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Multi-Level Prioritization Analysis of Water Governance Components to Improve Agricultural Water-Saving Policy: A Case Study from Korea

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Abstract: The challenge of unsustainable agricultural water usage in Korea has continued interminably despite persisting climate change impacts; thus, necessitating urgent actions to forestall future water crises. However, achieving this goal requires the involvement of stakeholders to develop an effective governance policy concerning water saving. This study investigates the components of water governance following existing water policy gaps. A multi-level Delphi-AHP technique was used to identify and prioritize the essential components of agricultural water governance that can specifically enhance water-saving policy in Korea. The analysis of twenty-nine formulated components (six main and twenty-three sub-components) based on the OECD water policy gaps was conducted. A Delphi-AHP technique with process evaluation of the agricultural water experts' opinions under pairwise comparisons was used to arrive at the relative order of importance of the components. The order of main components based on the consolidated weight follows core actors (0.316), law, policies, and systems (0.069), budget support (0.135), information sharing and communication (0.099), mutual learning (0.142), and external experts (0.239), while village representatives (0.353), legislation (0.358), central government (0.311), policy committee (0.309), education course (0.374), and facilitator (0.402) were considered as priorities, respectively, for the sub-components of water governance. The findings indicate that strengthening the informal institution could address the water governance gaps in the agricultural sector to achieve water-saving policies. This study recommends a bottom-up approach to water governance that could promote the active participation of core actors such as farmers and villagers in the design of policy and management of agricultural water resources.

Keywords: Delphi-AHP technique; water saving; agricultural water governance; water policy

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1. Introduction

Climate change and its associated impacts have continued to threaten the socio-economic development of many nations. This development has resulted in some countermeasures being promoted, including one of the Sustainable Development Goals of the United Nations (SDG 13–Climate action) [1], to mitigate this menace of our era. While various kinds of human endeavors have been adversely affected, either directly or indirectly, agriculture is recognized as the industry hit worst by the scourge of climate impacts (especially in Asia, due to inconsistency and uncertainty in climatic conditions) [2–4]. For instance, South Korea, one of the industrialized countries in the Asian continent with low ratings on climate policy [5], has continued to experience severe and frequent drought periods, with water scarcity problems which have continued to impact the existing fragile agriculture and crop production system [6,7]. Accordingly, the freshwater resources which are essential for unhindered agricultural production continuously experience depletion, in terms of quality and quantity, despite the increasing demand by both agriculture and non-agricultural sectors [8,9]. Recent studies have also predicted an increase in future water scarcity and drought risk by 2031–2060 and 2071–2099, respectively [10,11], thereby signifying a need for immediate short and long term mitigation strategies.

Water governance plays crucial roles ranging from political, social, economic, and administrative interventions that are responsible for the development and management of water resources to ensure water and food security [12,13]. According to the Organization for Economic Co-operation and Development OECD, 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*" [14]. However, the lack of sound regulatory framework and fragmentation in the institutional structure, including stakeholder participation, which is being promoted by the inefficient water governance are often responsible for inadequate agricultural water availability rather than water scarcity [15,16]. Moreover, the governance gap wherein appropriate stakeholders are not adequately involved could promote unsustainable use of resources, resources insecurity, and challenges in the adoption of a policy on agricultural water management [17,18]. The low level of awareness of the consequence of agricultural water mismanagement has also been attributed to ineffective governance and policy inadequacy [19]. According to the report from the water governance survey of 17 selected OECD countries, it was observed that there has been a huge gap in the number of authorities, ranging from only 2 in the Netherlands to 15 in Chile, involved in the water policymaking at the central government level [16]. The existing gap in the water governance program vis-à-vis stakeholders' involvement is evidence of the hindrance to the design and implementation of water policy programs [13].

While farmers are expected to be at the center of the water governance, being the primary users of the agricultural water and most hazard-affected by the agricultural drought [20], it is indeed imperative to also identify and prioritize other essential stakeholders involving in agricultural water governance-cum-policy to achieve the water conservation and saving goals. Recognizing the stakeholder influence on policymaking and implementation, water governance involving selected stakeholders or authorities has received great attention to combat the unsustainable use of water resources and ensure future water security. In Pakistan, the roles of formal institutions in managing climate change-induced drought and water scarcity, among others, were investigated [2]. Stakeholders' perception of key issues bothering the improvement of agricultural water resources in Malta was conducted [19]. Hargrove and Heyman developed an approach to identifying and classifying water stakeholders to ensure proper participation in the management of water resources problems of the Middle Rio Grande basin in the United States and Mexico border [21]. Isaac and de Loë investigated the influence of the participation of diverse agricultural actors to address the water quality problems in the Lake Erie basin that is jointly shared by both Canada and the United States [22]. Despite the state of studies on stakeholders' participation in water management policy, the essential components of water governance have not been adequately identified along with their roles and clarity for proper implementation [13,16,23,24]. The OECD report on the water governance program revealed the existing components gaps in water governance, which were referred to as key coordination gaps in water policy, hindering the water policy design and implementation in the 17 selected OECD countries and 13 Latin American countries [13]. Addressing the water governance gap requires a multi-level approach [25], which would not only ensure adequate representation of stakeholders' participation in water governance but also enhance the coherence in water governance and policy implementation. However, since the components of governance increase with the number of stakeholders' involvement, there is a need to prioritize the essential agricultural water governance components for effective and efficient policy interventions on water resources management.

The analytic hierarchical process (AHP) is one of the multi-criteria decision analysis tools used for the prioritization of essential factors obtained through the hierarchical structure of several levels to make an effective decision on water resources management [26,27]. The AHP, which was first proposed by Saaty [28], is used to quantify relative priorities based on established criteria among the set of relevant factors of a decision on a ratio scale while emphasizing the consistency among the comparison alternatives [29,30]. The AHP has been previously employed for water resources planning and management concerning stakeholders' participation [26,31–34]. The AHP analysis allows the systematic evaluation of various factors to provide a relatively simple solution to water resources management [27]. Since the decision-making process involving stakeholders is an integral part of water resources management [35], the AHP was employed in this study to assess the key components of water governance to aid the agricultural water-saving policy in Korea.

The study aims to identify and prioritize the essential components of water governance to improve the agricultural water-saving policy in Korea. Korea is considered an ideal case study in this context due to the existing lackadaisical attitude of farmers towards water saving [20], the increasing competition among various water users [36], the incessant drought periods and increasing drought risk [10], and the recent recommendation of integrated water management policy to improve water utilization efficiency [37], prompting the need for inclusive participation in water conservation governance and management. To the best of our knowledge, research that considers the components of water governance relating to agricultural water conservation is limited, particularly in Korea. This study is essential to improve the existing water conservation and saving policy by recognizing the roles of stakeholders via components of water governance.

2. Methodology

2.1. Study Area Description

South Korea is located between Latitude 33° and 42° N, and Longitudes 124° and 132° E in East Asia on the southern part of the Korean peninsula. The total amount of water resources in the country as of 2007 estimate is 129.7 billion m^3 (total available precipitation) with about 54.4 billion m^3 (42%) loss from evaporation and transpiration [38]. However, due to the mountainous terrains and shallow layers of topsoil in the country, which covers about 70% of the country's territory resulting in water draining to the sea, several reservoirs have been constructed across the country, especially for agricultural production (Figure 1). The current reservoir capacity is 3.3 billion m^3, occupying about 422 kg ha (Table 1).

Table 1. Status of irrigation facilities in South Korea.

Classify \ Year	2015			2020		
	Number	**Benefitted Area (ha),**	**Total Storage Capacity (1000 m^3)**	**Number**	**Benefitted Area (ha)**	**Total Storage Capacity (1000 m^3)**
Reservoir	17,310	435,086.3	3,038,927	17,106	422,051.6	3,300,829
Pumping & Drainage	8023	183,981.4	–	9077	173,617.0	–
Weir	18,142	58,791.0	–	18,201	50,028.4	–
Infiltration Gallery	2667	7230.4	–	2613	6071.9	–
Tube Well	24,479	36,439.8	–	28,231	23,886.1	–

Source: Ministry of Land, Infrastructure and Transportation of Korea (MOLIT) and Korea Water Resources Corporation (K-water) [39].

2.2. Selection of Agricultural Water Governance Components

The agricultural water use in Korea has been significantly impacted by climate change with anticipated intensity in the future. Recognizing the OECD's seven essential gaps in water policy (Table 2) [16,40], we formulated 29 important components of water governance, including 6 major and 23 detailed sub-components following the review of examples of well managed agricultural and rural governance systems among the OECD countries (OECD, 2011). These components were formulated based on their definitions and characteristics as they relate to agricultural water governance and management strategy.

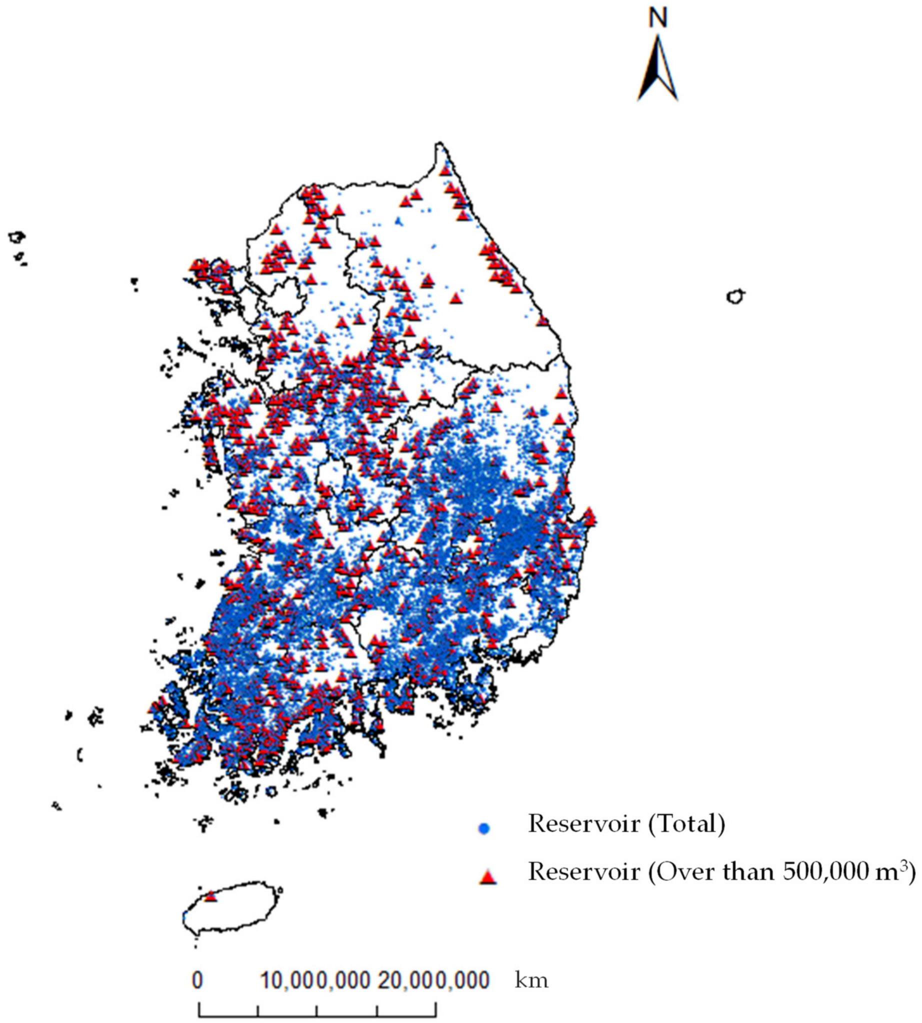


Figure 1. The spatial distribution of agricultural reservoir in South Korea.

2.3. Delphi Survey of Expert Stakeholders

Having understood the water governance gaps affecting the effective stakeholders' participation in managing water resources and formulating the water governance components, the consultation of stakeholders who are considered experts in the field was subsequently conducted. The policy Delphi survey was employed in this regard to seek experts' divergent opinions to prioritize the important components of water governance, among the pool of available components, that are applicable to agricultural water governance [41]. The choice of using the policy Delphi survey was well informed due to the impracticable of organizing face-to-face setting for all of the targeted experts [42]. Additionally, this method allows the expert stakeholders to reflect on their preferences from the first round of the survey. A total of 19 expert stakeholders consisting of core actors and external experts who are active in the domain of agricultural water use and management were sought. The core actors include farmers, village representatives, agricultural water facility monitoring personnel, and heads of local farmer groups, which were all selected based on the suggestion from the Korea Rural Community Corporation (KRC), a government agency in charge of agricultural water management in Korea. In addition, stakeholders from academia and policymakers were selected as external experts. The composition of the sought experts meets the diversity required to achieve the multi-actors collaboration on water-related problems [43]. The major requirements from the considered experts are their prior experience and understanding of the governance, rural communities, and current status of the agricultural water management system in Korea with more than five years of experience. The survey questions centered on the governance, rural communities, and agricultural water management systems that were communicated to the target expert stakeholders through interviews and electronic mail after the prior explanation of the study objective. The approval to conduct this study was sought from the Kyungpook National University, Daegu, Korea, an affiliation of the authors, through which the experts were contacted (Figure S1).

Table 2. The seven key water governance implementation gaps in water policy.

Gap in Water Governance	Description	Examples of Countries or Regions
Administration	Geographical "mismatch" between hydrological and administrative boundaries. This can be at the origin of resource and supply gaps	Australia, Greece, Italy, Korea, Netherlands, Portugal, Spain, United Kingdom, United States (Colorado)
Information	Asymmetries of information (quantity, quality, type) between different stakeholders involved in water policy, either voluntary or not	Australia, Chile, Italy, Korea, Netherlands, New Zealand (subnational actor), United Kingdom, United States (Colorado)
Policy	Sectoral fragmentation of water-related tasks across ministries and agencies	Belgium (Flanders), Canada, France (subnational actors), Greece, Israel, Italy, Korea, Spain (subnational actor), United States (Colorado)
Capacity	Insufficient scientific, technical, infrastructural capacity of local actors to design and implement water policies (size and quality of infrastructure, etc.) as well as relevant strategies	Australia, Belgium (Flanders), Chile, Greece, Italy, Korea, Netherlands, Portugal, Spain, United Kingdom, United States (Colorado)
Funding	Unstable or insufficient revenues undermining effective implementation of water responsibilities at subnational level, cross-sectoral policies, and investments requested	Australia, Belgium (Flanders), Chile, France, Greece, Israel, Korea, Mexico, New Zealand, Portugal, Spain, United States (Colorado)
Objective	Different rationales creating obstacles for adopting convergent targets, especially in case of motivational gap (referring to the problems reducing the political will to engage substantially in organizing the water sector)	Belgium (Flanders), Israel, Korea, Portugal
Accountability	Difficulty in ensuring the transparency of practices across the different constituencies, mainly due to insufficient users' commitment, lack of concern, awareness, and participation	Belgium (Flanders), Chile, Greece, Italy, Korea, Mexico, Netherlands, Portugal, United States (Colorado)

Sources: OECD Multilevel governance gaps [16] and OECD Water Governance Survey (OECD, 2010).

2.4. Analytic Hierarchical Process

Considering the level of pertinent expertise and highly motivated stakeholders that are considered in this study, the AHP was therefore used in the decision analysis to prioritize the components of water governance based on these experts' opinions. AHP has been considered to have advantages over other multi-criteria decision analysis tool in terms of policy evaluation and performance assessment, especially in the use of pairwise comparisons [44]. Moreover, the AHP makes use of small sample size based on experts' opinions to achieve the desired prioritization goal [45]. The AHP analysis flowchart applied in this study is shown in Figure 2, where a survey on the relative importance of experts' opinions on the components of water governance for agricultural water-saving and conservation policy is conducted to calculate the weight and the pairwise comparison among the evaluated alternatives based on the collected opinions.

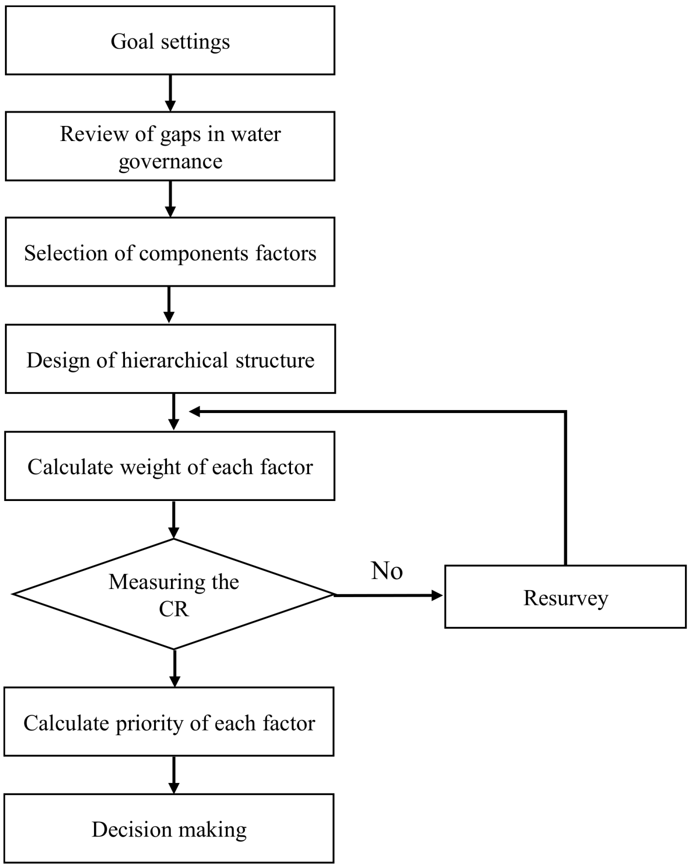


Figure 2. The Delphi-AHP flowchart for prioritizing the components of agricultural water governance.

However, in a case where the experts' opinions contrast based on the consistency ratio (CR) test, the resurvey was solicited from the concerned experts.

The steps for the weights estimation and CR calculation are as follows:

In the AHP analysis, for the lower layer consisting of n elements, the relative importance or weighting was derived by two binary comparisons of $n(n-1)$ times. In addition, the diagonal elements of a matrix have a value of 1, and the square matrix A centered on it is equivalent to Equation (1).

$$\mathrm{A} = \begin{pmatrix} 1 & a_{12} & a_{13} & \cdots & a_{1n} \\ a_{21} & 1 & a_{23} & \cdots & a_{2n} \\ a_{31} & a_{32} & 1 & \cdots & a_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & a_{n3} & \cdots & 1 \end{pmatrix} \tag{1}$$

where $a_{ji} = \frac{1}{a_{ij}}$ $(\mathrm{i}\,,\, \mathrm{j} = 1, 2, \cdots, \mathrm{n})$

In Equation (1), the values of each column in the matrix were normalized and averaged, and then multiplied by the weighted column vector,$\mathrm{w} = (w_1, w_2, \cdots, w_n)^T$, indicating the relative importance of the reference to the target in Equation (2).

$$\begin{pmatrix} 1 & a_{12} & a_{13} & \cdots & a_{1n} \\ a_{21} & 1 & a_{23} & \cdots & a_{2n} \\ a_{31} & a_{32} & 1 & \cdots & a_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & a_{n3} & \cdots & 1 \end{pmatrix} \cdot \begin{pmatrix} w_1 \\ w_2 \\ w_3 \\ \vdots \\ w_n \end{pmatrix} = \begin{pmatrix} nw_1 \\ nw_2 \\ nw_3 \\ \vdots \\ nw_n \end{pmatrix} \tag{2}$$

where w is the weighted column, and n is the maximum eigenvalue in matrix A.

Equation (3) is an eigenvalue problem that seeks a non-zero solution in the n system of the Equations (1) and (2), which is further summarized in Equation (4) in terms of w.

$$\mathrm{A}{\cdot}\mathrm{w} = \mathrm{n}{\cdot}\mathrm{w} \tag{3}$$

$$(\mathrm{A} - \mathrm{nI}){\cdot}\mathrm{w} = 0 \tag{4}$$

To obtain the overall order of the various alternatives to be evaluated, the relative weight of each element was synthesized to calculate a composite priority vector for all layers and prioritize the final evaluation and each alternative using Equation (5).

$$\mathrm{C}[1, k] = \prod_{i=2}^{k} B_i \tag{5}$$

where $\mathrm{C}[1, k]$ is the overall weight of the k-th layer element for the first layer, B_i is a matrix $n_{i-1}{\cdot}n_i$ containing a row constituting the estimated w vector, n_i is the number of elements in the i-th layer.

Pairwise comparisons of alternatives using experts' opinions were used to obtain the relative importance of both main and subcomponents with the Saaty's relative scale measurement as shown in Table S1 [40].

For inconsistency in the response in experts' opinions during a dual comparison, the relative importance of element i relative to element j of the paired comparison is defined using Equation (6).

$$a_{ij} = \left(1 + \delta_{ij}\right) \frac{w_i}{w_j} \tag{6}$$

where δ_{ij} is the degree of inconsistency with $\frac{w_i}{w_j}$, $\delta_{ij} > 1$.

The difference between the maximum hyperbolic λ_{max} obtained from the actual pairwise comparison matrix and the maximum hyperbolic n of the pairwise comparison matrix with complete consistency is expressed as Equation (7).

$$\lambda_{max} - n = \frac{1}{n} \sum_{1 \le i < j \le n} \frac{\delta_{ij}^2}{1 + \delta_{ij}} \ge 0 \tag{7}$$

If the estimated value a_{ij} matches with $\frac{w_i}{w_j}$, then δ_{ij}=0 and $\lambda_{max} - n$ is established. Therefore, the closer the λ_{max} is to n, the more consistent the respondent can be consdidered to be, where the repsondent's consistency index (CI) is defined in Equation (8).

$$\mathrm{CI} = \mu = \frac{\lambda_{max} - n}{n - 1} \tag{8}$$

For the AHP analysis, the consistency in decisions was determined using the consistency ratio of the consistency index to the average random index (*RI*) as indicated in Equation (9).

$$\mathrm{CR} = \frac{CI}{RI} \tag{9}$$

where CR is the consistency ratio, *CI* is the consistency index, and *RI* is the random index.

The average random *RI* for different sizes of a matrix is obtained from the empirical study by Saaty [46] as shown in Table 3.

Table 3. Saaty values of random consistency index for complete pairwise comparison matrices.

Size of Matrix (*n*)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

The zero value of CR indicates consistency in the survey responses for pairwise comparison. The pairwise comparison of survey respondents is adjudged to be consistent if the CR is less than 0.1, while the CR value of greater than 0.2 indicates inconsistent responses of the survey respondents; thus, a resurvey is required [46].

Microsoft Excel 2010 (Microsoft Corp., Redmond, WA, USA) was used for the AHP analysis.

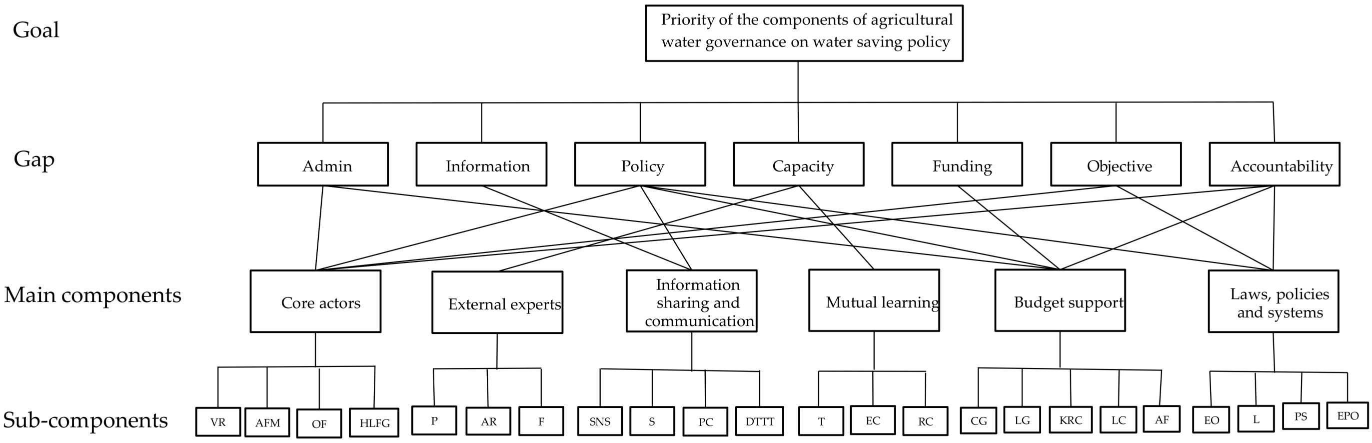
3. Results and Discussion

3.1. Agricultural Water Governance Components

Water governance involves the interaction of actors, institutions, and processes to provide efficient water service delivery under divergent socio-political, economic, and administrative levels [25]. The identified components of agricultural water governance that are considered to be important to improve the agricultural water-saving policy in Korea comprise 6 main components and 23 sub-components. The main components include core actors, external experts, information sharing and communication, mutual learning, budget support, and laws, policies, and systems, which were formulated based on the literature review of the reported gap in water governance in 17 OECD countries (see Section 2.2). These important gaps in water governance, including funding, capacity, policy, administration, information, accountability, and objectives were all considered responsible for or largely contributing to poor water policy design and implementation, including in Korea (Table 2) [16]. On this basis, the 26 sub-components targeting agricultural water governance were formulated (Figure 2). Berg [47] identified seven key elements of water governance for analyzing water infrastructural performance, which are interests (stakeholders), information, ideals (objectives), ideas, institutions, incentives, and individuals (leadership) [47]. In our study, all of these components are also captured as sub-components while linking them to the appropriate existing gaps in water governance (Figure 3).

3.1.1. Core Actors

The core actors (i.e., agricultural water users and political actors that are selected as components of agricultural water governance) are farmers, heads of local farmer groups, village representatives, and agricultural facility monitoring personnel. As part of the components of governance, core actors play an important role in the implementation of water-saving policy when they are appropriately engaged. One of the ways farmers and other core actors are engaged in water governance is through water user associations [48]. However, in some instances where such an association is not in place, the farmers are excluded in the governance and decision making, thereby leading to poor implementation of water conservation policy [49]. This was reported in the Saemangeum project in Korea where farmers were not involved in the water governance to tackle the water quality of the reclaimed area [50]. According to the survey on water governance in 17 OECD countries, six principal actors are responsible for the design and implementation of water policy in Korea while four actors for the policy regulation, with the central government acting as the dominant actor [16]. Thus, the inclusion of the core actors (farmers and other users of agricultural water) as part of the components of agricultural water governance is essential to achieve meaningful success in the design and implementation of any water conservation policy.



Key:
VR — Village representative
HLFG — Head of local farmer group
F — Facilitator
PC — Policy committee
EC — Education course
LG — Local government
AF — Association of farmers
PS — Policy support
AFM — Agricultural facility monitoring personnel
P — Professor
SNS — Social Network Service
DTTT — Developing textbooks and teaching tools
RC — Regional consultation
KRC — Korea Rural Community Corporation
EO — Enactment of ordinances
EPO — Establishment of professional organization
OF — Ordinary farmer
AR — Agricultural researcher
S — Seminar
T — Training
CG — Central government
LC — Local cooperative
L — Legislation

Figure 3. The multi-level hierarchical structure of agricultural water governance components.

3.1.2. External Experts

The academics (professors), agricultural researchers, and facilitators essentially constitute the components of agricultural water governance selected under the external experts. The role of academics, as conceivers of ideas to be implemented by the individuals in the society to change human behavior [47], necessitates the constituted external experts from the academia and researchers since the main goal is to achieve water-saving driving by human behavior (herein water users). The capacity gap in the water governance in Korea can be adequately addressed by involving the experts through the implementation of the relevant ideas on water saving policy. Recently, Lee and Choi developed a water-saving education model for Korean farmers to promote the adoption of water conservation and adaptation measures to prevent drought risks [20]. Incorporating such kinds of ideas from experts into water governance will promote the implementation and development of water saving policy. Moreover, Golabi et al. also emphasize the role and opinions of experts in water use efficiency in agricultural settings [51].

3.1.3. Informational Sharing and Communication

The poor state of communication between local farmers and governmental agencies and experts has led to an information gap with the exclusion of farmers from the governance, despite their central role in implementing the appropriate policy to address the water resources problem in Korea [50]. According to the OECD survey, Korea was listed as one of the countries where the information gap exists as one of the factors limiting the actualization of water conservation policy [16]. Knowledge communication plays an important role in the adoption and implementation of different environmental policies including water conservation. In fact, information plays a vital role in ensuring the timely implementation of policies, and it is essential to achieve any good governance objectives.

However, inadequate coordination of the knowledge flow has become a challenging factor considering the polycentric nature of water governance [50,52]. While smooth knowledge communication on the implementation of integrated water management exists at national and provincial levels, the local level (local farmers) is often disconnected from the knowledge [50]. In order to ensure available proper platforms for knowledge communication, the sub-components of water governance in information sharing and communication are formulated as textbooks and teaching tools, social network services, seminars, and policy committees. The role of the policy committee on information sharing and communication is to provide essential coordination required to ensure that adequate and accurate information reaches the target actors. In multi-level governance, it has been noted that mechanism of knowledge communication has always been a complex issue [53], with the adoption of technological approaches such as social network service suggested to be useful in managing the information and knowledge sharing [54]. It has also been suggested that the deployment of both water and information and communication technology can have a far-reaching effect in the management of water resources to deliver water services and ensure an efficient water allocation regime [55].

3.1.4. Mutual Learning

Adequate training and knowledge-sharing programs on water saving for the core actors such as farmers can ensure efficient water use practices [56]. Farmers primarily assume and take priority in increasing food production rather than being concerned with environmental activities, including water conservation. The farmers often withdraw water than required due to the inadequate knowledge on crop water requirements or water use efficiency in crop production. In fact, knowledge and information sharing have been regarded to be highly important when it comes to the sustainable development of water governance [54]. Consequently, there is a need for training activities and essential education courses on the environmental impacts of unstainable use of resources, conservation of water resources in the field, and opportunity cost of misallocation or misuse of water resources. To achieve this, the training of farmers and other water users on this important role through adequate interaction with the experts and relevant government agencies is essential as part of the water governance. The importance of the role of training of farmers and other stakeholders working in the water sector on economic, environmental, and social values of water cannot be overemphasized [15].

3.1.5. Budget Support

In the past, a significant investment was made available to support water resources management to meet water needs and protect floods and drought risks. This consequently drive and facilitated rapid urbanization and economic growth in Korea. However, the existing investment response in the water management resources in Korea needs a revisit considering the climate change impact and aging population that drives more demand for adequate quality and quantity of water resources with strain revenue coming from the water sector [55]. One of the major key gaps in water governance facing Korea is inadequate funding capacity [16,55], and this is expected to be more extended in the future if adequate innovations and efforts are not explored as the water sector is being greatly impacted by the climate change. Although there is a water fee being levied on water users such as industry and domestic users while farmers are exempted, the approach is however not targeted at promoting either water use efficiency or to addressing water scarcity as the generated revenue is not sufficient to maintain and expand the existing water infrastructure [55]. The major sources that could strengthen the funding capacity in terms of budget support in Korea are listed as the central government, local government, Korea Rural Community Corporation, local cooperatives, and associations of farmers to form components of water governance.

3.1.6. Laws, Policies, and Systems

The policy gap is essentially due to the institutional fragmentation in carrying out roles and responsibilities as related to water policies [25]. Aside from the actors and other components, the institution is considered an important part of water governance through which policies are supported and backed by appropriate laws. According to the OECD, the institutions provide a platform for stakeholders to come together and express their concerns and interests for appropriate decisions to be made by the policy-makers [14]. For instance, the policy supports the incentives for farmers regarding the efficient use of water resources as part of the European Union policy mechanism to promote water use efficiency [57]. This type of policy support was able to be implemented as a result of the existing sound institution. However, the institutional fragmentation has continued to affect the policy efficiency and its implementation in Korea where contradictory laws are being made by sisters institutions within the same water sector, thereby leading to a policy gap [55]. Nevertheless, the institutional water governance can be strengthened through the appropriate laws, policies, and systems comprising of enactment of the ordinance, legislation, policy support, and establishment of a professional organization. More importantly, the introduction of the informal institution at the local level of governance, where the farmers and other actors of water users can be actively involved in agricultural water governance.

3.2. Analysis of Delphi-AHP Technique

The Delphi survey of opinions was carried out by the stakeholders who are experts in the field of agricultural water resources and rural development in Korea. The distribution of the considered expert stakeholders shows that core actors, academics, and government personnel accounted for 16%, 26%, and 37%, respectively, and they are all male (Table S2). The cognizant experiences of the experts showed that 84% have more than five years of experience in agricultural water management and rural development in Korea while 68% have more than five years of experience in governance. It has previously been reported that experts' opinions can help to classify and rank complex factors of water resources management [35]. Meanwhile, the expert with a minimum of five years of experience on a subject is considered to have adequate knowledge to offer an appropriate and relevant opinion.

One of the primary functions of multi-criteria analysis-based AHP is an assessment of the significance or relative importance of a component over another. The opinions of the experts were subjected to relative weights using pairwise comparisons based on the AHD method. This process can be regarded as a group decision-making process based on the analysis of individual expert rankings aimed at finding appropriate alternatives to the water resources problem [35]. The result of hierarchical analysis with experts' opinions evaluation based on the relative weight of criteria for the main components of agricultural water governance showed that core actors (0.316) should be the first priority when it comes to achieving the goal of water conservation and water-saving policy followed by law, policies, and systems (0.239), budget support (0.142), information sharing and communication (0.135), mutual learning (0.099), and external experts (0.069) (Table 4). The rating of each of the components was based on the numerical scale for pairwise comparisons (Table S1), following experts' opinions. The consistency ratio of 0.061, which is less than 0.1, indicates the consistency and acceptability in evaluating the expert opinions on the ranking of water governance components [46].

Similarly, the order of priority of sub-components of agricultural water governance based on the main components under which they are classified follows village representative (0.353), legislation (0.358), central government (0.311), policy committee (0.309), education course (0.374), and facilitator (0.402) (Table 5). For instance, village representatives, agricultural facility monitoring personnel, ordinary farmers, and head of local farmer groups were evaluated under the main component of core actors. It can be observed that the consistency ratio for each of the main actors under which the sub-components were evaluated is less than 0.1 (Table 5), indicating the acceptability of the experts' opinion evaluation on the priority of the components of agricultural water governance. Moreover, the number of sub-components considered in each main component for pairwise comparison is within the acceptable limit to ensure the accuracy of the AHP technique [44]. While other experts offered their opinions once without reconsideration, the resurvey was carried out only once by the experts from the private agency to arrive at the consistent and acceptable level.

Table 4. The relative weight and consistency ratio of main component.

Main Components	Weight	Rank	Consistency Ratio
Core actors	0.316	1	0.061
Law, policies, and systems	0.239	2	
Budget support	0.142	3	
Information sharing and communication	0.135	4	
Mutual learning	0.099	5	
External experts	0.069	6	

Table 5. The relative weight and consistency ratio of sub-component.

Main Components	Detailed Sub-Components	Weight	Rank	Consistency Ratio
Core actors	**Village representative**	**0.353**	**1**	0.052
	Agricultural facility monitoring personnel	0.199	3	
	Ordinary farmer	0.349	2	
	Head of local farmer group	0.099	4	
Law policies, and systems	Enactment of ordinances	0.119	4	0.048
	Legislation	**0.358**	**1**	
	Policy support	0.277	2	
	Establishment of professional organization	0.246	3	
Budget support	**Central government**	**0.311**	**1**	0.053
	Local government	0.296	2	
	Korea Rural Community Corporation	0.245	3	
	Local cooperative	0.064	5	
	Association of farmers	0.084	4	
Information sharing and communication	Social network service	0.261	3	0.044
	Seminar	0.284	2	
	Policy committee	**0.309**	**1**	
	Developing textbooks and teaching tools	0.146	4	
Mutual learning	Training	0.259	3	0.044
	Education course	**0.374**	**1**	
	Regional consultation	0.367	2	
External experts	Professor	0.280	3	0.039
	Agricultural researcher	0.318	2	
	Facilitator	**0.402**	**1**	

The presented results are in agreement with the findings reported by Thungngern et al., where community representatives were recognized as the first priority of environmental factor followed by knowledge to achieve the objective of water resources management [35].

3.3. Prioritization of Components of Agricultural Water Governance

The prioritization of experts' opinions was based on the prior defined set assessment criteria targeting at improving the existing water-saving and conservation policy in Korea. The order of relative importance for the main components follows core actors, laws, policies and systems, budget support, information sharing and communication, mutual learning, and external experts.

The first priority of the major components of water governance is the core actors. The ranking of the core actors as the first priority in the agricultural water governance is not surprising since their involvement in the decision-making process could provide an avenue to identify the root cause of the water crisis while the suggested solutions can be fully implemented by these actors. For instance, some Korean farmers were reportedly expressed disdains towards government policies on water quality in the Saemangeum area of the country since they felt they were not carried along while the government was making such policies but were ordered to follow policies without considering the favorability or their lack of understanding of such policies [50]. The top-down approach of governance in the agricultural water sector where the policies are made at the central government without appropriate consultation from the core actors that are likely to implement such a policy will always create a lack of trust and engagement of stakeholders. However, the bottom-up approach of water governance in the agricultural sector will promote sustainable development of water governance since the farmers and other relevant water users will have a sense of belonging and consequently influence their active participation in the implementation of relevant policies. The village representative is ranked as the most important priority sub-component of agricultural water governance among the core actors. This is possibly due to the influence this core actor can have in representing the interest of the other core actors when involves in the decision-making process. For instance, village representatives were found to be instrumental in the approval of the irrigation facility to combat the incessant drought problem in the Wulai village of China [58]. Similarly, Meinzen-dick and Raju found out that traditional rulers acting as village representatives play an important role in lobbying and organizing farmers and other water users to partake in governance schemes at a relatively reduced cost [59]. Thus, a well-coordinated village representation could serve as a socio-political link between the farmers and government/policymakers to lobby for the provision of good water governance in the agricultural settings.

Law, policies, and systems have been ranked as the second prioritized component of agricultural water governance. The institutional approach of agricultural water policy where the irrigation or agricultural water management is devolved from the government bodies to local farmer groups or user associations is recognized as an emerging global consensus on how water resources could be efficiently managed [48,59–61]. Although combining both bottom-up and top-down approaches to resolving water challenges by ensuring cooperation among the stakeholders is regarded as good water governance by OECD [14]. Devolvement of water governance using a bottom-up approach allows the local authority to take ownership and maintenance of the water and its infrastructure [20]. This policy paradigm on water governance has also been adopted or aligned widely with the Dublin principles on water development policy, which encompasses ecological principle, institutional principle, and instrumental principle [62]. Moreover, the use of informal institutions for policy formulation at the local level of governance provides a required trust and satisfaction for the implementation of such policies by the farmers [63]. However, the central government still plays a dominant role in water policy in Korea on the basis of a top-down approach making the implementation of many water conservation-related policies which are difficult to be adopted by the farmers and other local actors. In this regard, the selection of legislation as the prioritized component is very important as this can be used to change the paradigm of top-down approach to bottom-up approach for effective designing and implementation of water conservation policy.

The third-ranked component of water governance to be prioritized is budget support, with the most important sub-component selected being central government support. Investment in the water sector is very key to actualizing the reform and objective of adequate water provision to meet growing demands. Water financing has also been identified as one of the major four target areas for improving water governance [60]. Although the reduction in water finance or budget has been continuously reported as one of the essential gaps affecting the water governance among the OECD countries [16], other underline issues need to be addressed which include lack of clarity on to address the lack of fund issue, lack of transparency in water pricing, inadequate monitoring system and data access, and conflicting interest in prioritizing water infrastructure spending above water demand management, among others [60]. The allocation of water use in the agricultural sector in Korea has continued to decline in recent times, and the debate on policy reform always met with the conflict relating to financial issues [37]. The unstable and inadequate funding sources have continued to undermine the effective and efficient implementation of water governance and responsibilities (especially at the local level). Water pricing plays a key role to meet a certain level of financial responsibility of water resources management [38]. However, agricultural water use in Korea is relatively free. Thus, the financial support from the central government could be the only way the funding gap issue can be addressed in the short term while the introduction of water pricing can be considered for long term solutions.

Information sharing and communication is ranked to be prioritized after budget support. This ranking cannot be denied as it has been previously noted (see Section 3.1.3) on the importance of this component to achieve any good governance objectives. While other formulated components of information sharing and communication are equally important, the role of the policy committee as being selected as a priority is highly significant. It was reported that there has been an information gap between the two important ministries in charge of agricultural water resources management (Ministry of Environment, and Ministry of Agriculture, Food and Rural Affairs) in Korea, and farmers are often intentionally deprived of information by the local and community actors [50]. Several reasons have previously been attributed to the gap in communication at a different level of water governance, which includes conflict of interests [64], lack of appropriate interactions among the actors at different levels [65], epistemologies [66], and boundary demarcation [50]. This indicates a policy problem rather than the lack of appropriate information, and the policy committee is in a better position to address the crisis of the information gap. This position has also been the opinion of some other researchers [60].

Mutual learning, as a component of agricultural water governance, is ranked as a priority after the information sharing and communication. These two components are relatively similar but they have different objectives. It has been identified that information is often provided from the sources (Ministries, for instance) but due to the various gaps in communication, such information is not reaching the target audience. However, with mutual learning, different levels of governance can have access to the required training. This is not surprising, as education courses are ranked as having the most priority under mutual training. An education course serves as capacity building for the farmers and other water users on water conservation techniques and management of water structures. The conduction of proper training for farmers has been reported to promote their good perceptions of the government institution including both formal and informal, while also positively influencing their perception and behaviors concerning water resources conservation [18,63]. Similarly, farmers expressed a lack of knowledge on the severity of climate change's impact on agricultural water availability, thereby resulting in their lackadaisical attitude towards unstainable use of the water resources. However, adequate training could improve stakeholder participation in water governance and the adoption of relevant schemes that can promote water conservation policy. The importance of knowledge of water resources management was also reported as one of the top priorities to address the water resources problem [35]. The water-saving education program that was recently conducted across some selected farming communities in Korea has been regarded as an eye-opener to the farmers on the impact of climate change and their attitudinal change towards protecting water infrastructure and water conservation [20]. The participatory learning approach where farmers are trained and share knowledge can strengthen their problem-solving skills and improve their level of confidence [15].

The finding in this study indicates that the role of external experts as a component of agricultural water governance is ranked as the seventh priority. While experts from academia or research institutes are responsible for the ideas that could be implemented by the core actors to achieve desirable objectives of water policy, the knowledge or information provided is often too technical for the farmers to comprehend. For the effective implementation of the ideas generated by the academic experts, there is a need for the translation and communication of such ideas in a plain or layman's language to farmers. This has possibly led to prioritizing the facilitator as the major important component of external experts in agricultural water governance. The facilitators are also among the external experts but are regarded as technical experts and can translate and explain the academic idea or knowledge of the water conservation issue to the local farmers in a plain language they can easily understand [50]. The technical expert should be someone that has previous working experience with the farmers since they will play an active role in knowledge communication and transfer.

4. Conclusions

This study was conducted to identify and prioritize the components of agricultural water governance in Korea using the Delphi-AHP technique with expert stakeholders' opinions evaluation based on the existing gaps in water governance. The components of agricultural water governance comprising of 6 main and 23 sub-components were formulated from the actors, institutions, and processes that are essential to enhance water-saving/conservation policy. The order of the main components in terms of their relative importance based on the consolidated weight follows core actors (0.316), law, policies, and systems (0.069), budget support (0.135), information sharing and communication (0.099), mutual learning (0.142), and external experts (0.239), while village representatives (0.353), legislation (0.358), central government (0.311), policy committee (0.309), education course (0.374), and facilitator (0.402) were considered as priorities, respectively, for the sub-components of water governance. This study identified the importance of the bottom-up approach of agricultural water governance to address the various existing water policy gaps in agricultural settings. Effective governance provides an avenue or platform for an efficient interaction among the components of governance comprising of actors, institutions, and processes to meet up with the objective of water service delivery. The informal institution, where farmers and rural communities will be at the center stage of policymaking and water resources management, can provide the coherence required for such effective governance in the design and implementation of water-saving/conservation policy.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su14063248/s1, Figure S1: A sample of ethic approval to conduct the study; Table S1: Saaty's numerical scale of importance for pairwise comparisons in AHP; Table S2: Sociodemographic characteristics of the expert stakeholders.

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