

A study on the influencing factors of river governance effectiveness in the metropolitan area: a case study on the Dali River Basin in Taiwan

Chang-Yen Lee^a and Wen-Jung Chang ^{b,*}

^a Graduate Institute of National Policy and Public Affairs, National Chung-Hsing University, Taiwan.

^b Department of Business Administration, National Chung-Hsing University, 145 Xingda Rd., South Dist., Taichung City 402, Taiwan

*Corresponding author. E-mail: s8511609@yahoo.com.tw

 W-JC, 0000-0003-2897-5267

ABSTRACT

Improving the governance effectiveness of river basin units (RBUs) is often the focus of academic studies. However, the literature on measuring the influencing factors of the river basin governance effectiveness in urban areas is relatively scarce. Therefore, this study employed the theory of governance across boundaries and adopted an exploratory research approach to discover influencing factors, namely Analytic Hierarchy Process (AHP) and SPSS questionnaire survey. Resulting from the analysis of in-depth interviews, the top three attention-getting influencing factors in descending order are organizational structure, overall plan, and landscape recreation. In comparison, resulting from the quantitative analysis of the AHP questionnaire, the top three attention-getting influencing factors in descending order are flood protection, overall plan, and ecological conservation. These two findings are significantly different. This study's findings also indicate that the public's satisfaction with the individual governance effectiveness reaches a score of 80.06. The analysis results provide a feedback to RBUs, which can be a policy for revising the plan-do-check-act (PDCA) cycle in order to improve the governance effectiveness.

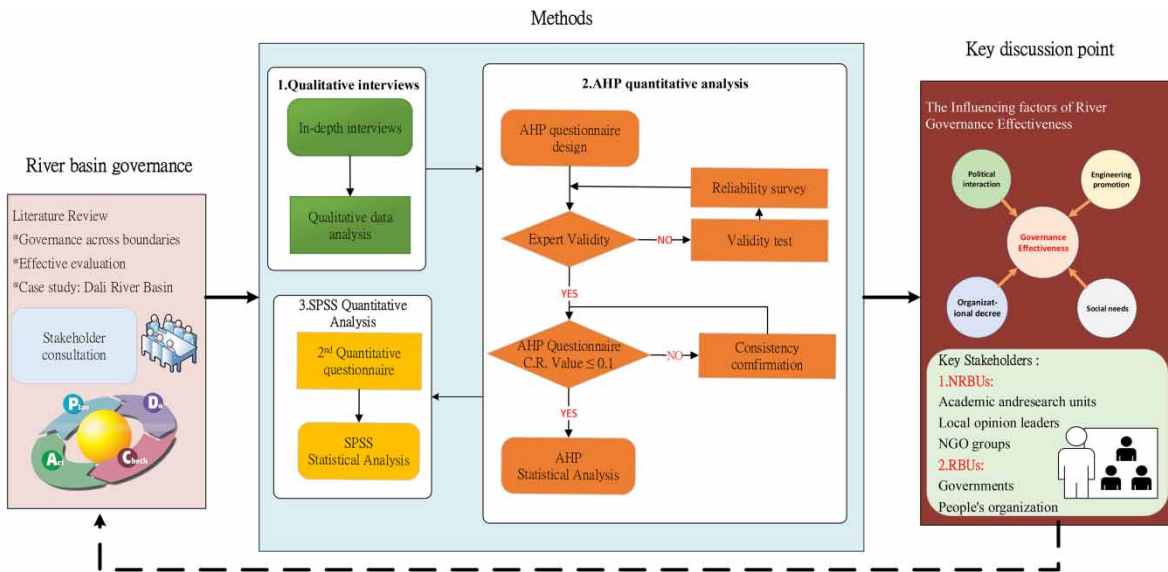
Key words: Analytic Hierarchy Process (AHP), Dali River Basin, Effective evaluation, Governance across boundaries, PDCA, River basin governance

HIGHLIGHTS

- Examines policy considerations from the perspective of the effectiveness of mutual interdependence governance.
- AHP examines policies to reconcile the heterogeneity between RBUs and NRBUs.
- Through the demonstration of multivariable linear equations, it can provide a reference for the feedback of the policy PDCA cycle.
- Effectively shorten the information gap between supply and demand for executive decision-making.

This is an Open Access article distributed under the terms of the Creative Commons Attribution Licence (CC BY 4.0), which permits copying, adaptation and redistribution, provided the original work is properly cited (<http://creativecommons.org/licenses/by/4.0/>).

GRAPHICAL ABSTRACT



INTRODUCTION

The United Nations Population Division estimates that the population of metropolitan areas accounted for approximately 30% of the world's total population in 1950 and reached 55% in 2018. It is estimated that as many as two-thirds of the world's population will live in metropolitan areas by 2050 (UN 2019; UNPD 2018). Accelerating urbanization and urban expansion results in water resource, ecological, and environmental problems that have attracted increasing public attention. Among these, utilization, development, and management of water resource facilities are especially important indicators for the urban development of all countries in the world. Compared with the continental areas, island areas, which are narrow and densely populated, rely heavily on these issues.

The governance and management of water resources worldwide have trended towards the comprehensive management development of river basins. Because the river basin governance is typically a cross-organization activity that requires governance across boundaries, many researchers had specifically explored and examined the various organizational types of river basin governance, in an attempt to address the problems faced by the traditional governance across boundaries and improve governance effectiveness (Paisley & Henshaw, 2013; Pritchett, 2014; Lee, 2016). In addition, numerous empirical studies were mainly focused on the implementation of the river basin governance, carrying out different basin management methods according to the characteristics of river basins, for example, Nebraska Natural Resources Districts (Gilmore *et al.*, 2019) and Potomac Watershed Partnership (Moltz *et al.*, 2020).

Deming, a management scholar, developed the plan–do–check–act (PDCA) cycle, which is a continually iterative and dynamic process for improvement. The PDCA cycle, which is widely used in service and manufacturing industries (Johnson, 2002), enables continuous learning from mistakes and growth through reflection. Implementing the overall execution life cycle into public sector decision-making is a continuous feedback loop for achieving continuous improvement and refinement of the policy for the PDCA cycle. Previous studies had focused on 'Plan and Do' stages with less attention to 'Check and Act' stages of river basin management systems

and organizational efficiency. After the decision is executed, it is necessary to review the test stage, analyze the execution results, and identify the learning improvement points (Claudia, 2009; Bouckaert *et al.*, 2018).

The 'Act' stage, logically, does not occur alone. It is often based on the knowledge or experience learned in examining the 'Check' stage; actions are then taken to provide feedback for modifying the decision-making direction (Claudia *et al.*, 2010; Moore, 2012; Longboat, 2013; Liu, 2015; Bereskie *et al.*, 2017; Isniah *et al.*, 2020; Matczak & Hegger, 2021). Previous research directions focused more on Planning and Do stages of river basin management systems and organizational efficiency and explored less the Check and Act stages. What are the influencing factors of river governance effectiveness in river basins? How effective is the systematic evaluation of the governance? Relevant literatures conducted relatively little research on feedbacking the important modification direction of the decision (see Figure 1). The current study intends to fill the existing research gap and conduct an exploratory research on the factors that affect the effectiveness of river governance in metropolitan areas.

In addition, Taiwan is an island-type region. Its geography, social, and organizational conditions for both public and private sectors are also not exactly the same as those of big river basins in Europe, the United States, and other countries. Accordingly, this study attempts to adopt an analysis perspective of 'governance across

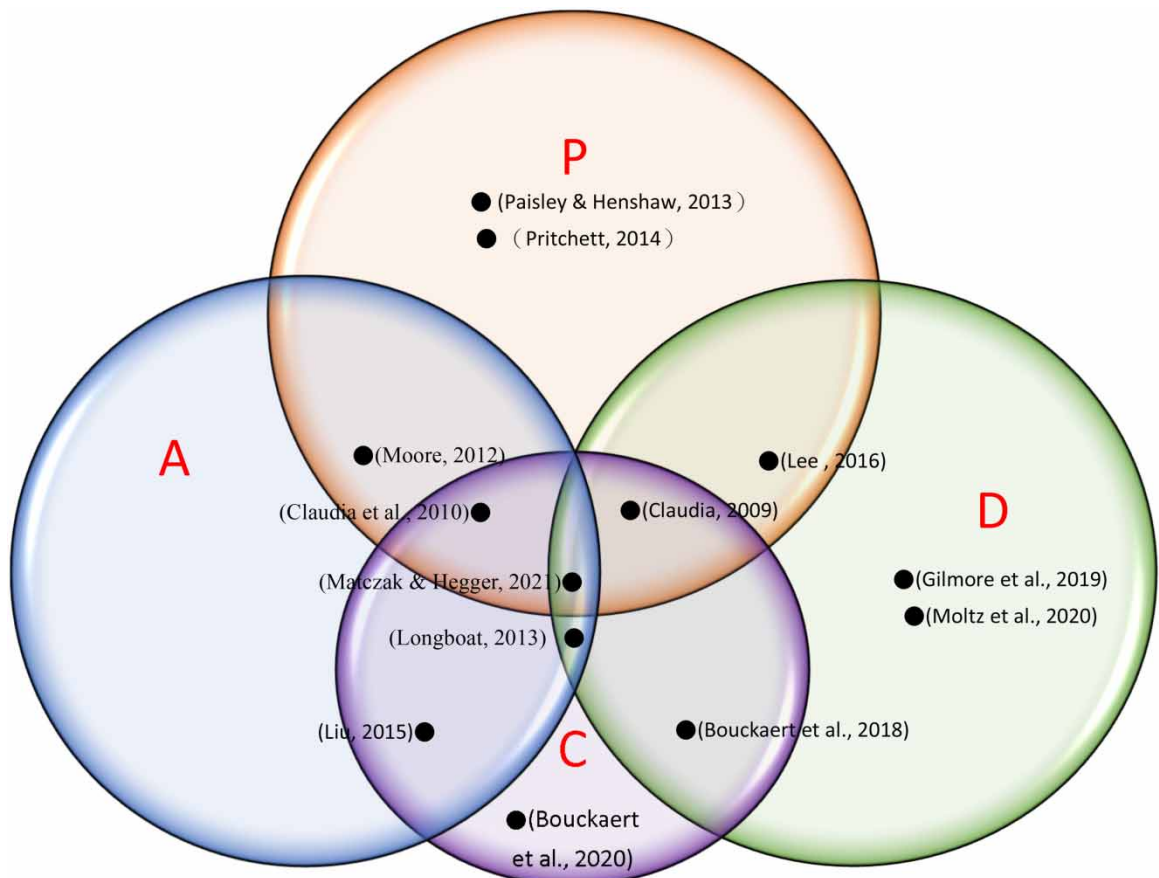


Fig. 1 | The PDCA research trend analysis of water resource governance and management.

boundaries' in the field of social science, employ an open-convergence exploratory research approach with both qualitative and quantitative methods, and focus on the rivers of Taiwan's metropolitan areas, in order to explore influencing factors of river governance effectiveness and construct an evaluation model and multivariable linear equations in order to evaluate governance effectiveness. Then, we embarked on a survey of the users (or the people). Afterwards, we used this research model to systematically analyze data and verified the governance effectiveness. The analysis results were fed back to the public sector to be used as a policy for revising the PDCA cycle, so as to improve the governance effectiveness of the public sector.

The research results of this study provide theoretical and practical contributions in river governance effectiveness, since there are few existing research papers on the PDCA cycle in the context of river governance effectiveness. This study hopes to inspire researchers to conduct more relevant research in this field in the future so as to provide policy planning and implementation of RBUs that meet public needs, leading to more effective results.

LITERATURE REVIEW

'Governance across boundaries' refers to the integration of governance across agencies, organizations, and jurisdictions. The governance model inevitably undergoes change qualitatively from the traditional public sector as the center, forcing the public sector to also cooperate with multiple administrative levels and departments to establish a cooperative and coordinated governance system to solve problems of difficult co-operation or coordination between construction and resources in local areas (Daniell & Kay, 2018).

In this study, the 'governance effectiveness' refers to the positive results achieved by the public sector in the implementation process of management. As to the factors that influence the governance effectiveness, previous studies mostly evaluated the factors that affected effectiveness (or establish indicators) regardless of whether the target is the private sector or the public sector. The research process emphasizes the objectivity, rationality, and effectiveness of the evaluation process, providing sufficient feedback for the application of each business function unit, such as ESG key performance indicators (environmental and social indicators).

After reviewing the relevant literature on the benefits of the river basin governance or governance across boundaries, this study finds that previous studies in the field of natural sciences, for example, water resources, water conservancy engineering, soil and water conservation, environmental protection and ecology, mostly conducted quantitative research, measuring return on investment, cost-effectiveness, etc. These studies had mainly focused on the implementation of the feasibility study stage of the governance plan and had seldom measured the governance effectiveness after implementation of the plan. In contrast, few researchers had focused on the literature theory and empirical research related to the field of social sciences, with most research directions focusing on river basin management systems, organizational efficiency, and so on, which belong to the stages of public administration planning and decision-making implementation.

This study applies the document analysis method to summarize and sort the relevant literature that affects governance and management factors of water resources as the research frame so as to facilitate subsequent research that can shape the 'governance effectiveness of metropolitan area rivers' and further establish a model that affects governance effectiveness. This study reviewed the relevant literature related to river governance effectiveness and analyzes such literature from the perspective of 'governance across boundaries.' Data were drawn from electronic journal databases, such as Web of Science, Airiti Library, and ProQuest Dissertations and Theses. The current study retrieved and analyzed 12 representative journals and doctoral dissertations published over 13 years from 2009 to 2022. After collecting and organizing the semantic keywords that affect governance effectiveness across various journals, the authors consulted repeatedly with senior experienced researchers and senior executive directors of the public sector. Consequently, we sorted out 12 key influencing factors. After the researchers

discussed and confirmed these again according to their attribute types, they were classified into four main facets. The main as well as influencing factors were categorized (see [Table 1](#)) and were used subsequently as the framework of the qualitative interview outline to sort out the in-depth interviews of each facet.

METHODS

Based on the analysis of the collected literature, this paper uses the qualitative interview as the basis, and draws up an evaluation framework based on the interview analysis, and then uses the AHP quantitative questionnaire to analyze and obtain a multivariate linear equation for the evaluation of governance effectiveness. Furthermore, in order to validate the proposed method, a metropolitan area river in central Taiwan was selected as the research empirical target. It is described as follows:

Research process and methods

In terms of research methods, this study conducted open-convergent exploratory research to propose and verify an evaluation model of river governance effectiveness in metropolitan areas. First, it used the document analysis to explore the factors that affect the effectiveness of water resource governance and management as the base of analysis. The document analysis was supplemented by the perspective of government across boundaries and extracted the research structure of influencing factors, as shown in [Table 1](#), in order to shape the outline structure of the subsequent qualitative in-depth interviews.

Next, we narrowed down stakeholders who affected the governance effectiveness of metropolitan rivers and then conducted in-depth interviews in order to complement the document analysis for missing or not enough data. We selected representative samples for semi-structured interviews. The interview results were analyzed by using MAXQDA software that systematically coded responses in order to obtain validity and reliability. We conducted systematic induction and analysis to construct influencing factors.

Further, we continued to converge and implement quantitative analysis of multi-criteria decision-making tools to evaluate sustainability model standards in various fields. Decision makers and researchers most widely use the Analytic Hierarchy Process (AHP) that was proposed by Thomas L. Saaty ([Dos Santos et al., 2019](#)). Accordingly, this study also employed AHP to construct the influencing factors of the hierarchical structure (see [Figure 2](#)). The first layer of the main body is the goal area (GA) of the ‘governance effectiveness of the Dali River Basin,’ the second layer is the main facets area that is divided into m facets, and the third layer is the influencing factor which is the main effectiveness indicator.

After the test results, we used the AHP software to analyze the factor weights of various levels (including the establishment of a paired comparison matrix, eigenvectors and eigenvalues, and the consistency test), and the calculation of overall level weights. The ‘model evaluation weight distribution value’ obtained from the analysis was combined with the evaluation model to systematically and clearly present the relative weights of the main and influencing factors, establish the ‘governance effectiveness evaluation model and weight system,’ and complete the multivariate linear equations.

Finally, we conducted field questionnaire empirical surveys, supplemented by SPSS statistical software to assist in analysis. Data obtained were brought into multivariate linear equations for verification. The calculation results obtained can be fed back to the main office of the public sector as a reference for planning the policy iterative feedback revision.

Research objects

Referring to the River Vision Exchange Platform’s meeting composition structure of Taiwan’s public sector, we obtained the research objects of this study’s qualitative interviews from snowball sampling and selected nine

Table 1 | Analysis of influencing factors deriving from literature review.

Periodical / paper	Engineering promotion				Political interaction				Organizational Decree			Social needs				
	Overall plan	Resource	Urban planning	Land acquisition	Intergovernmental relations	Collaborative partnership	Dialogue platform	Multi-participation	Organizational structure	Supervisory responsibility	Regulations	Flood protection	Landscape recreation	Urban development	Boost economy	Environmental ecology
Ulibarri & Garcia (2020)				cross-jurisdictional coordination		Inter-organizational collaboration		coordination		river basin scale		proposed law				
Koebele (2017)					collaborative water governance		coordination across alliances		expand citizen			legalization of decision-making				
Bischoff-Mattson & Lynch (2017)	development Goals		resource			participation and decision making from the		representative inclusion								
Chen & Huang (2009)							effective public participation			Information transparency						environmental pressure
Chang et al. (2020)								public participation		drainage and flood prevention			economic pressure			
Yu (2011)						politics							society			environment
Moore (2012)						network relationship		cross-border interaction	basin organization					economy		
Longboat (2013)	best practice	resource management	land control			informal collaboration		reasonable participatio		supervision fair						water safety
										Institutional Theory						
Periodical / paper	Overall plan	Resource	Urban planning	Land acquisition	Intergovernmental relations	Collaborative partnership	Dialogue platform	Multi-participation	Organizational structure	Supervisory responsibility	Regulations	Flood protection	Landscape recreation	Urban development	Boost economy	Environmental ecology
O'Flynn et al. (2014)					inter-organization service for many			many participants		enhance operational capabilities						
Feingold et al. (2018)		city blueprint strategy											society system		econom	environm
Liu (2015)					enterprise & Multilateral institutions			effective participant	decentralized management					city development		ecosystem
Stakhiv & Hiroki (2021)			zoning decision								economic and demographic		unexpected natural disaster			economic and demographic
Conallin et al. (2022)		resource				cross-departmental		public participation								urban sprawl, population

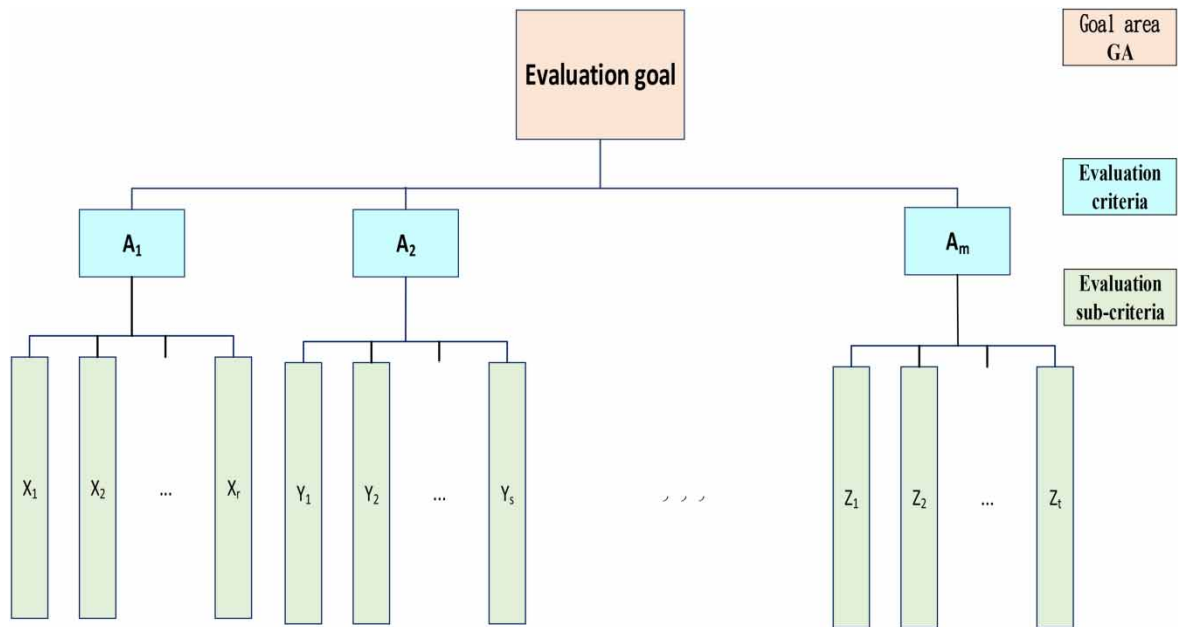


Fig. 2 | Scheme of the AHP hierarchy.

interview objects from the four major groups, as shown in Table 2. The objects of the AHP questionnaire survey were three to five objects recommended from the in-depth interview respondents so as to balance the opinions of various interest groups. The nature classification is divided into Related Business Units (including government agencies, local people’s organizations, abbreviated as RBUs) and Non-Related Business Units (including academic and research units, local opinion leaders, NGO groups, abbreviated as NRBUs).

Table 2 | Group code list of in-depth interview respondents.

Respondents	Group	Nature classification	Note
A ₁ 、A ₂	Academic and research units	NRBUs	
C ₁	Local opinion leaders		
D ₂	NGO groups		
B ₁ 、B ₂ 、B ₃ 、B ₄	Government agencies	RBUs	
D ₁	People's organization		Restructured as a government agency in 2020

In the empirical research stage, we selected the Dali River water system posted by Taiwan's public authorities. Its river basin is located within the single administrative district of Taichung City, the second largest metropolitan area, and its flat area exceeds more than half of the entire basin areas. The basin area is densely populated (41.84% of the total population, more than 1 million people) with developed transportation, industry, and commerce. It is one of the typical rivers in the metropolitan areas governed by the central government. Thus, we used it to provide longitudinal analysis data.

RESULTS

The research method of the previous chapter will be continued, and the analysis results of the open-convergent exploratory research will be explained one by one as follows:

Analysis and discussion of qualitative interviews

In this study, we conducted in-depth interviews with respondents for their contents' stem meanings. After systematic induction and analysis, we found that the social needs facet is more diverse. Next, after reviewing the results with another researcher and further sorting data out, we kept the main facets unchanged and partially revised the influencing factors, as shown in [Figure 3](#).

Main facets and influencing factors are analyzed using the MAXQDA software. Meanings of main facets are as follows:

- Engineering promotion refers to engineering planning, urban planning, and construction land acquisition operation, design, construction, completion and use, etc.
- Political interaction represents the difficulty of separating politics from the construction planning of public projects from the beginning. There is much related theoretical research into domestic and foreign practices as well as academic circles.
- Organizational decree represents all administrative actions, the essential principles that the public sector should abide by according to law.
- Social needs represent the desires and needs of the people. It is believed that the governance effectiveness of the river basin is related to the social needs of the people.

Using the MAXQDA software, it can be clearly seen that the in-depth interviews show different groups of respondents pay attention to different directions of governance effectiveness, resulting from differences in their positions, identity conditions, and differences in contact information. 'Social needs' governance effectiveness is the easiest to see in detail, with a high degree of recognition, but the distribution of influencing factors is the least even. In addition, in the process of engineering promotion, land acquisition is a key factor in the smooth progress of the project. 'The land is the source of all wealth' is the traditional Chinese Confucian's concept, which presents the second highest degree of concern and recognition.

Analysis and discussion of AHP questionnaires

After in-depth interviews and the qualitative analysis procedures, we used the AHP method to make a preliminary structure. The first level is the GA 'governance effectiveness,' the second level is the four evaluation criteria of the main facets, and the third level is the 18 sub-criteria of the influencing factors. We solve the complex decision-making problems in an orderly manner to establish an evaluation model.

Questionnaire design and distribution

After designing the first draft of the AHP questionnaire, we discussed it with another researcher and revised it as needed. In order to establish the appropriateness of term definitions corresponding to each question of the main

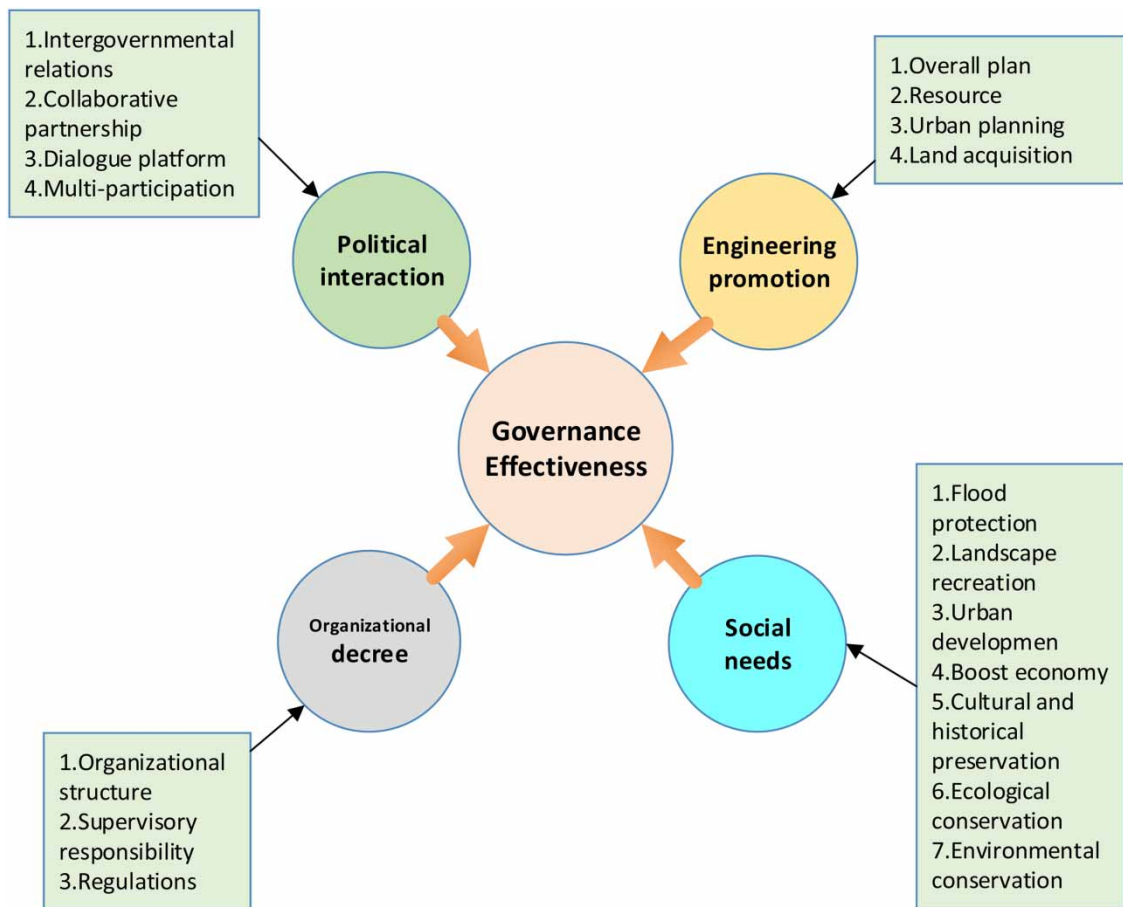


Fig. 3 | Main facets and influencing factors of the river basin governance effectiveness.

facets or influencing factors in the questionnaire, three scholars and experts conducted expert validity evaluation, resulting in revision of the questionnaire, so as to assist in checking the breadth and appropriateness of the questionnaire's contents and to establish the evaluation sub-criteria.

In addition to the demographic survey questions, the AHP questionnaire of this study has a total of 36 questions, all of which are based on a nine-point Likert scale. We sent out 40 questionnaires between April 25 and May 17 in 2018 and confirmed that the questions passed the AHP consistency check before officially completing the collection of questionnaires. Eighteen valid questionnaires each for RBU and NRBU were collected, and the valid response rate was 90%.

Questionnaire analysis using AHP and discussion

After analyzing the valid questionnaires and calculating weights of main facets and influencing factors (including the establishment of a pairwise comparison matrix, calculation of eigenvectors and eigenvalues, and consistency verification, $C.R. \leq 0.1$), we tested the reliability of the scale and confirmed whether the measurement results of the questionnaire are consistent and stable. After the consistency verification, the calculation and the analysis of

the weights between the main and influencing factors at each level were formally carried out (Saaty, 1980), and the governance effectiveness evaluation model and the weight distribution were completed (see Figure 4).

Main facets hierarchy: From the distribution result of the main facet weight (MFW), as shown in Figure 4, we can see the ‘social needs’ facet is most valued, and the ‘mechanism act’ facet is least valued. In terms of political theory, politics is a matter of managing the people, and the implementation of democracy should allow the people to be the masters. From a practical analysis, the current political and democratic atmosphere in Taiwanese society has evolved to the era of crowd management, which is verified by the survey results of this study.

Influencing factors hierarchy: regarding the ‘promote the plan’ main facet, ‘overall plan,’ and ‘land acquisition’ influencing factors have the highest weight distributions, both accounting for over 70% of the total influencing

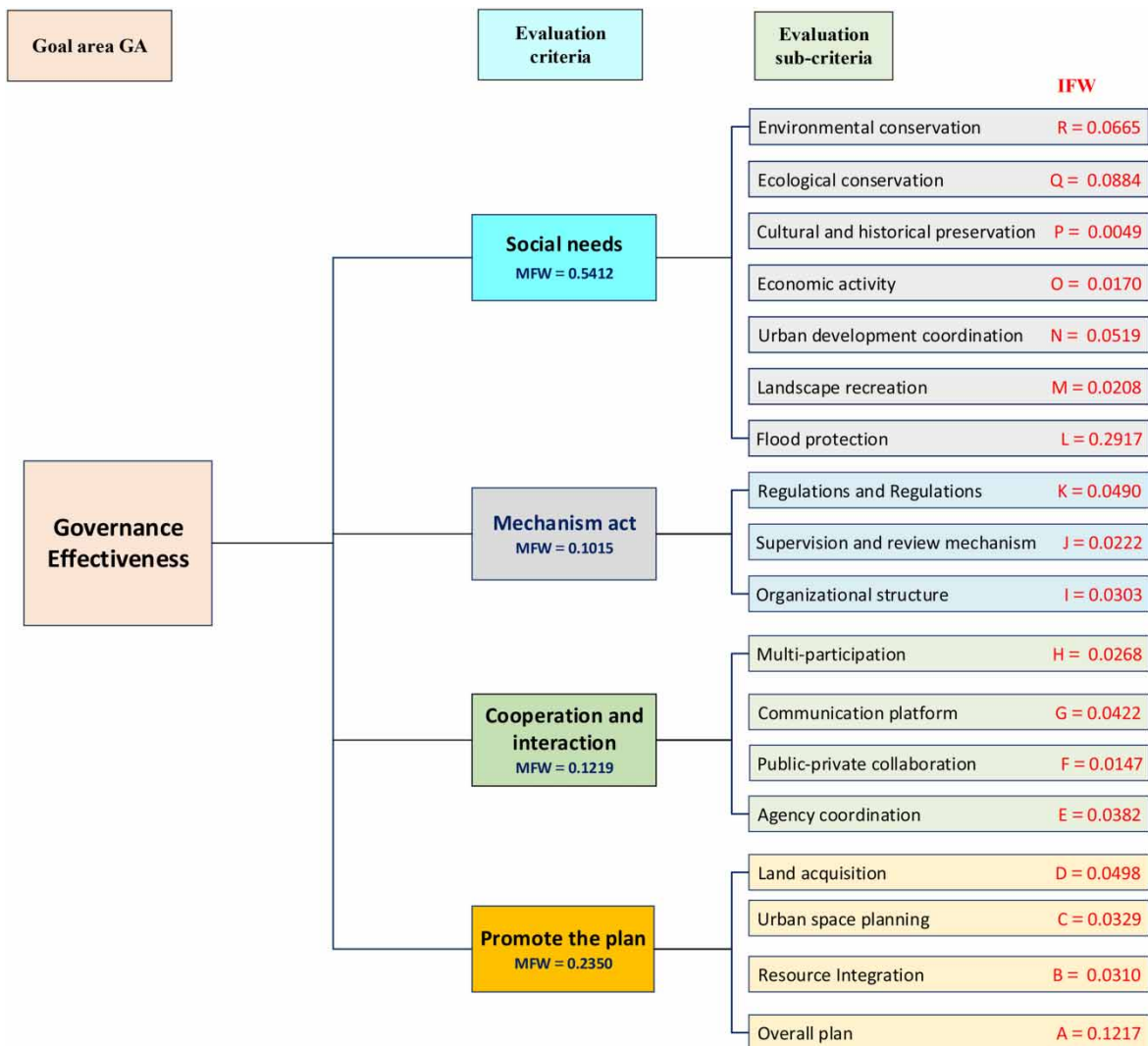


Fig. 4 | AHP model and weights of evaluation criteria of the basin governance effectiveness assessment. MFW, main facet weight; IFW, influencing factor weight.

factor weight (IFW). From a practical point of view, the river basin governance effectiveness emphasizes the completeness of the overall upper-level plan, the coordination of upper, middle, and lower levels of the jurisdiction, and the connections of district governances and division of labor. In terms of the ‘co-operation and interaction’ main facet, ‘communication platform,’ and ‘agency coordination’ influencing factors have the highest weight distributions, both accounting for over 60% of the total IFW. From a practical point of view, the opinions of public and private units or organizations can reflect the governance effectiveness of the river basin by improving and smoothing the communication platform. As to the ‘mechanism act’ main facet, ‘laws and regulations adjustment’ influencing factor has the highest weight distribution, as high as 0.4825. Practically, the regulations and rules should be adjusted in order to guarantee and protect the rights and interests of the people on the premise of a more efficient law. Among the influencing factors of the ‘social needs’ main facet, ‘flood protection’ gets the most attention, followed by ‘ecological conservation’ and then ‘environmental conservation.’ These three influencing factors account for over 80% of the total influencing factors weight (IFW), enough to show their importance. In practical terms, to return to the original ‘flood protection’ essence of the river basin governance, it is necessary to meet the basic requirements of the original design of river defense safety regulations to ensure the safety of people’s lives and property. However, in order to obtain the multi-goal benefits of the river basin governance and space utilization, it is necessary not only to create natural ecological resources that satisfy the people’s desire for water affinity but also to respect and value natural ecological resources. In addition to integrating with the surrounding environment, restoring the original ecological appearance of the river deserves diligent work.

Second-stage questionnaire survey

In the second stage of the questionnaire design of this study, we adopted the five-point Likert scale. There are 23 questions, including demographic survey questions. The questionnaire design was reviewed and revised by another researcher, and senior experienced researchers and senior executive directors of the public sector were invited to conduct expert validity evaluation and revision.

To ensure the reliability of the sampling, the sampling places were mainly nearby civilians’ activity areas covered by the Dali River Basin, and simple random sampling was adopted. In this study, within 6 months of collecting data on influencing facets, we collected AHP and public questionnaire data in different places to reduce common method variance. A total of 331 questionnaires were sent, and 316 were collected, with a 95.47% valid response rate.

We input statistical data of each influencing factors from the valid samples into the multivariate linear equation of the ‘governance effectiveness evaluation model’ (such as Equation (1)), to conduct a quantitative analysis so as to obtain the general civilians’ evaluation scores of the governance effectiveness of the Dali River Basin.

$$GA = \{(A \times X_1 + B \times X_2 + C \times X_3 + D \times X_4) + (E \times X_5 + F \times X_6 + G \times X_7 + H \times X_8) + (I \times X_9 + J \times X_{10} + K \times X_{11}) + (L \times X_{12} + M \times X_{13} + N \times X_{14}) + O \times X_{15} + P \times X_{16} + Q \times X_{17} + R \times X_{18}\} \times K \quad (1)$$

Among them GA is the value of river governance effectiveness, X_i ($i = 1-18$) indicates statistical data of each influencing factor, corresponding to its constant coefficient $A-R$ (see IFW in Figure 4). K is the adjustment coefficient 100/5. (Because we adopt the five-point Likert scale, in order to facilitate the interpretation, it is multiplied by the adjustment coefficient and replaced by the percentile.)

After replacing the individual adjustment coefficient of the linear equation with an unknown number, resulting in Equation (2)

$$GA = \{(0.127 \times X_1 + 0.031 \times X_2 + 0.0329 \times X_3 + 0.0498 \times X_4) + (0.0382 \times X_5 + 0.0147 \times X_6 + 0.0422 \times X_7 + 0.0268 \times X_8) + (0.0303 \times X_9 + 0.0222 \times X_{10} + 0.0490 \times X_{11}) + (0.2917 \times X_{12} + 0.0208 \times X_{13} + 0.0519 \times X_{14} + 0.017 \times X_{15} + 0.0049 \times X_{16} + 0.0884 \times X_{17} + 0.0665 \times X_{18})\} \times 20 \quad (2)$$

After inputting, one by one, each statistical average score X_i ($i = 1-18$) of the general people's response tendencies obtained from this study's questionnaire survey toward the governance effectiveness of the Dali River Basin into Equation (1) (multivariable linear equation), we obtained the overall governance effectiveness evaluation total score ($GA = 4.003 \times 20 = 80.06$). The result shows the general people give a mid- to upper-level highly recognized evaluation of the standard governance effectiveness. The finding provides a reference for policy iterative feedback.

DISCUSSION

Findings from the statistical analysis of the research data indicate that differences between the result of in-depth interview analysis and the result of AHP analysis exist. The top three attention-getting influencing factors resulting from the analysis of in-depth interviews are in the following order: (1) organizational structure, (2) overall plan, and (3) landscape recreation. In comparison, the top three attention-getting influencing factors resulting from the quantitative analysis of the AHP questionnaire are in the following order: (1) flood protection, (2) overall plan, and (3) ecological conservation. These two are quite different. On the other hand, the last three attention-getting influencing factors resulting from the analysis of in-depth interviews are in the following order: (1) economic activity, (2) urban development coordination, and (3) supervision and review mechanism as well as cultural and historical preservation, whereas the last three attention-getting influencing factors of the quantitative analysis of AHP questionnaire are in the following order: (1) cultural and historical preservation, (2) public-private collaboration, and (3) economic activity. It can be seen that the two are also quite different. Economic activity and cultural and historical preservation both fall into the last three.

The in-depth interview itself lacks structural relevance and is more difficult to control than general quantitative research methods. Also, standpoints and views are more subjective, but it can dive deeper and more broadly into discussing such issues. If it is used along with a practical structured AHP questionnaire, the relative weight relationship of each facet is more objectively meaningful. Respondents use the matrix comparison method to answer questions. When focusing on evaluating the relative importance of governance effectiveness, respondents subjectively answered based on the questions and situations described in the questionnaire. After consistency verification, opinions of respondents can be converged; the relative weighting relationship among influencing factors is more objectively meaningful. It is obvious from the findings that a high degree of interview attention is not necessarily an objectively important influencing factor of governance effectiveness.

This study also compared the evaluation differences of each AHP attribute among the main facets of RBUs, NRBU, and the general people; the comparison results are shown in Table 3. It can be found that the focus of NRBU is closer to the view of the general people, and the difference is more obvious in the main facets of 'mechanism act' and 'co-operation and interaction.' The key to the differences lies in the different standpoints. Public service units first focus on administration in accordance with the law. Whether it is law or administrative rules, public service units place more emphasis on crime prevention than prosperity, resulting in restricting the administrative actions of public agencies and also affecting administrative efficiency. However, with the surging tide of democratization, public participation has been seen as the key to enhancing the representativeness and

Table 3 | Attention drawing comparison of main facets of RBUs, NRBU, and the general people.

Order of importance	RBUs	NRBU	Evaluation of the people
1	social needs	social needs	social needs
2	promote the plan	promote the plan	promote the plan
3	mechanism act	cooperation and interaction	cooperation and interaction
4	cooperation and interaction	mechanism act	mechanism act

legitimacy of governance, while promoting government openness and accountability is unavoidable and cannot be avoided.

The public sector has been executing a 'comprehensive river basin management' strategy for Dali River Basin in Taiwan for decades and plans to consider the cost-benefit ratio between investment costs and output benefits. Based on the concept of 'comprehensive river basin water management,' lands are restored to their function of storing natural rainwater and carrying out 'outflow control' in downstream rivers and drainage confluence points to share the water volume in the river basin and avoid flooding due to the overflow of the embankment. The policy goal has shifted to the basic one of maintaining the overall environmental ecology of the river basin and takes flood protection and cost-effectiveness into account to rebuild the natural basin style. (WRA, 2009) This study examined policy considerations from the perspective of the effectiveness of governance across boundaries. Findings from empirical analysis of this study's construction model show that there is still room for policy adjustment and review between the public sector's core focus and the expectation of the general people despite the public has given a score of 80.06, an upper middle level evaluation, to the Dali River Basin governance effectiveness of the public sector.

This study adopted an open-convergent exploratory research method with qualitative judgment and quantitative decision and carried out an interdisciplinary exploration of four main influencing facets and 18 influencing factors. Balancing stakeholders' viewpoints, this study constructed an objective evaluation model composed of promoting the plan, co-operation and interaction, mechanism act, and social needs, and then constructed multivariate linear equations. The test results verify the applicability and accuracy of the evaluation model. By constructing the river governance effectiveness main facets and influencing factors in metropolitan areas, this research bridges the gaps in related studies. Moreover, results from importing the subsequent survey data into the governance effectiveness model and multivariate linear equations deduced from main facets and influencing factors can shorten the information gaps between the supply and the demand (public sector and the general people) and allow decision makers to make better decisions, enabling the policy to instantly receive objective iterative feedback and revision, leading to twice the result with half the effort.

In addition, this study found that due to the different standpoints of various stakeholders, the cognitive differences in the main facets of 'mechanism actor' and 'co-operation and interaction' are more obvious. NRBU focus more closely on public opinion. In contrast, RBUs place more emphasis on administration in accordance with the law, which restricts the administrative actions of public agencies and also affects administrative efficiency.

Nevertheless, with the surging tide of democratization, public participation has been seen as the key to enhancing the representativeness and legitimacy of governance, while promoting government openness and accountability is unavoidable and cannot be avoided.

This study has some limitations, which provide opportunities for future research. The forms of governance across boundaries in each river basin vary due to differences in administrative divisions, political attributes, geography, and humanities, or Eastern and Western cultural backgrounds. The main focus of this study is on a metropolitan river – Dali River Basin, in Taiwan. Due to limitations of research objects, literature collection, and related matching conditions, even though the open to convergence research procedure was adopted and the influencing factors had been rigorously reviewed, might not completely meet the current conditions of river basins in other regions, which may need appropriately modified methods.

CONCLUSIONS

From the perspective of governance across boundaries, this study explores the interactions between the public and the private sectors of Taiwan's current river basin governance. The main conclusions and findings of the study are as follows: First, there are considerable differences between RBUs and NRBU in the cognition of the relative importance of main facets and influencing factors, implying that the differences are related to the conservative mentality of relevant operational units under the bureaucracy, resulting in lack of innovation and positive actions. Second, our results imply that different standpoints have caused the disconnection between expectations of RBUs and other stakeholders. This study applied the document analysis method, combined with in-depth interviews and AHP research methods, to reduce the heterogeneity difference between RBUs and NRBU. The open-convergent complementary research method can make the research results more reasonable and objective and obtain a more moderate evaluation model to objectively judge the governance effect. Third, the statistical analysis results of practical verification indicate that due to the lack of structural relevance of in-depth interviews, the result analysis, and AHP analysis have considerable differences in the degree of attention to various influencing factors. Through the research method, the main facets of river governance effectiveness in metropolitan areas can be constructed, which can clearly identify the influencing factors while evaluating the influencing factors and total results and providing feedback to the public sector can be a policy for revising the PDCA cycle, thereby improving the governance effectiveness.

This study mainly focuses on the existing crux of governance effectiveness in the river basin in metropolitan areas. Based on the research results, we provide some suggestions for future studies: First, the allocation and the use of resources between RBUs of the central government and RBUs of the local government are moving towards systematization and rationalization. How to establish a public-private resource integration mechanism is crucial to make the use of resources more rational and the distribution of resources more systematized. The second is to build an equal, reciprocal and open two-way communication platform for RBUs and NRBU to promote the effectiveness of governance across boundaries. The results may be worthy of further exploration on how to use communication channels such as meetings and dialogue platforms to effectively resolve, eliminate, and merge differences of NRBU and then seek common ground to achieve acceptable consensus.

FUNDING

The author(s) received no financial support for the research, authorship, and/or publication of this study.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

REFERENCES

- Bereskie, T., Rodriguez, M. J. & Sadiq, R. (2017). Drinking water management and governance in Canada: an innovative plan-do-check-act framework for a safe drinking water supply. *Environmental Management* 60(2), 243–262.
- Bischoff-mattson, Z. & Lynch, A. H. (2017). Integrative governance of environmental water in Australia's Murray-darling basin: evolving challenges and emerging pathways. *Environmental Management* 60(1), 41–56.
- Bouckaert, F., Wei, Y., Hussey, K., Pittock, J. & Ison, R. (2018). Improving the role of river basin organisations in sustainable river basin governance by linking social institutional capacity and basin biophysical capacity. *Current Opinion in Environmental Sustainability* 33, 70–79.
- Chang, S. I., Zhao, M., Chen, Y., Guo, X., Zhu, Y., Wu, J. & Tao, Y. (2020). Evaluation on the integrated water resources management in China's major cities – based on city blueprint (R) approach. *Journal of Cleaner Production* 262, 1–20.
- Chen, H. C. & Huang, H. F. (2009). An analysis of evidence-Based policy-Making: the governance strategy for Nan-Shih Creek Basin. *Journal of Public Administration Research and Theory* 31, 101–148.
- Claudia, P. W. (2009). A conceptual framework for analysing adaptive capacity and multi-Level learning processes in resource governance regimes. *Global Environmental Change* 19(3), 354–365.
- Claudia, P. W., Holtz, G., Kastens, B. & Knieper, C. (2010). Analyzing complex water governance regimes: the management and transition framework. *Environmental Science & Policy* 13(7), 571–581.
- Conallin, J., Van Cauwenbergh, N., Duncan, N., Zin, W. W., Lunn, Z., Htike, H., Martin, G., Bogaard, T. & Franca, M. J. (2022). Supporting evidence-based decision-making: capacity building through research. *Water Policy* 21(3), 676–691.
- Daniell, K. A. & Kay, A. (2018). *Multi-Level Governance: Conceptual Challenges and Case Studies From Australia*. ANU Press, Canberra, Australia.
- Dos Santos, P. H., Neves, S. M., Sant'Anna, D. O., de Oliveira, C. H. & Carvalho, H. D. (2019). The analytic hierarchy process supporting decision making for sustainable development: an overview of applications. *Journal of Cleaner Production* 212, 119–138.
- Feingold, D., Koop, S. & van Leeuwen, K. (2018). The city blueprint approach: urban water management and governance in cities in the U.S. *Environ Manage* 61(1), 9–23.
- Gilmore, T. E., Korus, J., Pennisi, L., Martin, D. & Pekarek, K. (2019). Needs assessment: watershed science for water resources directors. *Journal of Extension* 57(4), 1–11.
- Isniah, S., Purba, H. H. & Debora, F. (2020). Plan do check action (PDCA) method: literature review and research issues. *Jurnal Sistem dan Manajemen Industri* 4(1), 72–81.
- Johnson, C. N. (2002). The benefits of PDCA. *Quality Progress* 35(5), 120.
- Koebele, E. A. (2017). *Collaborative Water Governance in the Colorado River Basin: Understanding Coalition Dynamics and Processes of Policy Change*. Ph.D. thesis, Colorado University, Ann Arbor.
- Lee, C. Y. (2016). How to strengthen the cooperation and coordination mechanism between the central and local governments. *Public Governance Quarterly* 3(4), 42–57.
- Liu, H. (2015). *Managing Urban River Ecosystems for Achieving Regional Sustainability in the Pearl River Delta Region*. Ph. D., The Chinese University of Hong Kong, Hong Kong.
- Longboat, S. A. (2013). *First Nations Water Security and Collaborative Governance. Chippewas of Kettle and Stony Point First Nation, Ontario, Canada*. Ph.D. thesis, Wilfrid Laurier University Canada.
- Matczak, P. & Hegger, D. (2021). Improving flood resilience through governance strategies: gauging the state of the art. *Wiley Interdisciplinary Reviews: Water* 8(4), 1–19.
- Moltz, H. L., Wallace, C. W., Sharifi, E. & Bencala, K. (2020). Integrating sustainable water resource management and land use decision-making. *Water* 12(8), 1–20.
- Moore, M. L. (2012). *Collateral Innovation: How River Basin Organizations and A Transnational Network Face Complex Governance Challenges*. Ph.D. thesis, Wilfrid Laurier University, United States.
- O'Flynn, J., Blackman, D. & Halligan, J. (2014). Crossing boundaries in public management and policy: the international experience. *Social Policy & Administration* 49(1), 136–137.

- Paisley, R. K. & Henshaw, T. W. (2013). Transboundary governance of the Nile River Basin: past. *Present and Future. Environmental Development* 7, 59–71.
- Pritchett, C. H. (2014). *The Tennessee Valley Authority: A Study in Public Administration*. UNC Press Books, Chapel Hill, NC.
- Saaty, T. L. (1980). *The Analytic Hierarchy Process*. McGraw-Hill, New York.
- Stakhiv, E. Z. & Hiroki, K. (2021). Special issue for un help: ‘water infrastructure planning, management and design under climate uncertainty’. *Water Policy* 23(S1), 1–9.
- Ulibarri, N. & Garcia, N. E. (2020). Comparing complexity in watershed governance: the case of California. *Water* 12(3), 766.
- UN (2019). World Population Prospects 2019. UN. Available from: <https://population.un.org/wpp/data> of access:2021/10/20.
- UNPD (2018). World Urbanization Prospects 2018. UNPD. Available from: <https://esa.un.org/unpd/wup/> data of access:2021/10/20.
- WRA (2009). *Dali River Management Planning Report*. Water Resources Department, Ministry of Economic Affairs, Taichung, Taiwan.
- Yu, L. H. C. (2011). Trans-boundary water governance in the Mekong River Basin. *Review of Global Politics* 36(36), 115–138.

First received 8 February 2022; accepted in revised form 14 July 2022. Available online 2 August 2022