as it could increase the danger of saline dust which is having noticeable impacts on the health and livelihoods of the inhabitants of the region (Dehghani et al., 2020; Feizizadeh et al., 2022; Maleki et al., 2018; Mohammadi hamidi et al., 2021; Samadi et al., 2019; Samadi et al., 2020). Other side-effects could also increase, for example, outward migration, increased unemployment, income reduction, with a corresponding fall in living standards, land remediation costs, healthcare costs, and feelings of hopelessness. Accordingly, the farmers' perception of the risk of Urmia Lake vanishing and the problems that this will cause are of fundamental concern in terms of farmers' decision-making regarding water-saving.

According to Grothmann and Reusswig (2006), self-protective behavior can reflect a person's perception of risk to a considerable extent. Moreover, belief in the efficacy and performability of a self-adopted strategy to deal with a problematic issue positively impacts people's protective actions. To characterize the vulnerability that farmers may feel due to the lake vanishing and water shortages that threaten their income, livelihood, and living environment—and also the decisions they may take to control the issue—one needs to consider how they make decisions. Understanding this will help provide insights into the protective actions they undertake when faced with circumstances that have direct effects on their property and income as well as indirect environmental side effects on other aspects of their well-being.

Individual decision makers cope with a threat in two main stages (Adger et al., 2009; Grothmann and Patt, 2005): first by perceiving the risk (threat), then by taking appropriate action (which can be an adaptive behavior) in response to it. Individuals' decisions regarding environmental risks can thus be influenced by their perceptions to the extent that they are able to orient their daily behaviors toward an adaptation pattern (Iglesias and Garrote, 2015; Kuruppu and Liverman, 2011; Mase et al., 2017; Menapace et al., 2015). Thus, if farmers could fully comprehend the issues related to the lake drying up, then this—alongside the already perceived/acknowledged risk of agricultural water deficit, which they already frequently experience—would trigger their motivation toward water preservation.

Based on this idea and using the PMT tool, the researchers evaluated: i) the factors influencing farmers' intentions to protect water and carry out environmental conservation; and ii) the effect of trusting in, and thus observing, governmental regulatory instruments. To the best of the authors' knowledge, no study to date has considered the effect of trust in governmental institutions (institutional trust) in a combination of PMT variables to evaluate the water-saving intention of the farmers in the ULB. The assumptions and data relating to the method used are described later in this paper.

The analysis was further developed based on the attribute of proximity to the lake, as this affects how farmers perceive the risk and hence how they develop the intention to act. Although this topic has been addressed by scholars (Brody et al., 2004; Peñalba et al., 2021), to the best of the authors' knowledge, a categorical analysis based on the farmers' locations vis-à-vis the lake, has never been conducted at the basin level. The findings of this study will include legitimate and pragmatic sources of information so that policies can be tailor-made for water consumption reduction in the agricultural sector based on farmers' actual water-saving intentions. Furthermore, these findings can be used within similar semi-arid and arid contexts where the agricultural sector is the major water consumer and there are related effects on the environment.

2.3.2.1.2 Theory, background, and hypothesis

The Protection Motivation Theory (PMT) was originally developed to help understand individuals' responses to fears arising from health threats. Its applicability has, however, broadened and it is now also used to assess responses to fear arising from natural risks and CC (Delfiyan et al., 2021; Grothmann and Reusswig, 2006; van Duinen et al., 2015). Nelson et al (Nelson et al., 2011) proposed using the PMT for a systematic analysis of water management campaigns to assess their effectiveness and success in achieving their objectives. The PMT benefits from the addition of parameters related to appraisal of threat and appraisal of coping which, together, help to clarify the intention of individuals to undertake a protective action. Pakmehr et al. (2020) used PMT to statistically investigate farmers' adaptation to the CC-induced water shortage. The present study aims to consider the majority of the above-mentioned concepts within an integrative approach that includes the implications of the receding waters of Urmia Lake. For this, we extended the model to combine the impact of trust in governmental measures (institutional trust) on the intention to conserve water using the main settings of the PMT. Accordingly, the farmers' intention to conserve water and their motivation to protect the lake were extensively assessed by both the original and extended models.

Generally, in the realm of health-protective behaviors, there are four main theories that share more similarities than differences (Weinstein, 1993). Of these, the health belief model [HBM] and protection motivation theory [PMT] are easier to apply in parallel with the theory of reasoned action [TRA], and the subjective expected utility [SEU] theory. Furthermore, some variables like response efficacy (RE) deserve greater attention in the HBM and PMT (Floyd et al., 2000). In a comparison between HBM and PMT, the difference arises from the acquisition mechanism. While the HBM incorporates a catalogue of behavior variables, PMT considers the relevant variables in two areas associated with the cognitive processes at the stages of i) appraisal of threat and ii) appraisal of coping when confronted by risk (Prentice-Dunn and Rogers, 1986). PMT is the only one of those four models that includes self-efficacy (SE) as a separate factor in its evaluation structure (Floyd et al., 2000). Moreover, the PMT is reported as the supreme environmental psychology theory for determining and illustrating health-protective behavior (De Steur et al., 2015). The PMT deploys a more rigorous framework for studying human behavior than other similar methods; this is so not only in health-related issues, but also in geographical sciences (McGuire, 1985). It has also been successfully used in assessing behaviors in the face of natural risks (Grothmann and Reusswig, 2006; Keshavarz and Karami, 2016; McCaughey et al., 2017; Schlef et al., 2018; SHANG and XIONG, 2021).

The PMT is an attractive variant of fear appeal theory, and it uses individual and social variables that jointly intervene in the cognitive decision-making process (Pakmehr et al., 2020). The main parameters involved in the organization of PMT are fear-induced, which can be predicted by considering the threat and the corresponding assessment of how to deal with it. In short, a comprehensive theoretical framework that is systematized by both the risk and coping appraisal aspects is used by the PMT (van Duinen et al., 2015). The threat- and response appraisal factors related to a given risk can embody an adaptive decision-making process, which is useful when studying and understanding intentions and behaviors in people encountering risk (Zhao et al., 2016). The threat appraisal encompasses an assessment of the severity of a given threat and the vulnerability to it. This stage depends on an individual's judgment regarding the magnitude of the severity of the threat, and the degree of vulnerability they feel to it. Likewise, in the coping-assessment stage, the ability to deal with the intensity and vulnerability related to the distinct threat is estimated. For this, the person uses tools such as the efficacy they can bring to deal with the risk or their ability to afford the costs related to the measures needing to be taken, as well as the efficiency of the strategy and actions to overcome the risk. If they assess the coping process as viable, then they may make corresponding protective arrangements.

As a whole, there are five main constructs framing the body of the PMT (Figure 2.3.4). Two of them, namely (i) Perceived Severity (PS) and (ii) Perceived Vulnerability (PV) are the threat-appraisal factors, and the other three perceived (iii) Response Efficacy (RE); (iv) Self-Efficacy (SE); and (v) Response Costs (RC) are used for the coping-appraisal tools.

The PS associated with risk reveals the extent to which a person may reasonably assume an upsurge in harm, and the PV indicates the anticipated impact of that hazard in terms of significant negative consequences for personal or related social/environmental initiatives. Moreover, RE reflects the expected adequacy of a solution to cope with the negative consequences of the risk, and SE refers to the belief in the performability of the prescribed solution based on personal competence and also the costs, RC, associated with solution integration.

For instance, in the context of the ULB, PS can be related to the effects of the drying up of Urmia Lake on the hydro-climatic and environmental characteristics of the region, which can lead to less arable land being available, especially if there are salt dust storms. Furthermore, it can assess the effect of such dust storms on the health of inhabitants or livestock, which can ultimately be problematic for day-to-day living, causing, among other things, hardship, poverty, and conflicts. Thus, if farmers perceive themselves to be vulnerable (PV) to these dimensions (PS), this self-reinforcing process can motivate their intention to protect the lake by saving water as a projected solution in this context. However, in the same way, they can evaluate the possibility of reducing their water consumption using sustainable operations. To do this, they may consider the effectiveness of a solution (RE), such as changing farming methods, products, and so on, in connection with its real cost (RC) and their potential to implement the solution (SE). Accordingly, if all this knowledge can be put into practice, farmers may be persuaded to undertake water-saving measures.

It is worth mentioning that although the utility of both the threat appraisal and the coping appraisal have been addressed in the literature, the coping appraisal is reported as the dominant estimator of intentions for protective behaviors (Floyd et al., 2000; Milne et al., 2000). Based on this, PMT is appraised as a worthwhile device for investigating the water-saving approach within a water-stressed environment, as it emphasizes coping constructs as essential components of persuasive communication (Ajzen, 1992; Hovland et al., 1953; Milne et al., 2000) for inculcating or preserving water protection behaviors.

Risk communication is a leveraging instrument for raising awareness of the risk. In water-scarce regions such as Iran, despite governmental arrangements to combat the effects of CC and droughts, the conservation of water resources has unfortunately, not been particularly successful (Yazdanpanah et al., 2015). In fact, encouraging compliance with governmentally tailored water and environmental conservation programs requires an understanding of the factors influencing farmers' water conservation behavior. Correspondingly, the mechanism of motivation toward change can be identified through the elaboration of a motivational tool. Increasing the level of awareness is proposed as just such a motivational tool (Kagoya et al., 2018; St-Laurent et al., 2019). However, the main issue is the imponderability of the solutions. To this end, "trust" in responsible authorities is declared as being a catalyst (Prager and Posthumus, 2010; Thaker et al., 2019). Not only in the water domain but also in other areas, trust has shown itself to be a substantial predictor of protective behaviors. For instance, according to Siegrist et al. (2000) trust is a major parameter for estimation of the perceived risks and advantages of a technology. Westcott et al. (2017) for example, emphasized trust in emergency services to save animals during bushfires.

Additionally, Lorenzoni et al (2007) discussed the role of distrust of government information with respect to CC issues in terms of the way it curtails public participation in policy outcomes. Moreover, it is argued that trust will, in due course, promote the acceptability of certain issues and assist with knowledge acquisition (Lorenzoni and Pidgeon, 2006). In fact, trust acts as a kind of a magnet in the water community that helps draw together both demand- and supply-side players in a structured configuration to confront a common loss. In this area, Paton (Paton, 2007 and 2008) outlines the role of trust in mediating the relationship between the structural placement of the participants and the preparedness for natural hazards. Consequently, trust is recognized as an influential component in the formulation of an evaluation tool to analyze the motivation to protect a common resource. This study thus uses trust in governmental entities in its extended form to assess the farmer's intention to adapt to save water and preserve the environment. Even though institutional trust (IT) has been emphasized in the literature, it has not received due attention in the PMT user community, particularly in behavioral studies on agricultural water conservation. In this study, the authors adapt it to PMT settings.

To conclude: the research was carried out in line with the following hypotheses (Hs), namely that motivation to protect in line with the restoration of a natural ecosystem (Urmia Lake) through agricultural water saving under drought and water scarcity will be likely if: (i) the severity (PS) of disaster associated with the drying up of the (hypersaline) lake and loss of freshwater resources is fully understood [H_1]; (ii) the significant vulnerability (PV) linked to the water deficit/shortage and to the environmental side effects is fully grasped [H_2]; (iii) the remediation prescribed (RE) is diagnosed as having the potential to work efficiently [H_3]; (iv) the implementation of the solutions is judged feasible and reasonable (SE) and (v) the affordability of the associated costs (RC) is also identified as being feasible and reasonable [H_4 and H_5]; and (vi) there is an acceptable level of trust in institutions (institutional trust) that can facilitate/accommodate this water-saving regime [H_6]. For this concept to work, it is assumed that except for the response costs (RC), which can have a negative effect on intentions toward adaptation, the other factors (PS, PV, RE, SE, and IT) will be positively associated with motivation toward water and environmental conservation.

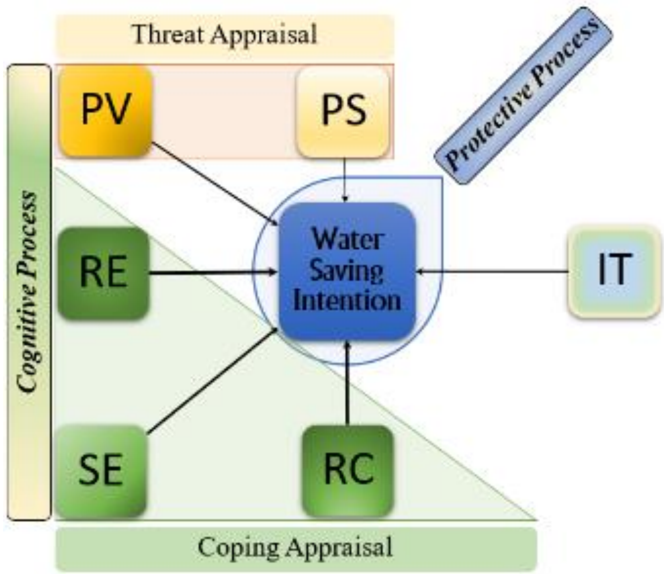


Figure 2.3.4 The organization of the Protection Motivation Theory.

2.3.2.1.3 Method

2.3.2.1.3.1 Participants

Following the literature and desk reviews, and in order to implement an evidence-based assessment of the farmers' intention to save water and to preserve the lake, a quantitative cross-sectional survey was designed. Accordingly, 300 farmers were selected for the survey through a multi-stage, clustered, random sampling method in agriculturally important locations. The zones of focus are located in western catchments of the Urmia Lake Basin—around Urmia City, the capital of West Azerbaijan province— where the availability of surface water, and also the extent of the incursion of saline dust storms driven from the lake shores, vary according to proximity to the lake (Figure 2.3.5). This attribute is associated with the decline in surface water volume by the time it reaches the lake. As the sources of the entering surface water to the lake are mainly the mountains on the western side of the lake, the waters become less and less plentiful as they near the lake as a result of upstream abstractions, evaporation loss, infiltration, etc. This arrangement was investigated in such a way that it could cover the study objectives related to the effect of proximity to water sources and the degraded lake.

The participants were all men aged from 24 to 75 years old, with a mean age of 54.06 years and a standard deviation (SD) of 9.73 years from the mean (the female farmers in the selected catchments refused to participate in the survey). The associated level of education of participants was in the following range: 5% not educated, 26% high school education, 36% diploma, 22% upper diploma certificate, 10% bachelor's degree, and 1% graduate degree. The mean family size of the sample was 3.97 persons per family. In terms of land tenure, more than 70% of the participants were the owners of their lands, and except for six farmers who only were utilizing surface water resources for irrigation, most of them were extracting groundwater for their needs, with 32% utilizing water from both sources.

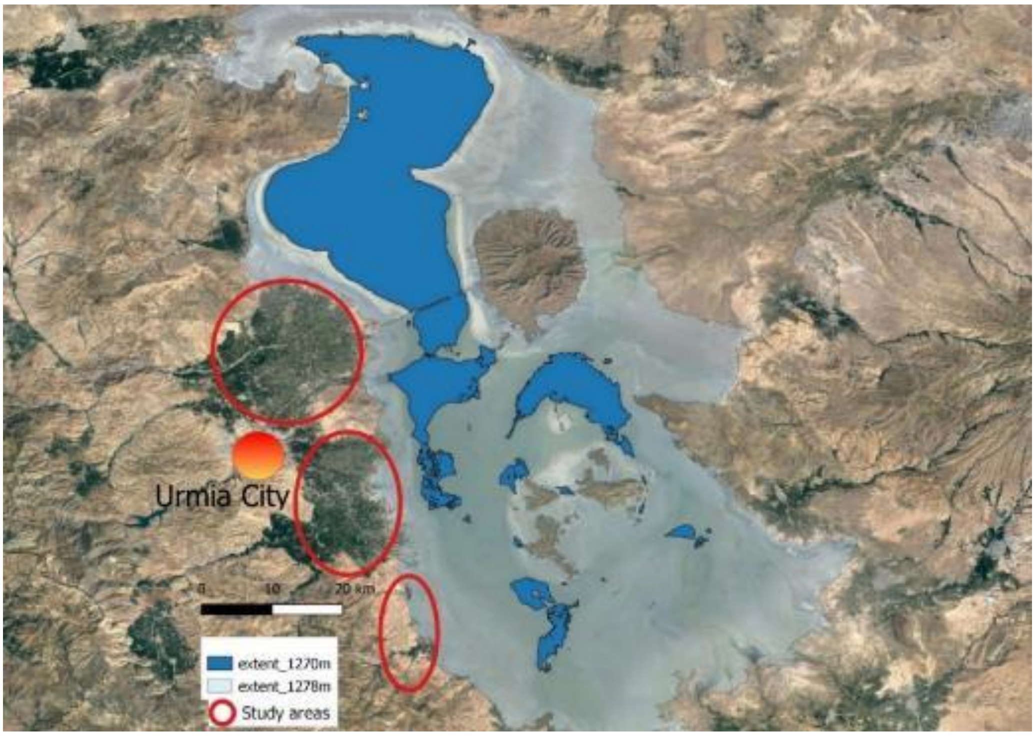


Figure 2.3.5 Case study catchments, western side of Urmia Lake, Iran.

2.3.2.1.3.2 Data and questioner

The main constructs and their appropriate associated variables were derived based on an extensive study of PMT applications in water and environmental concerns, with a particular focus on drought and water scarcity. Moreover, to enrich the appropriateness of variables, technical discussions were carried out with both academic scholars and experts from agricultural organizations (including environmental and socioeconomic specialists) together with some farmers in the region. Given the six hypotheses [H1- H6] outlined in section 2.3.2.1.2, and in line with the information obtained via literature/desk reviews and expert-user knowledge, a structured questionnaire encompassing the relating parameters and other socioeconomic features was elaborated for data collection. The indicators and measurement scales were validated using properties employed in former investigations (Chen, 2015; Gebrehiwot and van der Veen, 2021; Homburg and Stolberg, 2006; Pakmehr et al., 2020; Rainear and Christensen, 2017). Correspondingly, a utilitarian pilot assessment was conducted to scrutinize the internal reliability of the questionnaire by means of Cronbach's alpha test score. The results confirmed the range of acceptable to excellent rates with respect to the outputs. In general, this test displayed a scale of 0.651 to 0.917 (Table 2) which safeguards the transparency, relevancy, and credibility of the final questionnaire.

To mitigate the statistical problem of extreme skewness, during the questionnaire formulation, a 5-point Likert scale (1–5: strongly disagree–strongly agree), was tailored to all variables of the theory. We respected the farmers' right to accept or deny being interviewed and reassured them of their anonymous status. The survey was conducted by researchers personally in the chosen locations through face-to-face interviews during the early months of 2022. It should be mentioned that the participants received no financial or other inducements to engage in the process. The data were generally collected at farmers' dwellings, and questionnaires took about 40 minutes to fill in.

Table 2 The internal reliability of latent variables in PMT setup of the study.

Variable	Item
	Please express the extent of your agreement with the item (strongly disagree – strongly agree [1-5])
Risk Appraisal	Risk assessment according to the consequences of the disappearance of Lake Urmia and the increase of salt dust in the environment:
	PS (α: 0.839, mean: 4.213, SD: 0.822)
1	The extent of disagreements and conflicts will increase among the inhabitants of the villages and rural districts.
2	Hardship and poverty will increase in the region in addition to crimes such as theft and other wrong-doing
3	Summers will be warmer, winters drier, and environmental conditions will become more difficult for living.
	PV (α: 0.775, mean: 4.222, SD: 0.696)
1	The soil quality and the extent of arable land will be decreased
2	You or your family members will be prone to cardiovascular, respiratory, skin, and other diseases.
3	Your costs will have to increase to deal with the adverse effects of the lake drying up on livestock, land, and crops.
Coping Appraisal	To save the lake by means of modification of agricultural practices and water saving:
	SE (α: 0.651, mean: 2.847, SD: 0.963)
1	If I wish to, I can easily change my farming and irrigation methods.
2	I'm sure I can change the way I usually farm in a way compatible with reducing water consumption.
	RE (α: 0.917, mean: 3.679, SD: 1.162)
1	Fallow farming
2	Modification and optimization of crop cultivation methods
3	Cultivation of alternative and fewer water-consuming crops
4	Adopting protection measures to lessen the evaporation of water around the crop/plant roots
5	Collecting and (re)using the recycled water sources for irrigation such as rainwater or sewage
	RC (α: 0.802, mean: 3.109, SD: 1.064)
1	I'm not used to changing my farm irrigation methods
2	Changing my method of irrigation will reduce my income
3	Learning the skills and methods of cultivation and growing of the alternative or low-water consuming crops is time-consuming and tedious for me
	Intention (α: 0.875, mean: 3.067, SD: 1.132)
1	I intend to provide the necessary items to cultivate alternative crops and fewer water-consuming ones.
2	I intend to use recycled sources of water such as sewage or rainwater for irrigation
3	I intend to participate in meetings and training courses about agricultural water consumption reduction
4	I plan to start optimizing my farm's canals/irrigation system soon
	Added Construct (in the extended form)
	IT (α: 0.889, mean: 2.528, SD: 1.296)
1	I trust governmental institutions.
2	The information provided by governmental agencies is reliable.

2.3.2.1.4 Analysis methodologies and results

Following the early phase statistical analysis of the participants' socioeconomic circumstances (e.g. age, education, land tenure), as mentioned before, the internal reliability of constructs was assessed through Cronbach's alpha coefficient using IBM SPSS Statistics 27(George and Mallery, 2019). Additionally, a Pearson's correlation test was conducted to investigate the relationship between the latent variables. The results of this test revealed that, except for SE, the contributing variables were significantly correlated with the water-saving intention (Table 3).

Table 3 Pearson's correlations (PMT)

Variable		PS	PV	SE	RE	RC	IT	Intention
1. PS	Pearson's r	—						
2. PV	Pearson's r	0.584 ***	—					
3. SE	Pearson's r	-0.090	0.063	—				
4. RE	Pearson's r	0.748 ***	0.498 ***	-0.076	—			
5. RC	Pearson's r	0.097	-0.176 **	-0.354 ***	-0.002	—		
6. IT	Pearson's r	0.405 ***	0.271 ***	0.287 ***	0.517 ***	-0.281 ***	—	
7. Intention	Pearson's r	0.488 ***	0.391 ***	0.049	0.535 ***	0.201 ***	0.170 **	—

** p < .01, *** p < .001

Furthermore, to assess the effects of those variables on intention—as a dependent variable—and to test our hypothesis, the structural equation modeling (SEM) method was applied using IBM SPSS Amos 27 (Thakkar, 2020). The hypothesis was modeled in two forms: i) the original form in which the five main constructs of PMT affect the intention (Figure 2.3.6), and ii) the extended form, including the institutional trust (IT) as an influencing factor on water-saving intention (Figure 2.3.7). SEM is a comprehensive multivariate path analysis method that incorporates a statistical approach to testing hypotheses about influences among dependent variable(s) and latent factors/constructs (Hoyle, 1995). In the "International Encyclopedia of Education–Third Edition" (Peterson et al., 2010), it is indicated that SEM is an extension of factor analysis and has the objective of testing evidenced theories by pragmatic data. The measurement model in the SEM framework is a confirmatory factor analysis (CFA) model in which the latent variables are deduced from the conjectured variables (Bagozzi, 1994). Uni-dimensionality of the indicators of each factor is an essential requisite of this method, and the validity of the constructs are gauged in the model based on this default. Brown (Brown, 2015) argued that CFA is a tool that can help further verify the latent structure of a test instrument (e.g., a questionnaire) by taking into account the relationship between factors and their underlying variables (factor loadings). These factors and their reflecting variables, which together make up the measurement model, can be correlated in the CFA mechanism. The issue of construct validity includes several requirements. In this context, a key point is the fit of the measurement model according to the observed data. This fit should be consistent with the criteria emphasized by the majority of scholars. In this domain, the smaller the model test statistic, the better the fit (Bentler, 1995). Moreover, there are other indicators that should be considered as approximate fit indices (Rose et al., 2017). These indices provide complementary components to evaluate the model fit. To this end, some rates commonly specified by experts (Bentler, 1995; Kenny, 2015; Kenny and McCoach, 2003; Marcoulides and Yuan, 2017) are summarized as the comparative fit index (CFI), normed fit index (NFI), and goodness-of-fit index (GFI) ≥ 0.9; the adjusted goodness-of-fit index (AGFI) ≥ 0.8, and the root mean square error of approximation (RMSEA) ≤ 0.08.

By evaluating the construct validity of our research instrument using CFA, SEM was systematized to analyze the path between intention and other variables according to the two aforementioned PMT combinations. Respectively, the original and extended models, both showed good fits—χ^2 (chi-square) ≤3—based on the estimation of maximum likelihood (ML). This fact is further supported by good approximate fit indices. Correspondingly, the original model showed very good fit criteria, and similarly, in the extended model, the same outcomes with slightly inferior rates were captured (Table 4).

Table 4 Approximate Fit Indices (CFA-PMT)

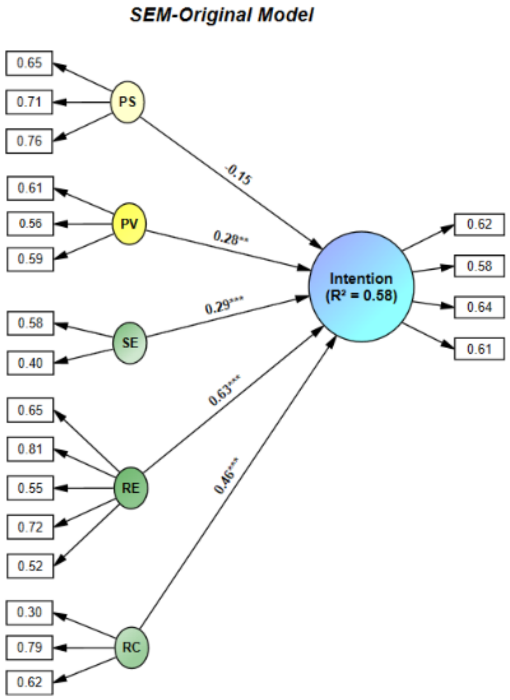
	Indexes	RMSEA	Cmin/df	CFI	NFI	IFI	GFI	AGFI
SEM (CFA)	Recommended value	≤.08	≤3	.9≤	.9≤	.9≤	.9≤	.8≤
	Original PMT	.07	2.7	.931	.896	.932	.889	.838
	Extended PMT	.07	2.8	.921	.884	.922	.872	.817

Based on the measured effects of the estimators (on intention), apart from the PS, all the factors showed a significant influence on the intention to save water both in the original and extended models (Table 5).

Table 5 The effects of estimators on intention (PMT)

	Original Model		Extended Model	
Reg.coe	β	P	β	P
Factor				
PS	-0.149	0.236	-0.143	0.289
PV	0.281	0.001	0.233	0.013
SE	0.287	< 0.001	0.416	< 0.001
RE	0.633	< 0.001	0.819	< 0.001
RC	0.456	< 0.001	0.429	< 0.001
IT			-0.266	0.005

Interestingly, the outputs of the extended model, projected a considerable increase in the rate of the relationship between intention and SE, as well as RE, after the contribution of institutional trust. Furthermore, while the predictors of intention in the original model explained 58% of its variance, they revealed a better estimation rate, 63% of its variance, in the extended model. This value strongly increased the role of institutional trust in increasing the intention to save water, which is related to efficacy parameters. On the other hand, contrary to expectation regarding the effect of cost on intention, this did not show up as negative in the outputs. Indeed, contrary to assumptions, institutional trust revealed an inverse relationship with intention.



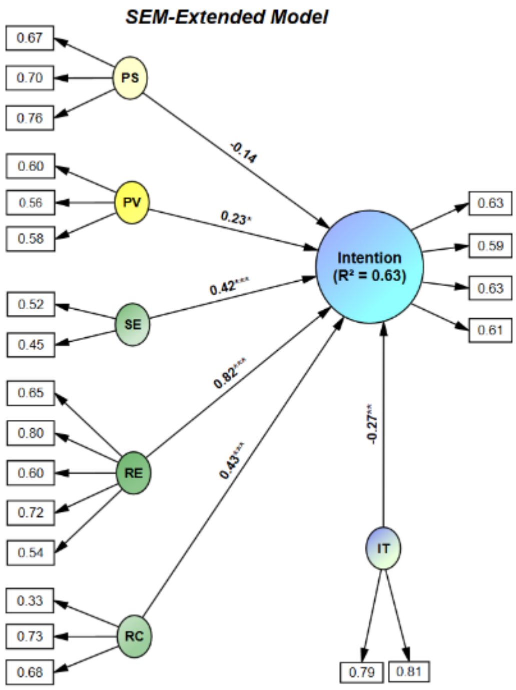


*Figure 2.3.6 The original SEM-based model (** p < 0.01, *** p < 0.001) Figure 2.3.7 The extended SEM-based model (* p < 0.05, ** p < 0.01, *** p < 0.001)*

The SEM-based analysis was even further revitalized using estimations in association with the proximity to the lake which, to date, have not been considered in the water-saving behavior studies for the ULB. According to the literature, specific contextual characteristics and personal experiences may also interfere with risk perception and adaptation to prevailing conditions. For instance, residential proximity to a water body is reported as a significant factor in understanding the water body and the risks related to it (Brody et al., 2004; Peñalba et al., 2021). Our work thus tackled an extra hypothesis about the moderating role of distance from the lake. Accordingly, it was assumed that "the distance from the lake does not have a significant effect on the determinants of intention". In other words, the distance of a farmer's residence from the lake does not affect the performance of factors affecting a farmer's intention to save water. If this hypothesis can be rejected, the possibility that proximity affects intention is significant enough to be considered. Statistically, this means that there is a significant difference between the unconstrained (base) and constrained (hypothesized) model.

Within the region, based on the distance from the lake, 32% of the farmers live very close to the lake (up to 5 km) ("Near"), 43% live between 5 and 10 km of the lake ("Middle"), and the rest are located over 10 km from the lake ("Far"). A "multi-group analysis" was conducted, which showed some peculiar results. In a first step, the null hypothesis was rejected based on the correctness of the basic (unconstrained) model. In this regard, the difference between the degrees of freedom of the two models was 12, with a chi square of 21.579 and a p-value of 0.043, which shows the significance of the difference between the unconstrained and constrained models. Then, the effect of proximity to the lake was investigated in the three groups "Near", "Middle", and "Far". The results showed that the effect of proximity to the lake was greatest on the "Middle" group. For farmers in the "Far" group, however, the relationship between proximity to the lake and the estimation of intention factors was not significant at all. The results of this analysis showed that in the "Middle" position, the effect of proximity was especially noticeable from the significant effects of SE, RE, and RC ($P < 0.001$), even more so regarding institutional trust ($P = 0.02$), and PV ($P = 0.03$). Regarding intention, however, the relationship between PS and intention was not significant ($P = 0.1$). Nevertheless, in the "Near" field, variables were less sensitive to proximity. For example, in addition to PS ($P = 0.99$), PV ($P = 0.189$) also did not show a significant relationship with intention. Similarly, the significance of the relationship of institutional trust with intention was lower compared to the "Middle" position ($P=0.06$). However, both RE and RC remained in the same situation ($P < 0.001$) as the "Middle" group, and SE ($P < 0.02$) still had a significant relationship with intention.

2.3.2.1.5 Discussion

The Urmia Lake region, with a mean annual winter temperature of below -10 °C and a mean summer temperature of around 40°C, is classified as having a Mediterranean pluviseasonal–continental climate (Sharifi et al., 2018). The region has been used for agricultural and animal husbandry for millennia (Azizi and Rezalou, 2020). While, historically, climatic fluctuations have been experienced in both wet and dry periods (Khoshravan and Jabbari, 2015), the impact of the recent prolonged droughts has been more significant (Mirgol et al., 2021). Social-ecological systems rely to a large extent on balancing mechanisms for the dynamics of their systems to be sustainable. In developing areas, however, there is a debate as to how best to balance environmental and development needs (Dixon and Carrie, 2016). In such contexts, a severe early-phase problem, such as paying for the daily necessities of life, can be more visible/influential than the later consequences of environmental disasters. In the ULB, it is significant that while the agricultural sector requires a large amount of water, this need is, in fact, contributing to the disappearance of the lake, and in due course, the region as a whole will suffer adverse effects. Governmental interventions are addressing the problems by expediting arrangements for the lake restoration. To make these strategies work over the long term, the cooperation of the farmers is required. The farmers' cooperation is thus a major determinant of success. Farmers' intentions should thus be analyzed in depth, as this will further facilitate cooperation, which is vital given the status quo regarding CC, the reduction in the waters of the lake, the environmental effects of the drying, as well as the farmers' own belief that water is becoming scarcer.

Trust-based communications can boost information within the farmer's community (Haynes et al., 2008; Marion Suiseeya et al., 2021), with trust playing the role of a "promoter of acceptance". Trusted communications would be able to draw a picture of future conditions linked to the dramatic decline in water resources and lake volume. It can also be pointed out in such communications that lake loss will adversely affect the whole region at a certain point. Moreover, the government is aiming to solve the problems by ordering the expedited restoration of the lake, and for the long-term implementation of these strategies, the cooperation of farmers is essential. The establishment of joint "trust in the information source," "threat perception of resource status," and "efficient and feasible solutions" can lead to farmers' decisions to undertake water- and environment-saving strategies. The design of government policy and regulations to protect lakes and water resources should thus take into account (i) farmers' perceptions of both the risks associated with the drying of Urmia Lake and their adaptation strategies, and (ii) the need for increased trust in the institutions communicating the risk and proposing solutions to deal with it.

In line with this concept, research was formulated to acquire evidence-based information to assist in the development of feasible policies based on empirical data. A dedicated study was undertaken to identify tools able to assess farmers' perception of risk with respect to the drying-up of Urmia Lake and the deterioration in water resource supply and quality in the region. The PMT is an exceptional tool for this purpose, as it incorporates components of risk and a well-defined appraisal of both threats and coping. Moreover, the PMT showed its flexibility in terms of using context-based variables in its evaluation mechanism (Pakmehr et al., 2020), as well as the ability of its framework to embrace institutional trust in different fields (Al-Rasheed, 2020; McCaughey et al., 2017; Tapsuwan et al., 2017).

To sustain top-down provisions to save water and maintain the existence of the lake in the region, bottom-up actions are indispensable (Hudson et al., 2019). However, to make this setup work as smoothly as possible, institutional trust can play a critical role (St-Laurent et al., 2019). The research thus aimed to evaluate the function of institutional trust by incorporating it in the original structure of the PMT. Both models satisfied the requirements of the analytical device relating to fit indices. Based on the results, apart from the PS, all the (latent) variables were shown to be significant predictors of water-saving (protective) intention. Notably, whereas PV and RC in both models maintained the relationship with intention in almost the same ranges, the coefficients of RE and SE projected a considerable rise in the extended model. Furthermore, the extended model accounted for 63% of the variation of (protective) intention while the original model accounted for 58%. This increase endorsed the inclusion of institutional trust in the PMT framework, increasing its predictive power in our case.

The results revealed response efficacy (RE) to be the strongest predictor of intention to conserve the water/lake. RC and SE ranked second and third, respectively. These results can be well characterized by disclosing the results of multigroup analysis to assess proximity to the lake. Based on the results of this evaluation, the "Middle" group showed more connection with the proximity of the lake than the others. Indeed, this feature seems reasonable if the comparison is applicable only to the "Far" and "Middle" groups. However, the fact that the influence of proximity (to the lake) on the intention to conserve water of the "Near" group also ranked below the "Middle" group, may raise questions.

These results are, in fact, mainly related to the appraisal of risk and coping. Farmers who live near the lake are the ones with the least benefit from surface water resources. They, more than any others, face the destruction of the lake. Thus, the PS about the state of the lake has already exceeded the threshold of perception in their cognition process. In addition, their perceived vulnerability (PV) has become distorted by their prolonged experience of water scarcity and by the frequent incursions of salt dust. They thus consider themselves as already being “inside the problem” of PV; they have moved on and are trying to introduce a coping strategy to manage the needs they have, including water. However, their agenda may be more concerned with seeing to their immediate needs than saving the lake (development versus environmental needs). Thus, coping factors that connect to water (self-)management practices in particular remain stronger than risk perception factors for the “Near” group. Although institutional trust was not a statistically significant determinant of intention in this population, its effect cannot be fully judged based on the p-value (0.06). Logically, institutional trust may oscillate between "high” and “low" because the government is hardly able to provide the expected minimum of water, despite its promises; farmers and the local population still need government support and they rely on solutions provided by government instruments to combat the effects of disappearing lakes and dust storms. Additionally, as mentioned, the “Near” group sample was smaller than the “Middle” sample, which may indicate sample size issues in the estimates.

It is clear why the “Far” group, which had greater access to surface water sources, did not show any relationship with the proximity to the lake. As mentioned, the “Middle” context reflects the greatest sensitivity to the proximity of the lake. This group of farmers was further away from the lake and at the same time had less access to water resources than the “Far“ group. Therefore, this group reflected the conservative intention, namely, to conserve water and the lake. Even though their intention was not significantly connected with PS, their perceived vulnerability (PV) was significant, as the amount of water they were able to obtain became less attainable. Here, the importance of PV is related to the reduction in rainfall and access to water, more encounters with salt dust storms than in previous years, temperature anomalies, and so on. In addition, their coping phase factors (RE, RC, and SE) showed stronger relationships with their intention compared to other groups, and the importance of institutional trust was reflected in their group. This group appears to be the most compliant community in terms of following government actions regarding lake restoration and water conservation.

As specified in Table 5, except for the PS, the attributes of the underlying parameters—deduced from the relevant data (300 farmers)—confirmed their role as an estimator in the settings of the PMT. Furthermore, in accordance with results from other studies (De Steur et al., 2015; Kantola et al., 1983; Milne et al., 2000), the coping appraisal constructs are apparently more dominant estimators than the risk appraisal factors. PV, as a variable of the risk appraisal phase emphasized its significant relationship with intention, specifically among the “Middle” group. PS was not singled out as an estimator of water/lake saving intention. The explanation may be that farmers still do not realize or believe in the true consequences of the lake drying up. This stems from their partial perspective that covers only the most tangible problems and information exchange within the limited local boundaries of their residential environments. Basically, their level of education (67% without college or university degree) shows that it is very difficult for them to obtain comprehensible information from advanced sources of knowledge such as research centers, universities, virtual university websites, and so on. On the other hand, information provided by government agencies, for security reasons, may filter out some information that raises public concerns. This can also reduce the perceived severity of the threat to the area, which is significantly related to health issues. Hence, the potential damage that could be caused by the disappearance of the lake may be obscured for the risk perception. However, the risk of unavailability of the required water can remain strong. In this context, the severity of the risk is complex.

Due to the long-term familiarity with water scarcity and drought in the region, the issue is not raised in a range that can meet the severity indicators in the knowledge of farmers. On the other hand, the farmers of the region hesitate to take responsibility for the deterioration of water resources and strongly emphasize the responsibility of the government to supply the water they need. In other words, they optimistically reassure themselves that the government can somehow solve their problems. Therefore, even though institutional trust is fully present, it inversely affects the intention to conserve water/lake. This point is clear in the relationship of institutional trust with intention, which is negative. Another aspect worth mentioning is that trust is less important in the “Near” group than in the “Middle” group. This may indicate a decrease in confidence in the competence of government programs to provide "expected" water following the growing experience of water scarcity. This can lead to reduced trust in such institutions. Despite this, if perceptions of the "expected" amount of water can be changed to some degree in line with CC effects through awareness raising, adaptation can be improved by enhancing perceptions about coping tools. This can be achieved by trusting the government's information about risk and countermeasures. Obviously, other factors can influence farmers' intentions, which were not investigated in this research. Further extensive research to evaluate their value for enriching the model is worth implementing.

In terms of policy implications, this study confirms the effects of the main PMT variables, except PS, on the motivation to protect water and the environment. Therefore, formulating appropriate policies to encourage the intention of farmers to protect water and the environment under the effects of CC in the ULB can benefit from these factors. Moreover, as the inclusion of institutional trust in the model increased its predictive power and the relationship of efficacy variables (RE and SE) with the intention, it is recommended that the dimensions of institutional trust be considered in such policy formulation. As observed, coping evaluation constructs convey most of the estimated weight of water conservation intention. Accordingly, RE, RC, and SE are the dominant determinants of the intention to save water in the farmers' community. Therefore, the government should adopt a comprehensive approach to strengthen farmers' information about methods of reducing water consumption and increase their awareness. This may be implemented through the educational arms of the institutions concerned such as the Agricultural Extension Service. In fact, in addition to the goal of proposing an efficient methodology, farmers' understanding of the application of the proposed solutions (efficacy) should be characterized by government support. This scope can be enhanced by introducing low-cost adaptation techniques or cost-effective practices (McKenzie-Mohr, 2011; Rosa et al., 2020).

While simple individual strategies are key, government support can dramatically increase water and environmental savings. The government can facilitate and strengthen access to water through the creation of relevant and efficient infrastructure, in addition to injections of appropriate loans or subsidies to review water saving plans at the farm level. This service can be especially suitable for the community of farmers who are far from water sources and close to the lake. Although financial and monetary support from the government is important, it should not be the main goal of projects in the field of institutional assistance. Instead, the main focus should be on the cognitive barriers affecting the adaptation process in the farmers' community. To solve this issue, policies should be designed to meet awareness-raising goals with their associated courses of action (Grothmann and Patt, 2005). Considering the government's role in persuading actions toward water conservation, trust in government institutions is decisive for strengthening the degree of farmers' belief in government actions. Therefore, maintaining institutional trust at a secure level should be considered as an essential element in policy formulation.

After discussing the PMT variables related to the policy field, this research can express other aspects resulting from the influence of proximity to the lake. In the light of multi-group analysis, it is recommended that policies be prepared more proportionately. The results of the evaluation show that residents of different districts can have different perceptions based on their proximity to the lake and water sources. Accordingly, the "Middle" group showed a significant perception of vulnerability, while the others did not. Moreover, institutional trust and other related factors were more meaningful for this group. This may indicate that this group is more willing to accept proposed regulations to save water and the environment. Hence, farm-level support by the government can facilitate the adaptation process, while in the “Near” category, institutional trust is prone to be overlooked. This may be due to the feeling of hopelessness from not having regular access to water, in addition to the stress of recurring dust storms, which may collectively make this group feel neglected. As a result, policies need to be implemented that make large investments in transferring water to their regions and strengthening their confidence in guidelines that may save water in their agriculture. Of course, both “Middle” and “Near” communities should be supported by individual level grants as discussed. Although the results showed a dissociation between determinants and intention in the “Far” group, the authors also had concerns about the issue of sample size that could be propagated in the attribute calculations. However, the fact that this group has the dominant access to water resources with the least noticeable effects of lake drying cannot be ignored. Likewise, policies could consider a restrictive approach through fines or other means to control water use in their areas. After all, crop change policies can be applicable to all groups.

2.3.2.1.6 Conclusion

The PMT model was successfully examined in this research, and insights into its use were provided. The model investigated the water-saving intention of farmers in a severely CC-impacted basin (ULB). The outcomes illustrated that efforts to motivate the farmers to save the water and lake that are instigated by public/governmental instruments can achieve reasonable outcomes if the process of motivation toward conservation is designed and implemented in a sound manner. As well as governmental planning aiming to incorporate the immediate provisions, the lake can be sustainably protected by the farmers voluntarily saving water, provided that they are well briefed and they consent to the measures applied. A huge effort is needed by both macro/meso (organizational) and micro (individual) level players for successful outcomes.

Hence, a detailed strategy to broaden farmers’ PS by increasing their level of awareness about the side-effects of Urmia Lake vanishing should be initiated at the basin level. Accordingly, the appropriate techniques for water-saving (RE) should be extensively explained to help farmers realize the procedures for water-saving and adopt the appropriate methods based on their own Self-Efficacy. The costs in relation to these water saving processes (RC) should be supported by proper financial aid (e.g. loans) from financial institutions (e.g. banks). Moreover, the cognitive barriers should be overcome regarding institutional trust to make farmers aware of the limited availability of water resources and the possibility of its reasonable supply by the government. On the other hand, the effect of institutional trust is important in communication and acceptance by farmers of the risks of Urmia Lake disappearing and of the water-saving solutions needed to help the lake restoration. Thus, this factor should be taken into account particularly in relation to the farmers whose location is “Near” to the lake and who have low access to surface water resources. To this end, the government should try to maintain the “Near” group farmers’ institutional trust by investing in water infrastructure and ensuring a fair water supply in their area.

Farmers as micro-level players should be well aware of the importance and necessity of conserving Urmia Lake, which can be implemented by sparing agricultural water consumption. Therefore, the perceptions, cognition, and experiences of the farmers regarding the ways in which the lake and water resources are deteriorating, along with the actions related to them, can support the drawing up of improved and appropriate plans to cope with the situation. This, in turn, can lead to a fruitful system of cooperation between government institutions and farmers.

2.3.2.2 Expanding the rational approach by means of the Theory of Planned Behavior

2.3.2.2.1 Introduction

As mentioned in section 2.2.2.1, the ULRP was constituted to help revival of the lake. Indeed, such a huge program with the clear goal of 40% water-saving in the agricultural sector has been dealing with the farmers community in its substance. Therefore, it is expected that the farmers have been informed directly or indirectly about the ULRP and its strategies to save water for the lake revival. On the other hand, the analysis based on the PMT uncovered that PV is among the significant determinants of the water-saving intention within the farmers' community. Having these attributes, an analyst may see the basis of further evaluations by means of the Theory of Planned Behavior (TPB) since not only there are reasonable intimations about the farmers hearings about the water-saving importance but also the significance of PV reveals their perception of the consequences of the lake drying up, thus the necessity of planning for water conservation. Except for this reasoning, protection motivation may not necessarily lead to actual behavior due to major barriers as lack of time, money, knowledge or other resources (Grothmann and Reusswig, 2006). Such shortages may not be counted at the time of intention forming (Grothmann and Reusswig, 2006). PMT, hence, well recognizes the intention but may underestimate the actual behavior. Therefore, to analyze a post intentional or volitional phase, the TPB was utilized to assess the farmers' water conservation behavior. During volitional phase it is expected that the farmers develop strategies and plans in order to ensure that their intention will be enacted (Milne et al., 2002).

2.3.2.2.2 Theory, background and hypothesis

The TPB (Ajzen, 1985; 1991) is a prominent social cognitive framework that schemes variance in volitional behavior (Yazdanpanah et al., 2014). It is an evolved version of the Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975).

TPB implies that the key proximal determinant of an action is the person's behavioral intention to engage in that behavior (Conner, 2020). *Behavioral intention represents one's motivation in the sense of her or his conscious plan, decision, or self-instruction to exert effort to perform the target behavior* (Conner, 2020).

TPB outlines three factors as the determinants of behavioral intentions. They are represented as (i) attitude toward the behavior, (ii) subjective norm concerning the behavior, and (iii) perceived behavioral control (Ajzen, 1991). It is noted that the perceived behavioral control (PBC), the perceived ease or difficulty of performing the behavior, is equivalent to the self-efficacy (Ajzen, 2002). Subjective norm is a social factor which implies that a person may decide to perform or not to perform a behavior based on the perception of a social pressure that is induced by the opinions of those who have a significant impact on the person (Ajzen, 1991; 2002). Attitude refers to a favorable or unfavorable evaluation of a behavior by a person (Ding et al., 2020). To date the TPB has been employed to study a range of behaviors in water arena such as water-saving and conservation (e.g. Yazdanpanah et al., 2014; Warner and Diaz, 2021; Mahdavi, 2021; Si et al., 2022), water conflicts analysis (e.g. Mohammadinezhad and Ahmadvand, 2020; Veisi et al., 2020; Tatar et al., 2022), water pollution control (e.g. Wang et al., 2019; Mu et al., 2023) etc.

Accordingly, having the scientific basis of the application of the TPB for analysis of the water conservation behavior of the farmers, the circumstances which discussed in section 2.3.2.2.1, and the context of the ULB, employing the TPB, further behavioral assessments were conducted in line with the rational approach. To do so, the model was formed based on the following hypotheses (Figure 2.3.8) including the IT in its extended form matching up with the PMT model.

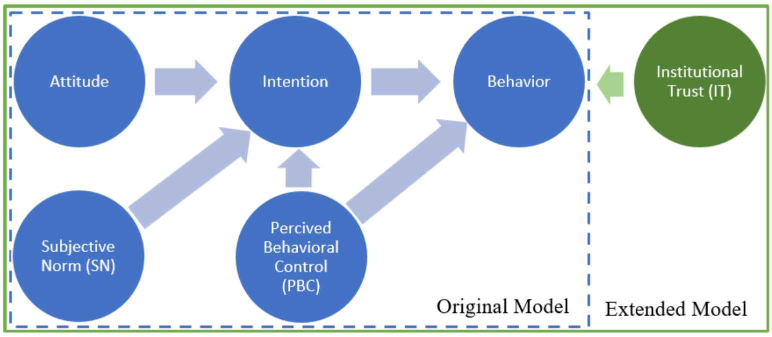


Figure 2.3.8 The Original and Extended TPB Models

i) Original model hypotheses:

1. Attitude to help revival of the lake through water-saving has a significant effect on water conservation intention [H_1];
2. Subjective norms for preserving the lake through water-saving can significantly affect the water conservation intention [H_2];

3. The perceived behavioral control (self-efficacy) on water-saving has a significant effect on water conservation intention [H_3];
4. The perceived behavioral control (self-efficacy) on water-saving has a significant effect on water conservation behavior [H_4];
5. The intention for preserving the lake through water-saving has a significant effect on water conservation behavior [H_5];

ii) Additional hypothesis to extend the original model:

6. Trust in (governmental) institutions' propositions for preserving the lake through water-saving has a significant effect on water conservation behavior [H_6]

2.3.2.2.3 Method, questionnaire and data

The method has been explained in section 2.3.2.1.3, and the questioner which was developed based on the six hypotheses in the previous section and the explained procedure in PMT analysis, is enclosed in this section (Table 6). The data were collected based on the following questioner for the TPB analysis.

Table 6 The internal reliability of latent variables in TPB setup of the study

Variable		Item
		Please express the extent of your agreement with the item (5-point scale from "Strongly Disagree" to "Strongly Agree")
Attitude (α: 0.912, mean: 3.043, SD: 1.214)		
	1	Reducing agriculture water use is wise to preserve the lake
	2	Reducing agriculture water use is very useful for preserving the lake
	3	Reducing agriculture water use is always (and in every season of the year) necessary to preserve the lake
	4	Reducing agriculture water use is a priority to preserve the lake
SN (α: 0.822, mean: 3.603, SD: 0.953)		
	1	People important to me approve of my behavior if I reduce water consumption to preserve the lake
	2	People important to me expect me to use less water for farming to save the lake
	3	My family and friends encourage me to use less water for farming (to save the lake)
PBC/SE (α: 0.651, mean: 2.847, SD: 0.963)		
	1	If I wish to, I can easily change my farming and irrigation methods.
	2	I'm sure I can change the way I usually farm in a way compatible with reducing water consumption
IT (α: 0.889, mean: 2.528, SD: 1.296)		
	1	I trust governmental institutions
	2	The information provided by governmental agencies is reliable
Intention (α: 0.790, mean: 3.816, SD: 0.913)		
	1	I tend to use farming methods that require less water.
	2	I want to modify my crop cultivation methods to reduce water consumption
	3	I intend to incorporate protective measures such as watering at night to reduce water consumption
Behavior (α: 0.867, mean: 3.518, SD: 1.125)		
	1	I reduce my water consumption by optimizing the route, shape, dimensions, and cover of watering channels
	2	I change the basin irrigation to furrow
	3	I encourage other friends and community people to reduce agricultural water consumption

The Cronbach's alpha test was conducted to evaluate the internal reliability of the questionnaire based on the pilot test data which its results confirmed the range of acceptable to excellent rates with respect to a scale of 0.651 to 0.912 in the domain of the contributed variables to the model (Table 6). Thus, like the PMT, the credibility, transparency, and relevancy of the final questionnaire was confirmed.

2.3.2.2.4 Analysis methodologies and results

The analysis methodologies encompassed the same as section 2.3.2.1.4, however, the used software to do the analysis was JASP-Version 0.16 (Love et al., 2019). Thereupon, compatible with the PMT method, the results of the TPB analysis are disclosed below (Table 7, 8 and 9).

Table 7 Pearson's correlations (TPB)

Pearson's Correlations

Variable		Attitude	PBC	SN	IT	Intention	Behavior
1. Attitude	Pearson's r	—					
2. PBC	Pearson's r	0.120 *	—				
3. SN	Pearson's r	0.411 ***	0.108	—			
4. IT	Pearson's r	0.292 ***	0.287 ***	0.290 ***	—		
5. Intention	Pearson's r	0.244 ***	0.291 ***	0.280 ***	0.318 ***	—	
6. Behavior	Pearson's r	0.138 *	0.069	0.390 ***	0.500 ***	0.485 ***	—

* p < .05, *** p < .001

Table 8 Approximate Fit Indices (CFA-TPB)

	Indexes	RMSEA	Cmin/df	CFI	NFI	IFI	GFI
SEM (CFA)	Recommended value	≤.08	≤3	.9≤	.9≤	.9≤	.9≤
	Original TPB	0.08	2.90	0.937	0.908	0.938	.981
	Extended TPB	.078	2.85	0.934	0.903	0.935	0.977

The results of Pearson's correlation test (Table 7)–to investigate the relationship between the latent variables–exposed that all the contributing variables were significantly correlated with the water-saving intention. Also, except PBC, all variables were significantly correlated with the water-saving behavior. Whereas PBC and SN did not correlate with each other, the other variables correlated strongly with each other.

The outputs of the CFA–to evaluate the reliability and validity of the measurement model–projected a very good fit in both original and extended models (Table 8).

Afterall, the results of SEM (Figure 2.3.9 and Table 9)–regarding the effects of predictor variables on intention and behavior based on the test hypotheses–revealed that except Attitude, in both models, the given factors have significant relationship with the water-saving intention and behavior. However, the PBC has a negative relationship with behavior despite the hypothesis. Furthermore, IT confirmed its significant positive effect on behavior in the extended model. As a spectacle, the contribution of the IT in the model similar to the PMT constitution, increased the predictive power of the model. To this end, while the predictors of the intention and behavior in the original model explained 29% and 40% of their variances respectively, they showed an enhanced estimation rates of 31% and 55% in the extended model.

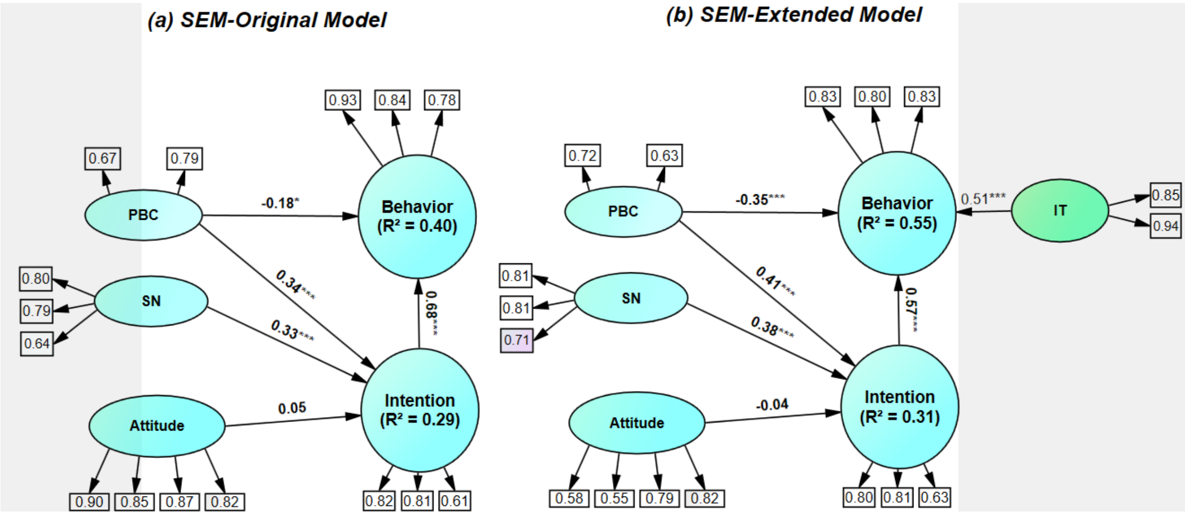


Figure 2.3.9 The original (a) and extended (b) TPB SEM-based models ($p < 0.05$, *** $p < 0.001$)*

Table 9 The effects of estimators on intention and behavior (TPB)

		Original Model		Extended Model	
Predictor	Outcome	P-Value	β	P-Value	β
Attitude	Intention	0.520	0.053	0.640	-0.043
SN	Intention	< .001	0.333	< .001	0.377
PBC	Intention	< .001	0.344	< .001	0.408
PBC	Behavior	0.026	-0.178	< .001	-0.346
Intention	Behavior	< .001	0.684	< .001	0.567
IT	Behavior	—	—	< .001	0.512

2.3.2.2.5 Discussion

The results evidenced that the attitude is not affecting the intention significantly. Therefore, despite the hypothesis, this factor was not found as the determinant of the water-saving intention. Attitude is composed of cognition, affect and conation in association with the belief about attitude object (Ajzen,1989). Behavioral belief is associated with an attribute of the object which its subjective value will impact the person's belief (Ding et al., 2020). Beliefs from the subjective appraisal of behavior or object can lead to an act which the intention regarding that act is its major determinant. Consequently, based on scholars, attitude influences the intention after a process via theoretical analysis and practical exploration passing through the cognition, affect and conation (Ding et al., 2020). Therefore, the adoption of water-saving measures to restore the lake can not only depend on the attitude of the farmers, but also on other influencing external factors (Ajzen and Madden, 1986). Indeed, the belief about the feasibility of UL restoration through agricultural water-saving is controversially interlinked with the farmers attitude for water conservation. Whereas, a positive attitude can denote the opinions and feelings of the farmers as short-term sights, the creation of a behavioral intention can also be impacted by the action or opportunity costs of the lake revival relevant arrangements as well as their related uncertainties in a long run. Therefore, although the farmers may have a positive attitude toward the lake and water conservation, they may not transform it to the intention for stepping in water-saving measures which can lead to challenges for short-term achievements. This can also be connected with the lack of experience in incorporation of the water-saving measures. Farmers who have only heard of the water-saving methods/technologies without their real implementation/application may have some reservations in shaping an attitude toward them. To this scope, Fazio et al. (1982) expressed that a direct experience with an object can lead to form an attitude towards it. Upon this statement, another factor supporting the insignificant relationship of farmers' attitudes with water-saving intention can be their unsensed contact with water-saving workings and their lack of empirical experience in this arena.

The SN confirmed its significant effect on water-saving intention and nominated itself as a determinant of the water conservation intention. According to the theory of reasoned action (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975), besides the beliefs about the outcomes of performing a specific behavior which is interconnected with the attitude, the normative beliefs are associated with the subjective norms. Normative beliefs manifest the strength of the influence of social communities in affecting a person's behavior. Beliefs stem from a certain behavior or object, so the subjective norms eventuated by beliefs can influence people's intention (Ding et al., 2020). In fact, the belief in responsible water using apart from its relation with the lake revival, tangibly has existed within the society of farmers in such a dry region for centuries. Even though, during the recent decades due to a fast-paced agricultural development, the farmers have increased their water consumption, their old belief in usage of water with care is still in power. This matter has also roots in their cultural and religious beliefs which emphasize on responsible water usage. Therefore, there, normative beliefs about caringly consuming water are strong and thus, the subjective norms have produced a power affecting the water-saving intention of the farmers based on such early shaped opinion.

Ajzen (1989) stated that besides the behavioral and normative beliefs which determine the attitudes and subjective norms, the control beliefs determine perceived behavioral control (PBC). The PBC represents the belief about the feasibility of performing an act either with the presence or absence of the required resources and utilities (Ajzen, 1989).

Whereas the PBC demonstrated its significant positive effect on intention, this factor revealed a significant negative relationship with water-saving behavior. Ajzen (1991) argued that to perform a real behavior, the influence of non-incentive factors such as ability and time should be counted. Thereupon, although some farmers may become motivated to save water and the lake if other community members deploy actions in this line, they will not step in real actions unless they become confident of overcoming the obstacles and difficulties in this way. Indeed, the cost, time and availability of the required tools and facilities associated with their control on the planned performance can significantly affect their actual behavior. To this aim, the certainty or uncertainty regarding the desired outputs of the action is also impactful. Furthermore, two extremes in behavior are pinpointed by Ajzen (1985). First, the type of acts which are often controllable, and the second type of acts which are out of individuals' control. The majority of the behaviors fall between these two extremes, Ajzen believed. However, he emphasized the role of habits which is indicated as an obstacle for behavioral control. Overcoming habit issues also could be associated with a cost which is considered by the farmers who are willing to change their irrigation or farming methods for saving the water and lake. In analysis based on the TPB, while PBC affects the water-saving intention positively, it negatively affects the behavior. As a matter of fact, intention is a perceptual cognition, whereas behavior is a complex endeavor. The farmers may intend to perform a certain behavior if they conclude that it is not hard to save the water and lake. In spite of this conjecture, several factors shall be taken into account when PBC is directly transformed into behavior.

In the ULB, the majority of the farmers, given their age, education and financial conditions do not have the facilities or utilities to conduct water-saving implements. If they decide to transform their PBC into water-saving action, they need to consider the potential risk, cost, habitual changes, as well as short/long-term benefits, opportunities or disadvantages. On the other hand, Gong et al. (2016) mentioned that the small-scale farmers (such as many farmers in the ULB) are careful to avoid the risk of yield decline. Therefore, even though farmers can positively estimate their ability to change their farming/irrigation methods, they may have stronger PBC over their conventional methods. Based on this, they prefer acting based on their usual methods than the new ones which to them, the new methods require more effort, cost and time. Hence, farmers in the ULB, given the impact of uncertainties and habits, resist developing their control for the new real water-saving actions despite their intention for that. This attribute embeds the negative relationship between the PBC and behavior even if the PBC positively affects the intention.

Ultimately, IT as an extended variable, significantly and positively affected the water-saving behavior in the model. As discussed within the PMT analysis (section 2.3.2.1), trust in responsible institutions supports adaptation to water conservation (Thaker et al., 2019). Trust role plays as a conservation acceptance promoter for implementing a collaborative water-saving approach. It is stated as a relationship mediator between the structural placement of the participants and the preparedness for natural hazards management (Paton, 2007 and 2008). On the other hand, to the best of my knowledge, to date IT has not been applied as a determinant factor of the water-saving behavior in the ULB within the TPB analysis models. Therefore, in this study, I did an additional hypothesis based on the mentioned attributes, furthermore, in line with the conducted PMT analysis (section 2.3.2.1) to evaluate the effect of IT in TPB's constitution. Hence, according to the H_6, it was assumed that IT affects the water-saving behavior positively and significantly which the analysis results evidenced this concept. Thereupon, besides the discussed main variables of the TPB, IT also revealed its effect in the extended model. Indeed, the contribution of the IT in the model increased its predictive power which is remarkable. To this end, the predictors of the intention and behavior in the extended model explained their variances with higher estimation rates of 31% and 55% respectively in analogues to the original model rates (29% and 40%). Hence, consideration of the impact of IT as an influential factor on water-saving actions in the region shall deliberately be highlighted.

2.3.2.2.6 Conclusion

Expanding the rational approach for water conservation analysis in the ULB, the TPB model was successfully examined for the research aim. The model provided more insights for understanding the real action or volitional phase (a post intentional stage) determinants to incorporate water-saving implements with the ultimate goal of the lake revival. The outputs demonstrated whereas PBC, equivalent to the SE in PMT analysis, can have a significant positive effect on water-saving intention, it negatively impacts the behavior due to external forces. Ascribable to the difficulties arising from the influence of uncertainties and habits interlinking to the risk, cost, opportunities or disadvantages in short/long term, the farmers are hesitant to transform the PBC into water-saving actions. Thus, although the PBC affects positively their intention, this construct makes a negative relationship with the behavior. Also, the weak belief in feasibility of UL restoration through agricultural water-saving and lack of experience in incorporation of the new water-saving workings (associating with an assumptive cost and uncertainty), interrupt the relationship of the attitude with intention of the farmers to revive the lake through water-saving. SN as expected positively affected the intention, hence, it should be noticed as a predictor of the water-saving intention for setting the appropriate water conservation policies in the region. IT enriched the model and revealed its positive and significant effect on water-saving behavior. This variable proved its improving effect in both PMT and TPB models for strengthening the predictive power of the models. Hence, its position in behavioral analysis and behavioral change strategies design in the ULB should be considered.

Upon the findings, the water-saving opinion and belief should be scaled up and reinforced to boost the effect of the SN within the farmers' community. This provision eventually can lead to an increase in the water-saving intention, thus behavior. Importantly, the policy design should tackle increase of the awareness about the effectiveness of the water conservation for the lake revival by communication and dissemination of the scientific data, information, and results into the society. This mandates the close cooperation of the academic entities with responsible governmental organizations such as the agricultural extension units to plan for interpreting and spreading the outputs of studies, modeling, simulations and so on among the ordinary/uneducated farmers. Such a strategy also shall lead to growth of the attitude for water-saving since it expectedly can increase the belief in the feasibility of the lake restoration through water conservation. However, attitude can also be influenced by the lack of experience in incorporation of new water-saving implements. Hence, besides reducing the uncertainties about effectiveness and efficiency of water conservation measures and methodologies (to save the water and lake and belief raising) specifically by means of trust in government's proposed and planned solutions (IT), specific facilities shall be provided helping farmers to experiment and contact with the new methods and instruments. This process can encompass a living lab approach (McPhee et al., 2021) or other similar provisions. Nevertheless, facilitating financial supports such as bank loans can help farmers deal with the associated water-saving costs and start practicing new methodologies. This event can decrease their uncertainties and increase their ability of overcoming habits, also, their PBC on new workings. It is transparent that IT should be maintained at a high level since it not only directly affects the water-saving behavior but also implicitly through reducing uncertainties about the viability of the lake revival can have positive effects on the attitude. Such schemes for decreasing the uncertainties can also be developed by presenting the lessons learned from local, national or international cases through the in charge scientific and administrative entities. The decline in uncertainties accompanied with further perception of the opportunities or advantages can support the direct positive relationship between the PBC and behavior. Withal, given the effect of the IT, a cooperative plan by both academic and executive institutions for dispensing the knowledge to the farmers community, thus increasing their belief in, and understanding of the lake restoration through water-saving should be arranged. Such movement can also indirectly develop and spread normative beliefs and lead to SN's strengthening in their society.

2.3.2.3 Application of the Norm Activation Model and the role of Place Attachment

This section is under preparation for submission (2023) as

Activation of Personal Norms for Water Conservation and The Role of Place Attachment

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2.3.2.3.1 Introduction

Beside the rational approach for understanding water conservation behavior in face of environmental consequences a question may raise here that "do moral factors also interfere in protection of UL and the environment?". To answer such question, I decided to investigate the encouraging variables of farmers' ethical responsibility, morality and environmentally friendly actions by decreasing their water consumption and then help restoration of UL.

Scientists have argued that moral respect can lead to the preference of a collective interest to one's own self-interest (e.g. Van der Werff and Steg, 2015). Simply saying, following the environmental protection measures as one's less water usage–despite its effect on the person's income or convenience–to benefit the environment and others is considered as a kind of altruistic behavior (Charnov and Krebs, 1975). This means that farmers who decrease their use of water to support the environment and eventually the other inhabitants in the region, may not achieve the immediate or desired benefits like the satisfactory yield, expected harvesting or the interested income. Although, the probability of the impact on the livelihood is high, due to the ethical responsibility and feelings farmers may step in this stream (Hamid et al., 2021).

On the other hand, extension and awareness programs developing the understanding of the value of water-saving for the environmental conservation such as UL ecosystem can play a key role in rise of the environmental realizations of farmers in the region. This realization may nevertheless evoke their moral consciousness in common. Therefore, based on the programs that implemented in the ULB to broaden the farmers' vision on CC effects and environmental devastation and complication, it is possible that the farmers' moral cognition about saving the water and environment has grown in the ULB.

Apart from that, the majority of farmers, furthermore their predecessor, grandparents, parents, and relatives have been living in the region since many years. This can convey a memory/feeling which associates farmers' moral sentiments by the area. Therefore, theoretically, the farmers' behavior not only can be shaped by the rational factors but also can be influenced by the moral parameters. Thereupon, the study tackled farmers' moral considerations on UL's condition, furthermore their living area, and hence their water-saving actions. To conduct the assessments regarding the farmers' intention for water and environmental conservation based on moral determinants interlinking to the circumstances of the case region, the Norm Activation Model (NAM) was utilized.

In 1977, for the first time, Schwartz suggested the concept of personal norms (PN) to explain altruistic behavior (Schwartz, 1977). The concept is associated with the self-expectations for distinct action in specific circumstances which can be discerned as feelings of moral obligation (De Groot and Steg, 2009). PN are enterprise of value-based perceptions shaping by edification inducing from social interactions about how should or should not behave in situations (Rosenthal and Ho, 2020). Having a strong personal norm implies that an individual is intrinsically motivated to assert a pro-environmental behavior even if it is costly (Van der Werff et al., 2013).

As an instrument of PN function, NAM captures the process of an altruistic behavior by the agency of the sense of moral obligation. However, such obligation feelings based on the appropriateness or strongness of the obligation can be neutralized by defensive cognitions (Schwartz, 1977). When a person becomes aware of the consequences of his/her act on others (as well as environment), and accept the responsibility of that behavior, the personal norms manifest their activation. Yet, the norm activation may be irrelevant to the situations that return high costs to the actors due to insertion of a restorative act. This is associated with the denial of the personal responsibility which is exerted through defensive cognitions. Thus, individuals will sense an obligation to incorporate the altruistic approach if personal norms could be activated along with the rejection of the defensive interfering cognitions (Schwartz, 1977). Researchers underpinned that an ascription of personal responsibility can be provoked by the awareness of consequences. This results in formulation of a personal norm with the ultimate achievement of altruistic intentions/behaviors (e.g. Clark et al., 2003; Bamberg and Möser, 2007; De Groot and Steg, 2009). Therefore, according to the NAM, farmers are more likely to reduce their water consumption when they feel ethically responsible for that. This is associated with the experience of a strong personal norm to save water.

NAM accounts as one of the most widely used methods for estimating pro-environmental behaviors. Various studies (e.g. Clark et al., 2003; Harland et al., 2007) have got benefit of NAM to explore pro-environmental approaches in diverse contexts. To this end, for instances Bamberg and Möser (2007) used it for assessing people's intention for using public transportation instead of their personal vehicles, or Van der Werff and Steg (2015) and other scholars (e.g., Wittenberg et al., 2018; Song et al., 2019) applied it in the field of energy for assessing the energy-saving behaviors. Furthermore, it has been used for evaluating pro-environmental practices in line with carbon footprint initiatives (e.g. Vaske et al., 2015; Qiao and Gao, 2017), or to study intentions toward using technological appliances (Ho and Wu, 2021) and so on.

NAM encompasses three behavioral determinant factors in its mechanism of evaluation. These factors are namely i) personal norms (PN), ii) ascription of responsibility (AR), and iii) awareness of consequences (AC). As mentioned, PN contributes to individuals' personal concepts interlinking to a sense of moral obligation for incorporating a particular action like environmental-friendly behavior (Thøgersen, 2006). Within various criteria personal standards have been addressed as the significant influencer of pro-environmental behaviors such as recycling behavior (e.g. Thomas and Sharp, 2013; Nketiah et al., 2022) or water-saving behavior (e.g. Rahimifayzabad et al., 2016; Savari et al., 2021) and electricity-saving behavior (e.g. Zhang et al., 2013; Song et al., 2019) etc.

Behavior-specific approaches should be persuaded in association with awareness of consequences (Van der Werff and Steg, 2015). For instance, if the goal is to reduce water consumption in a region, users should be made aware of problems that can be produced by use up or misuse of water to boost their awareness of consequences of the problems. Therefore, AC is a pillar in behavior-specific approaches which has played a major role in behavioral assessments by NAM. AR also has been restressed as a main component of NAM (Winingsih et al., 2022). AR reflects the responsibility senses in individuals regarding the negative consequences of not taking up the restorative actions in an endangered situation (Bamberg et al., 2007, De Groot and Steg, 2009). AR has been introduced as a determinant of pro-environmental behavior in many studies such as residents' waste separation behavior (Wang et al., 2019), organic food buying behavior (Lafontaine et al., 2021), drivers' speeding behavior (Javid et al., 2021), water consumption behavior (Gómez-Llanos et al., 2020) and so on.

Beside the discussed NAM factors (PN, AC and AR), the place attachment variables in influencing moral approaches regarding a pro-environmental behavior are suggested within several studies. For instance, place attachment's effect has been labeled about citizens' recycling intention (Nketiah et al., 2022), tourists' pro-environmental behavior (Ritchie et al., 2022), water conservation behavior (Valizadeh et al., 2020), conservation of native vegetation (Raymond et al., 2011) etc.

Place attachment (PAT) implies "*the human experience represented by affect–feelings, moods, emotions, etc.–which people experience in various ways, forms, degrees, with varying awareness,* *with reference to the places in which they are born, live and act. Also, in relation to the other persons who live and operate in the same places*" (Giuliani, 2003).

Low and Altman (1992) extensively described the attachment to a variety of places-homes, plazas, neighborhoods, landscapes as well as place attachments at different life stages as childhood, middle years, and later years. To this aim, they addressed the contributions of researchers of different disciplines who implemented integrative analyses of place attachment from the theoretical and methodological perspectives of their fields like landscape architecture, psychology, social ecology, sociology, and urban planning etc. Among sub-elements of PAT, the place identity (PID), place affect (PAF) and place dependence (PDE) have been discussed predominantly within the body of literature (e.g. Trąbka, 2019; Zheng et al., 2019; Valizadeh et al., 2020; Cole et al., 2021; Naiman et al., 2021).

In addition to these aspects, emotions are considered as parameters role playing in moral approaches (Pizarro, 2000). Emotions are inherent in normative process and may reflect the affectedness of a (pro-environmental) behavior based on the alternations in personal norms or other determinant variables of that behavior (Onwezen et al., 2013). This is in line with the anticipation of Schwartz (1977) that obeying a personal norm can cause positive emotions and otherwise can result in negative emotions in one's self-perception.

Based on studies not only the effect of emotions on behavior can be mediated by personal norms (Schwartz, 1977) but also, they can influence the intention/behavior independent of personal norms (e.g. Han et al., 2017; Wang et al., 2019; Rosenthal and Ho, 2020). On the other hand, awareness of consequences of an environmental issue furthermore disengagement for its resolve may lead to anticipated negative emotion if the problem lasts (Han et al., 2017). Although, theoretically based on the norm activation, the negative emotions are mainly relevant to the self attributes, if the personal norms in presence of the awareness of consequences are strong, they may boost the concerns above the immediate control of individuals leading to behave beyond their share of responsibility about an environmental problem (Rosenthal and Ho, 2020).

To explore the moral determinants of water conservation intention of farmers in the ULB, the analysis got benefit of previous studies which followed the NAM with some extension. To do so, beside the main factors of NAM, the PAT variables were contributed to the model in line with the notion by Axelrod and Lehman (1993). In this domain, they outlined that individuals are encouraged to pinpoint problems based on the perceive of existence of a problem with its relation to something important to them. This argument with implications of Giuliani's description of PAT (Giuliani, 2003), had consented me to make use of PAT and expression of emotions (EOE) variables in the constitution of NAM. Worth mentioning that Rosenthal and Ho (2020) had applied the community attachment and anticipated negative emotion factors in NAM regarding the management of the litter-related behaviors. To this end, they examined various combinations of the model based on the contributing variables' relationship. Since, their work has similar substance to this work in terms of contributing factors in the model, I adopted some concepts of their best predictor model for my case. Ultimately, an extensive norm activation model enriched with the PAT and EOE variables was incorporated to study farmers' water-saving intention and behavior with altruistic approaches. **Of course, in the ULB, to the best of my knowledge, the developed extended NAM is incorporated for the first time to study farmers' behavior regarding water and environmental conservation**.

More specifically, to analyze farmers' water-saving intention and behavior in the ULB in face of the consequences of UL vanishment on their society and environment, the feelings/emotions of the resident farmers around the lake, further with their attachment to their living area and society were installed in NAM through the appropriate hypotheses (Hs). To this end, farmers were supposed to reduce their agricultural water consumption in spite of their needs, to help restoration of UL in association with these hypotheses:

H_1: Awareness of the consequences of UL drying up has a significant positive effect on ascription of responsibility about it.

H_2: Awareness of the consequences of UL drying up has a significant positive effect on personal norms.

H_3: Awareness of the consequences of UL drying up has a significant positive effect on expression of emotions about it.

H_4: Ascription of the responsibility to UL drying up has a significant positive effect on personal norms.

H_5: Ascription of the responsibility to UL drying up has a significant positive effect on expression of emotions about it.

H_6: Place attachment has a significant positive effect on expression of emotions.

H_7: Place attachment has a significant positive effect on personal norms.

H_8: Expression of emotions about UL drying up has a significant positive effect on water conservation intention.

H_9: There is a positive relationship between awareness of consequences of UL drying up and water conservation intention, which expression of emotions mediates.

H_{10}: There is a positive relationship between ascription of responsibility to UL drying up and water conservation intention, which expression of emotions mediates.

H_{11}: There is a positive relationship between place attachment and water conservation intention, which personal norms mediate.

H_{12}: There is a positive relationship between place attachment and water conservation intention, which expression of emotions mediates.

H_{13}: Place attachment has a significant positive effect on water conservation intention.

H_{14}: Personal norms significantly and positively affect the intention.

H_{15}: Intention toward water-saving significantly and positively affects the behavior.

H_{16}: Personal norms significantly and positively affect the behavior.

2.3.2.3.2 Method and results

The method including the questionnaire, the participants and the data encompassed the same procedure as the PMT (please see section 2.3.2.1.3). Similarly, after the initial analysis of the participants' socio-economic circumstances (e.g., age, education), the Cronbach's alpha test was conducted to evaluate the internal reliability of the questionnaire based on the pilot test data. The results of this estimation confirmed the range of acceptable to excellent rates with respect to a scale of 0.721 to 0.936 in the domain of the contributed variables to the model (Table 10). Thereupon, the transparency, relevancy, and credibility of the final questionnaire was ensured.

Table 10 The internal reliability of latent variables in NAM setup of the study

Variable		Item
		Please express the extent of your agreement with the item (5-point scale from “Strongly Disagree” to “Strongly Agree”)
EOE (α: 0.785, mean: 4.041, SD: 0.684)		
	1	When I consider how much the drying up of the lakes affects my farming, I feel depressed.
	2	When I consider how much the drying up of the lake affects my life, I get annoyed.
	3	I cringe when I think about how much the drying up of the lake will affect my agriculture
PAT (α: 0.936, mean: 3.927, SD: 1.021)		
	1	I am proud to live in this area
	2	I feel belonging to this area
	3	I strongly feel my roots with this region
	4	Living in this area gives me a sense of peace that I don't have anywhere else
	5	I am happy inside when I am in this area
	6	This area is the best place to do what I enjoy
NAM variables:		To save the lake by means of modification of agricultural practices and water saving:
AC (α: 0.741, mean: 4.326, SD: 0.684)		
	1	Violation, transgression and crimes such as: theft, guilt, etc. will increase in the region
	2	The probability of migration of villagers from their place of residence will increase.
	3	Summers will be hotter, winters will be drier, and environmental conditions will become more difficult for living
AR (α: 0.900, mean: 3.038, SD: 1.101)		
	1	I think I have a role in drying up of the lake
	2	Agriculture and farmers are responsible for the high consumption of agricultural water
	3	I think agriculture and farmers are to blame for the drying up of the lake
	4	I feel responsible for the reckless use of water and preventing the lake from drying up
PN (α: 0.721, mean: 3.270, SD: 1.011)		
	1	I feel that I am paying my debt to protect the lake
	2	Regardless of the performance of others, based on my principles/values, I feel obligated to this matter.
Intention (α: 0.790, mean: 3.816, SD: 0.913)		
	1	I tend to use farming methods that require less water.
	2	I want to modify my crop cultivation methods to reduce water consumption
	3	I intend to incorporate protective measures such as watering at night to reduce water consumption
Behavior (α: 0.861, mean: 3.464, SD: 1.140)		
	1	I reduce my water consumption by optimizing the route, shape, dimensions, and cover of watering channels
	2	I implement fallow agriculture in my land.
	3	I encourage other friends or community to reduce agricultural water consumption

Furthermore, a Pearson’s correlation test was conducted to investigate the relationship between the latent variables. The results of this test revealed that all the contributing variables were significantly correlated with the water-saving intention. While PAT and AR did not correlate with behavior, the other variables correlated strongly with that. Also, the correlation of the main constructs of NAM was significant (Table 11). Furthermore, EOE correlated strongly with PAT and AR. However, EOE reflected a strong negative correlation with AC.

Table 11 Pearson's correlations (Extended NAM)

Variable		PN	AC	AR	EOE	PAT	Intention	Behavior
1. PN	Pearson's r	—						
2. AC	Pearson's r	**0.403** ***	—					
3. AR	Pearson's r	**0.331** ***	**0.362** ***	—				
4. EOE	Pearson's r	-0.075	-0.116 *	0.138 *	—			
5. PAT	Pearson's r	-0.109	0.099	0.080	0.156 **	—		
6. Intention	Pearson's r	**0.182** **	**0.263** ***	**0.298** ***	**0.381** ***	**0.226** ***	—	
7. Behavior	Pearson's r	**0.355** ***	**0.402** ***	0.102	**0.256** ***	0.077	**0.506** ***	—

* p < .05, ** p < .01, *** p < .001

Also, the Confirmatory Factor Analysis (CFA) was carried out to evaluate the reliability and validity of the measurement model. The results of CFA demonstrated an acceptable and adequate fit of the measurement model to the data (Table 12).

Table 12 Approximate Fit Indices (CFA-NAM)

	Indexes	RMSEA	Cmin/df	CFI	NFI	IFI	GFI
SEM(CFA)	Recommended value	≤.08	≤3	.9≤	.9≤	.9≤	.9≤
	Extended NAM	.075	2.67	.911	.867	.912	.984

Correspondingly, to assess the effects of predictor variables on dependent variables and eventually on intention and behavior, moreover, to test our hypothesis, the structural equation modeling (SEM) method (Figure 2.3.10) was applied using JASP-Version 0.16 (Love et al., 2019).

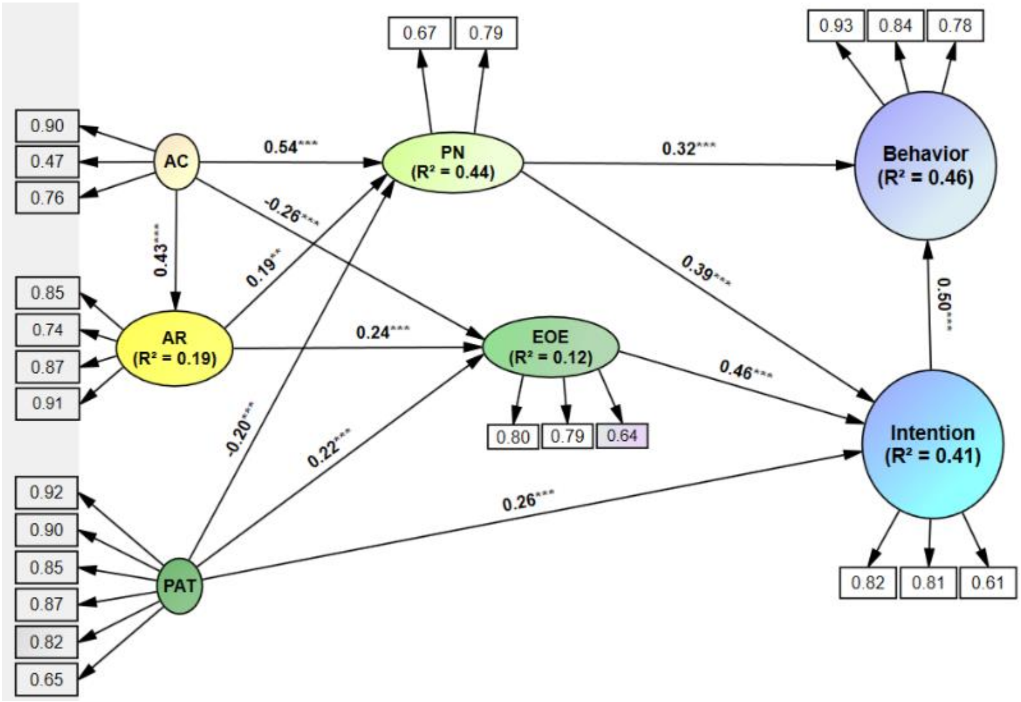

Figure 2.3.10 The extended constitution of SEM for NAM with inclusion of PAT and EOE factors. The significancy of relationship is distinguishable by "" which follows: ** p < .01, *** p < .001*

The results of SEM (Table 13, and Figure 2.3.10) revealed that AC had a significant direct effect on AR (β=0.43, P< .001) and predicted 19% of its variance, furthermore AC had a significant effect on PN (β=0.54, P< .001), also, AR (β=0.19, P=.004) and PAT (β=-0.20, P< .001) had respectively significant positive and negative relationship with PN. AC, AR and PAT in overall predicted 44% of PN's variance. Regarding EOE, the determinant variables reflected significant relationships. However, PAT (β=0.22, P< .001) and AR (β=0.24, P<.001) projected a positive relationship and AC (β=-0.26, P< .001) a negative one with EOE, furthermore, they predicted 12% of EOE's variance. Moreover, all hypothesized factors endorsed their relationship with intention. To this end, PN (β=0.39, P< .001), EOE (β=0.46, P< .001) and PAT (β=0.26, P< .001) revealed a significant positive effect on intention. Finally, both PN (β=0.32, P< .001) and intention (β=0.50, P< .001) displayed their significant positive effect on behavior and the model predicted 41% and 46% of variances in intention and behavior, respectively.

Table 13 The effects of estimators on dependent variables (NAM)

Predictor	Outcome	P-Value	β
AC	AR	< .001	0.434
Intention	Behavior	< .001	0.504
PN	Behavior	< .001	0.320
PAT	EOE	< .001	0.223
AC	EOE	< .001	-0.264
AR	EOE	< .001	0.244
PN	Intention	< .001	0.386
EOE	Intention	< .001	0.459
PAT	Intention	< .001	0.256
AR	PN	0.004	0.193
AC	PN	< .001	0.540
PAT	PN	< .001	-0.205

2.3.2.3.3 Discussion

Incorporating this study, the research aimed to explore the moral determinants of water conservation behavior in the ULB through a general conceptualization of the NAM. This approach is mainly important for a pragmatic assessment, since it can embed outputs that help the policy makers develop appropriate mechanisms of water and environmental preservation based on the moral factors. Such factors can result in activation of PN in relation to the problems that can raise by UL drying up as well as water resources depletion in the region. Correspondingly, with strengthening the users' PN to save water, such mechanisms can affect many specific water-use behaviors at once leading to UL and environmental conservation.

To the best of my knowledge, no study to date has explored farmers' water-saving intention and behavior by means of the combination of NAM and PAT in presence of EOE in the ULB. Therefore, the findings of this work can contribute to a growing body of literature using psychological models in behavioral decision making to help reduce agricultural water consumption.

In line with the hypotheses, AC, AR, PN, also PAT, and EOE announced their relationship with water-saving intention and behavior. To this end, the proposed model respectively predicted 41% and 46% of the variance in intention and behavior. Regarding the predictive power of the proposed model, in analogous to the researches which have employed NAM to study water conservation behavior in Iranian contexts (e.g. Savari et al., 2021; Zobeidi et al., 2022), it showed a quite well competence exposing similar rates.

Indeed, SEM showed that there is a direct strong positive relationship between AR and AC. On the other hand, AR affects the intention and behavior through the mediations by EOE and PN. Therefore, AC eventually can be influential on intention and behavior. This highlights the role of AC, then, the importance of the level of awareness. Thus, the increase of AC such as probability of the increase of conflicts/violation in the region, or migration from their place etc. can establish a potential circumstance for evoking water-saving intention facing the side-effects of the UL vanishing. To this aim, the increase in the level of awareness is argued as an arousing tool for perception of the threats (e.g. Kagoya et al., 2018; St-Laurent et al., 2019). Scholars have outlined that environmental awareness can increase the value associated with the conservation of natural resources growing users' perception of the consequences of the resource diminishment (e.g. Slimak and Dietz, 2006; Shahangian et al., 2022). So, boosting AC is principal in both rational (e.g protection motivation) and moral behavioral approaches.

Like AC, PAT is also a pure predictor in the model. There are two obedient and one contrast relationships upon the hypotheses relevant to PAT. In this scope, PAT displayed a significant positive effect on Intention and EOE, however, its relationship with PN is significant but negative. To explain this, I refer to the notification by Portes (1998) which uncovered that some dimensions of PAT can have opposite features like damping norms to resist extreme obligations and restrictions that limit innovation and entrepreneurship. This divulges that, perceiving UL drying up consequences, in an immediate phase, farmers recognizing their place at risk may not step in moral obligations which can limit their water abstractions for improving their place. Then, having a strong attachment to their place, they try to contrarily affect their norms by defensive cognitions (Schwartz, 1977). Therefore, in this case, there, an opposite relationship between PAT and PN can be shaped.

On the other hand, emotions and intention can be affected in association with the living area further in relation to neighbors, friends, relatives, family or other persons who live and operate within that area (Giuliani, 2003). This attribute is transparent regarding this study since PAT has a positive significant effect on Intention and EOE. According to the assumption, EOE reflected a significant positive effect on Intention, also PAT and AR exposed their positive and significant relationship with EOE. However, there is a negative significant relationship between EOE and AC relevant to the case of this study. Regarding such a circumstance, Schwartz (1968) based on his findings, emphasized that "*a person may defend against disturbing anticipatory emotions either by denying the expected consequences of his acts for the welfare of others, or by denying his own responsibility for these acts*". Relevant to the scope of this study, according to Schwartz

(1968), farmers try to overcome the utility of their emotions by rejecting their responsibility to decrease their water use and protect the lake. Thereupon, AC affects EOE negatively in relation to UL's circumstances. Also, another comprehension may arise in this regard based on the mean of AC. Being aware of the consequences of a problem to a certain extent can place a concern in a person's cognition. However, if the consequences are perceived as high as unsolvable, the person may deny the concern to reject its force on his/her feelings. The mean of AC (Table 10) has already been recognizable as high (4.326). This can transmit that whereas the majority of the farmers are aware of the consequences of UL drying up to a sufficient extent, they may find such consequences too extreme to be resolved (at least in a short time) and hence they try to calm themselves by overcoming their feelings, sadness or concerns regarding the consequences. This substance can work to shape a negative relationship between EOE and AC in this case. Afterall, the Intention and PN confirmed their significant relationship with behavior based on the hypotheses.

In light of the results and the discussed implications, this study tried to input some theoretical notifications. The first is NAM benefits from the involvement of PAT and EOE. I would accordingly propose such socio-psychological model embracing PAT and emotion's role within Schwartz's ethical model (NAM) to investigate intentions/behaviors for natural resources management. This is also compatibly addressed by Rosenthal and Ho (2020). In this domain, they stated that incorporation of community attachment within NAM is beneficial to study behaviors tackling less visible problems as CC influences on a community. On the other hand, since in such moral approach the individual may go beyond their self-requirements and act altruistically to help others/nature, the constitution of the developed model can be proposed for the participatory approach assessments in water and environmental conservation. Second, PAT can be an essential factor for promoting environmentally sustainable behavior (Bonaiuto et al., 2016). This can arise from various dimensions of PAT such as PID, PAF and PDE. Indeed, some norms are context based (Goldstein et al., 2008) which are activated in relation to the locus where people are living. Such process can encompass both commitment and attachment senses of the people to help their environment's sustainability (Rosenthal and Ho, 2020). Therefore, inclusion of PAT can promote understanding local or contextual pro-environmental behaviors.

Nonetheless, the emotions embedded in the normative process and their contribution to behavioral assessments can unveil specific characteristics. Furthermore, relevant to emotional responses over water shortages and scarcity researchers have reported the effect of emotions in climate risk or water insecurity situations (e.g Wutich and Ragsdale, 2008; Acharibasam and Anuga, 2018).

2.3.2.3.4 Conclusion

The findings of this study can have practical implications for water conservation and governance. To this end, they envisage particular information for the governmental water management departments. Specifically, they can benefit the public advisory and extension services which try to communicate, inform and encourage the farmers to reduce the use of the available water and responsibly consume that.

Due to the relationship of AR and AC, to elevate the farmers responsible water consumption, AC can play an important role. Upon this feature, consequences of UL vanishing must be broadly discovered, documented, and communicated. Indeed, the findings of scientists in different disciplines particularly in climactic, hydrological, environmental, agricultural, and medical fields have sufficiently addressed the problems of UL and the effects of its drying. Nevertheless, the rest of the mission tackles the communication, illustration and dissemination of the issue within the society and more relevantly in the farmers' community through public/agricultural organizations or local rural associations.

Generally, the communication of the environmental consequences is a levering instrument for raising awareness about them. Apparently, awareness communication can eventually impact the AR by increasing AC within the region. Also, since AC confirmed a direct significant positive effect on PN, it is perceivable that in a similar way, the awareness communication can affect PN. This issue is remarkable since rising awareness not only reveals its effect on rational intentions/behaviors (Arjomandi A. et al., 2023), but it also indirectly affects personal norms and moral intentions/behaviors regarding water-saving within the farmers community in the ULB.

The results of this research emphasized the importance of farmers' training and education for adaptation to CC, and less consumption of water for irrigation to save the water and environment leading to more potential and healthier space for living. Consequently, investing in awareness increase among the farmers in the ULB should be the prime policy. This can be further developed by proliferating the farmers' consciousness of the economic, social, and environmental challenges realizing them in sequence by extension and spreading of saline dust storms over the region with its adverse effects. The message of AC increase shall reflect the threats of health-related issues and diseases such as cardiovascular, respiratory, skin related etc., besides, water and soil problems and biodiversity loss and so on. Notwithstanding, such a message shall make the farmers understand and feel that they can support the resolve and decrease of these issues by changing their actions and practices. Through this implement enhancing moral obligation, the stimulation of the farmers' intention and behavior to lessen and responsibly use of water is expected.

Another stream is to support farmers by keeping their PAT. This may improve their PN for water conservation in due course if the plan could be progressed by investing on programs training and educating the farmers for engaging in other sources of income. This is to say that, in one side the farmers' PAT and feelings should be supported to increase their water-saving intention and on the other side they should feel that they will have a reasonable economic condition if they reduce their water consumption for saving the lake. To this end, Agyeman et al. (2009) acknowledged that due to CC as potential factor of place detachment, the inhabitants who find their homes under the risk of CC affect, intentionally unleash their ties and shape new ones to other areas. This issue can be relevant to the scope of this study since as discussed, around the lake some farmers have already adversely been hit by the lake drying up outcomes such as saline dust storms (see section 2.3.2.1.5). Then according to the findings of Agyeman et al. (2009), they may have loosened their ties and think to move to other places. Proposing and supporting the establishment of new earning ventures which can improve their hope to stay, can help prevent farmers intentional loosening of ties to their place. Therefore, besides investments and programs for increasing the level of awareness regarding CC and environmental issues, adaption to the situation and efficiently and less water using, it is necessary to help opening new gates of income and supporting the development of local enterprises.

Additionally, besides PAT, personal norms and emotions are significant positive influencers of the Intention in the model. Even more, PN strongly reflected their effect on Behavior. These attributes revealed a very potential and positive ethical characteristics within the farmers' personal cognition regarding the situation. This endowment should be valued and reinforced by prevailing the farmers involvement in design and implementation of the envisaged programs/projects for the lake and water conservation.

Finally, AC, AR, and PN as the original factors in the NAM strongly endorsed their significant effects on Intention and Behavior in the model. This feature underlines the usefulness of NAM for investigating farmers' water-saving intention and behavior in the ULB. Having this advantage, the incorporation of PAT and EOE and their significant effects on intention and accordingly on behavior were found as an asset. Thereupon, the developed model's employment is recommended for similar contexts.

Chapter 3

3 Overall Conclusion

The life-giving water, nowadays, struggles to flow uninterruptedly according to the biophysical rules in human-affected regions. The human-developed rules associated with their objectives have impacted water cycles in many areas. Given the competition between developmental goals and environmental requirements, the conservation of water has become more complex. Particularly in (semi)arid regions, exacerbated by CC, the situation threatens the water availability and hence the life and livelihood of its dependent nonhuman and human beings. To manage the issue, a proper CC adaptation interlinking to the goals/objectives of both human and their created systems is key. Such adaptation encompasses the governing factors of human and system behavior in relation to water and environmental conservation. The systems' behavioral change is connected with their structural changes to the extent that water and environmental conservation objective is privileged. The superior the position of water conservation objective, the fitter the water governing system structure to the hydrological scale. In individual level, also, a better perception of the importance of water and environmental conservation can lead to change in goals/objectives, thus behavior in line with adaptation to CC. However, what matters is the degree of cognition in both system and individual levels to deliberately appraise the meaning of water and environmental conservation and deservingly adjust this aim besides competing objectives which shape the systems'/individuals' behavior. To this end, understanding the factors interfering in water governing systems' and water users' pro-environmental behavior is essential. Urmia Lake as a severely stressed water body in northwest Iran is the live evidence of the direct and indirect influences by the CC, and human decisions. The lake's fate is connected with the reasonable adaptation to ecological requirements and water demand/consumption decrease. This attribute is associated with the structural reforms in the water governing system generating more fit to the basin, as well as, saving water by the users, majorly, in agricultural sector based on the region's context. This can produce an efficient mechanism of water conservation governance in the basin.

To detect the water governing system fit to the basin a methodology, capable of overcoming the multiple scales/levels issues, was developed and applied. Incorporating a statistical mechanics approach, a many-body problem was diminished to a one-body problem to study the water governing system behavior more easily. Thereupon, the effects of political, security, economic, institutional, biophysical, and other objectives/factors on shaping the governing system structure was appraised in the quintessence of the external forces and interaction rates for water demand-supply. A function of external forces together with interaction forces produce system cost for administration of the water demand-supply in the basin. Such (system) cost results from the summation of the individual costs of entities in association with their politically/administratively permitted interactions for water demand/supply. In the fitter system structures, such an overall cost (system cost) per the permitted interactions becomes smaller than the cost of the unmatched system structures (to the basin). Employing this method, the contemporary structure of water (demand/supply) governing system was formulated, and its cost was estimated correspondingly. Also, to see the effects of feasible reconsiderations in spatial partitioning of the region (which is mainly connected with the political, security, economic, social and jurisdictional objectives), two other water governing structures were concepted and their costs were calculated. Accordingly, in horizontal scope, it was found that if the water demand/supply administration in the basin could be shared between the two provinces (West Azerbaijan and East Azerbaijan) instead of three (contemporary state), the system cost becomes smaller. Respectively, this form indicated its better fit to the basin. Moreover, in vertical scope, based on the inclusion of the environmental objective of Urmia Lake restoration which placed the ULRP's organization in the water governing system, the system fit to the basin was further improved. This vertical (re)arrangement let the provincial entities interact with the ULRP entities and changed the water demand-supply administration structure in the basin. Through this provision, besides the system cost reduction, the headquarters (provincial entities) costs decreased. Also, the four local entities with higher water demand rates compared to the others experienced a noticeable decline in their costs. Furthermore, through the conception of the fulfillment of the ULRP water-saving policy associating with the forty percent less water demand-supply in agricultural sector, the system cost reduced more than twice in analogous to the cost decline by solely the structural reform. Also, by accomplishing this policy the interactions of all entities in the governing system were handled. These attributes further endorsed the constitution of the ULRP and the performance of its policy. Through this framework, calculatedly it was identified that how in addition to the water resources availability (biophysical factor), the agricultural development plan (political-economic factor) and, the ULRP (political-environmental factor) basically could affect the water allocation, demand and supply volumes (J) in the basin. Forbye, the provincial/jurisdictional boundaries in the region and administrative-jurisdictional interaction rules (political-security factors) shape the water demand-supply interaction formation (αm), encompassing the number of entities (i) and impact the water volumes (αJm). Indeed, governing the water demand-supply process in the basin is associated with a (Hamiltonian) cost interlinking to the combined function of the abstract of external forces (h) inducing from those factors, and their initiated interaction forces (αJm). This device enabled a swift scan of the system state based on its cost, furthermore, facilitated the fast conceptual formulation of the other structures and their quick comparison to detect the system fit. Indeed, this framework can open an immediate window to assist the policy/decision makers differentiate and select the most feasible structure based on the pertinent circumstances in a short time.

It is obvious that, either the political/jurisdictional boundaries or basin approach may be revised for fitter water demand-supply administration system in the Urmia Lake Basin. The fit range, revealed by the cost rate, is proportionate to the governing system (re)formation extent within the vertical and/or horizontal dimensions. Therefore, whether the water governing system structure is deformable entirely or partially, its fit can be enhanced accordingly in the basin. This issue shall be considered by decision/policy makers for design of fit and hence efficient water governing systems. In fact, the fitter the system structure, the less the system cost, and the more benefit for the system entities.

Apart from system (macro/meso) level enhancements, the individual (micro) level adaptations are crucial for devising an efficient mechanism of water conservation governance. The water conservation governance cannot reach its goals/targets unless the major water users accompany the water-saving measures and reduce their water demand. Also, the users' water demand reduction–affecting the water demand/supply amounts (J) in the system–can lead to changes in system level interaction rates (αJm) and hence system cost (H). These attributes mean the water-saving behavior of the farmers– as the major water users in the basin–critically role plays in the success of water conservation governance. In fact, the individual level water conservation intention and behavior is determined by the contributing factors in their cognitive decision-making process regarding water consumption. Hence, understanding of what factors govern the water-saving intention, given the farmers' personal conditions, environmental threats of Urmia Lake drying up and water scarcity in the region was fundamental. This could reinforce the apprehension of the farmers adaptive decision-making to save water in a risky context (relating to the consequences of Urmia Lake vanishing), besides their moral senses and feelings about the lake and their place. To identify the factors affecting water-saving intention of farmers in the ULB, getting the benefit from the pro-environmental theories, two distinct approaches were incorporated according to the case context. First, having the risks of Urmia Lake drying up effects on farmers' health, livelihoods, and their residential areas, the protection motivation theory as a rational approach was utilized. Furthermore, this model was enriched by inclusion of the factor of institutional trust in its extended form. The assessment was extra detailed by conducting a multigroup analysis based on the categorization of the farmers' residential distance from the lake. Based on the results of the SEM, the factors of "Perceived Vulnerability", "Self-Efficacy", “Response Efficacy” and “Response Cost” identified as the significant determinants of the water-saving intention in the original model. The inclusion of the “Institutional Trust” factor increased the model’s predictive power in its extended form. In general, the coping appraisal factors were the dominant predictors of water-saving intention. While “Response Efficacy” was recognized as the most significant determinant of the intention, the “Risk Perception” was not distinguished as a predictor of the intention. This matter communicated a noticeable issue that either some farmers didn’t have enough information about the side effects of the lake vanishing, or for some of them the risk perception phase was over, and they were finding themselves inside the problem sensing the vulnerability to the risks. So, the Risk Perception couldn’t make a strong relationship with the intention. Complementing the rational approach, to explore more about the post-intentional or volitional phase, and identify the real action determinants, the rational analysis was additionally expanded through the theory of planned behavior. To harmonize this model with protection motivation theory model, the factor of institutional trust was contributed to this model as an extended variable. In the analysis based on the theory of planned behavior, having the SEM outputs, it was identified that although the “Perceived Behavioral Control” or in other words the self-efficacy similar to protection motivation theory analysis, affects the intention positively, it negatively influences the behavior. This attribute stems from the impact of the uncertainties and habits interrelating to lack of experience in/affinity with new (water conserving) farming and/or irrigation methods and the farmers’ estimation of the risks, costs, disadvantages or opportunities in a short or long period. Also, due to the weak belief in viability of UL restoration by agricultural water-saving, and shortage of knowledge and experience in implementing the new water-saving methods which also can tackle costs and uncertainties, the relationship of the “Attitude” with intention of the farmers to revive the lake through water-saving was not significant. Except these contradictory states with the model hypotheses, “Subjective Norms” affected the intention significantly and positively also “Institutional Trust” did the same regarding the behavior. Therefore, through the rational approach, besides the findings of the assessment via protection motivation theory, the consideration of the impact of the subjective norms on intention should be stressed.

Second, based on the expected memory/feeling associating with farmers moral sentiments about the lake, their community and residential area, the norm activation model was incorporated to study their altruistic behavior for reviving the lake. The outputs of SEM analysis revealed that “Awareness of Consequences” of the lake drying up, “Appraisal Responsibility” in this regard and “Personal Norms” as the original model constructs, together with “Place Attachment” and “Emotions” variables in the extended model, eventually affect the water-saving intention and behavior. Concludingly, both rational and moral factors contribute to the farmers' cognitive decision-making process about water and environmental conservation in the basin.

For policy implications in micro level, the main requirements were identified as: i) to make farmers understand reasonably that the water resources are limited, and it is not possible to supply water immeasurably; ii) the consequences of the lake drying up should be pictured for them more transparently; besides, iii) while their beliefs in reviving the lake by means of water-saving should be reinforced, their uncertainties about their gain in association with water-saving performance should be reduced. This awareness increase can be implemented by communication, illustration and dissemination of the issue through the academic/executive arms of the government or private enterprises. Indeed, increasing the level of awareness in the farmers community can lead to improvements in both moral and rational water-saving behaviors; iv) the awareness increase also shall include the solutions for water consumption reduction and adaptation to CC to grow farmers' gratification for performing water-saving actions. This issue can have a twofold effect. First, by describing response efficacy of the solution the uncertainties can decrease and beliefs can increase to adopt the conduct, second, elucidating the incorporation process their perceived behavioral control on the method can raise and this attribute can facilitate the farmers overcome their habits of doing their traditional works; v) farmers' water-saving intention can increase by expediting reasonable financial aid or loans which reassure their efficacy in incorporating an appropriate solution. Hence, facilitating such supports through the banks or financial institutions is recommendable; vi) moreover, enabling the development of the local enterprises and income sources which need less water usage, can boost the farmers place attachment and hence water-saving intention; vii) promoting the engagement and participation of the farmers in design and implementation of the water-saving plans and policies can satisfy their emotions and thus lead to increase in water-saving intention. This circumstance can also contribute to the escalation of the effect of subjective norms within the farmers' community because of the increasing number of the farmers becoming aware of the usefulness of the water-saving strategies, even more, involving practically for such aim; viii) to boost farmers attitudes, the scientific findings need to be considerately transmitted to an easy-to-understand setup for the farmers' better perception and understanding of the lake restoration viability through the agricultural water-saving; ix) the academic and executive institutions shall align with each other for a comprehensive cooperation and work plan to continuously maintain the farmers trust in a high level. This matter links to their beliefs strengthening and uncertainties weakening about the feasibility of the lake revival through water-saving, moreover, the corresponding benefits of such preservation and eventually can increase their attitude for water conservation; x) specific investments for organizing water conservation workshops, living labs and experimentation facilities/utilities shall be provisioned. This helps farmers practice and become familiar with new water-saving methods and instruments to increase their perceived behavioral control and their confidence/control on such mechanisms assisting them to overcome their habits or uncertainties and take the new actions more admittedly. After all, the government shall incorporate distance-tailored water conservation strategies according to the farmers proximity to the lake and water resources. In this scope, farmers who live near to the lake with less access to the surface water require the government’s support by infrastructure development and reasonable water supply, also farm level financial facilities. However, the water consumption of the farmers who are distant from the (drying) lake and living closer to the surface water sources or more water available/accessible areas, should be controlled and restricted by proper methods.

Finally, for water conservation governance, both systems and individuals should align and act committedly in line with the objective of water and environmental preservation. This issue specifically during climate change within the water-scarce context of the Urmia Lake Basin needs a tight cooperation between the political, economic, scientific entities, besides the individual users to consider the major factors including the environmental parameters in design and shaping of the water governance and conservation platform. Increasing environmental awareness in both system and individual levels can improve the comprehension of the realizing problems and boost the consensus among entities and disciplines to think and behave pro-environmentally. Eventually, understanding the necessity of modification of the objectives and hence behaviors in both levels is the basis of system change in line with climate change.

Chapter 4

4 Constraints and Recommendations

The research encompassed the analysis based on the available/collected data. Relevant to the system level analysis, the data was adopted from the latest available national reports of the MOE including the master plan study of the ULB. Thereupon, the water demand/supply volumes were relevant to the year 2005. Although, this issue does not interrupt the developed framework and its application based on the mentioned data, a repetition of the assessment is recommendable if the new report/data become available. Indeed, the year 2005 was a critical period and around then a sharp decline in Urmia Lake volume occurred. Nevertheless, implementing water conservation mechanisms by that period could have been more efficient/advantageous. Furthermore, due to unavailability of the official data for the time when the ULRP was incorporated (2013-2022), the effect of ULRP's inclusion in the water governing system of the basin was evaluated with the assumption of its incorporation in the year 2005. Therefore, it is also recommendable that if the updated data becomes available, the model be retuned, and the system cost be recomputed based on the new data. However, this recalculation will not influence the methodology and system structure formulation. Worth mentioning that the system structure was appraised based on the real time state of the interactions in the system and was compared with two other feasible forms based on the political-jurisdictional circumstances in the region. It could be recommended to also investigate the fit of water governing system structures when the political-jurisdictional restrictions could be neglected, and thus interaction configurations can be altered in a way that could provide fitter system(s) to the basin.

On the other hand, in the individual level analysis based on the extensive studies and expert discussion sessions the most relevant pro-environmental theories and sociopsychological models were extracted, their relevant data was collected and applied. This doesn't exactly mean that all the interfering factors in water-saving intention are identified in the region. Therefore, other pro-environmental behavior models may be discerned and examined to explore some other variables which can affect the water-saving intention and behavior of the farmers. To this end, the role of collective efficacy and perceived benefits is recommended to be investigated.

به پایان آمد این دفتر حکایت همچنان باقیست

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