REVIEW ARTICLE

Identification of influencing components on water scarcity management performance for sustainability in limited water resource area: a review

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ABSTRACT

Water management by policy makers is based on multi-perspective information. In the case of water, scarcity causes public health, economic, and ecosystem problems because of the lack of safe water when the demand exceeds its availability. This study identified the influencing components of water scarcity management performance by systematic review methods based on two English full-text databases: Scopus and ScienceDirect from 2012 to 2022. A total of 22 studies were selected from 850 records by using the inclusion criteria and performance evaluation by the scoring rubric method. Moreover, the article quality was assessed using a critical appraisal tool by the Joanna Briggs Institute (JBI) critical appraisal checklist method. The result of this review revealed that the main influencing components of water scarcity management are related to the availability of water quantity and demand. Water availability is associated with the hydrological cycle which has uncertainty due to climate change. While the demand components depend on water use, population, industry and urbanization. Most of the studies in the literature review considered only water balance of water availability and demand. Such an approach is insufficient to achieve water security for sustainable development goals. Additional components including environmental components such as water quality degradation should be considered as these components can reduce the availability of freshwater resources. From an economic point of view, the benefit of water utilization should be prioritized in scarce water management in consideration of fairness in water rights. It is also essential to consider the contribution to socio-economic aspects from stakeholder meetings and participation.

Key words:
water scarcity; water security; ecosystem; water quality; water governance; sustainable development.

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INTRODUCTION

There are many problems related to water resources, such as floods, droughts, water scarcity and pollution, etcetera. Lack of sufficient water supply to meet water demand results in water scarcity problems and water stress. Water demand depends on the activities of water users. In contrast, water supply depends on the output of meteorological and hydrological conditions, which may be uncertain due to climate variability and climate change. Wastewater from agricultural and urban areas carries water-borne diseases and due to toxicity is unsafe for drinking resulting in the death of people, especially children[1]. Due to the increasing number of populations, the number of people affected by water scarcity is increasing, whereas the weather patterns have become more unpredictable and extreme.[2] Besides, the environment of an ecosystem which needs water to preserve is also affected due to scarcity. Water use has been growing more than twice in the last century, reaching the limit at which water services can be sustainably delivered, especially in arid areas.[3] Water use is critical to social and economic development and affects society. Therefore, managing water resources under scarcity should be recognized for conflict resolution to develop policy options stimulating adaptive processes and strengthening social resource capacity.[4] However, the uncertainty of climate change should be considered in water resource management. Finally, efficient and effective management of scarce water resources is essential to balance human and environmental necessities to reach future sustainable development goals.

Water resource management is the activity of planning, developing, distributing and managing the optimum use of water resources.[42] In limited water resource areas, water availability is restricted to meet the needs. Meanwhile, the demand is not limited and tends to increase depending on the population and activity change; this may cause well-being problems, people cannot get enough to drink, wash, or feed crops and economic decline may occur. Diseases can lead to people's death because water quantity will be only one interest and quality is ignored. However, few studies have converted environmental component into an indicator for assessment because it is difficult to improve the problem of water environment pollution fundamentally.[12] Then environmental component should be considered by grey water footprint and carbon emission to reduce the pollution[27,30,32] that may cause to carry more significant stress on the water source than freshwater consumption[30] and affect human health by consumption of the contaminated water. Consequently, it is necessary to develop low-carbon energy technologies and improve water quality enormously.[32] Furthermore**,** improvement of community knowledge about the water cycle and water issues[34] aims to protect, recover and promote the sustainable functioning of ecosystem services, such as water regulation, maintenance of biodiversity, carbon sequestration and storage, and regulation of natural risks.[14] Some studies which referred to management among various water-use sectors (agricultural, industrial, and domestic) always conflicted when they mentioned the productivity or financial benefit[26] in the limited water resources area. The management must clarify the rights and equity of users and are submitted to a sophisticated tax system. As more activities compete for the relatively constant amount of water, water gradually becomes a precious resource; users will have to pay for it and wastewater discharge. Water rights and allocation plans must be set up to minimize and mediate conflicts.[5] Therefore, a collaboration between researchers and the national authority will be the key. Maximizing the benefits for decision making and new initiatives must motivate co-operating stakeholder interest in governance through natural resources that become vital players or set decisions to reduce their influence if their interests continue to conflict with approaches.[14] In addition, the potential solutions could be the complete substitution of freshwater with seawater by desalination process in the industry and substituting crops from water demanding crops to less demanding crops.[20] Hence, integrating socio-economic and environmental aspects is critical in achieving sustainable development.[18]

A systematic review is a technique to discover, evaluate and synthesize relevant research results. Procedures of a systematic review are clearly defined in advance to ensure that the implementation is transparent and can be replicated, and designed to minimize bias. Therefore, a systematic review is a powerful tool to determine the influencing components related to water scarcity management performance for sustainability in the limited water resource areas. Furthermore, a systematic review can summarize the best available research on a specific question related to water scarcity which can cause problems to water resources, human well-being and the ecosystem; this is done by synthesizing the results of selected studies. Ultimately, this study aims to identify the components influencing water scarcity management performance in limited water resource areas and any missing research gaps to address in future studies for the effective implementation of sustainable water scarcity management.

METHODS

The identification, selection and reporting of results were mentioned as a systematic review method.[6] Further the framework will be created based on the synthesis procedure by conducting reviews of qualitative and quantitative studies.[7] This was used for data extraction and categorizing components affecting water scarcity management performance. Accordingly, all systematic review procedures are described in the following information.

Search and selection strategy

The search and selection strategy was explored from two English full-text databases: Scopus and ScienceDirect from 2012 to 2022. The main subject would be the factor affecting water scarcity management performance in limited water resources areas. The search items used in this review were: “"influencing components”" AND “"water scarcity management”" AND “"limited water resource area”" OR “"Water Stress Index”" OR “"Water Scarcity Footprint”". Additionally, citations from each database were exported to the Endnote application in RIS format. Potential studies first go through a duplicate search to narrow the scope of relevant studies. The first screening used keywords, titles and abstracts with the appropriate selection criteria. After that, full-text screening was done to assess eligibility by inclusion and exclusion criteria. Furthermore, the eligible papers will be evaluated based on a scoring criteria method (Rubrics) for the final selection. Finally, the quality of the papers should be assessed using a critical appraisal tool by JBI.[43]

Study selection criteria

The studies in this review are based on the following: 1. the studies were published after 2012 A.D. 2. The studies were published in the peer-reviewed literature and research paper. 3. The studies were published in the English language only. The studies included only the Environment and Engineering fields. The first step was to remove the duplicated articles from two databases. The second step was separating information by selecting irrelevant and unrelated topics to the main subject following the keywords. The importance of data screening was done without bias. Therefore, the screening criteria must determine what kind of data is selected and what is removed? The third step was the selection of the eligibility of full-text articles using selection criteria that should be established at the planning stage in the review and be consistent, as shown in Table 1. Last step, the details of eligible articles were evaluated by the Scoring Rubric method for final paper selection, which will be synthesized in the future framework.

Table 1: The selection criteria

Selection criteria	Inclusion criteria	Exclusion criteria
Population	- Water scarcity area - Limited water resource area - Specific area	- Sufficient water area - General area
Component	- Water Stress Index - Water Scarcity Footprint - Related water scarcity assessment	- Non-related water scarcity assessment
Outcome	- Water scarcity management - Water security	- Water management was not mentioned

A rubric is a performance criterion that can help define important outcomes for populations.[8] First, the focusing topic should identify the characteristic of an expressly stated learning outcome. Then, each rubric item will usually focus on a different skill or competency and keep it simple with five items. Score 5 is the most crucial item that matches goals and objectives, as shown in Table 2. Finally, the paper with a score higher than 70% (10 points) of maximum score (15 points) was selected as a revealed article.

Table 2: Rubric scoring items

Score	Description
5	Water scarcity assessment, WSF, WSI, related index of water security
4	Limited water resource area/related area
3	Water management/SDG/Sustainable
2	Policy recommendation
1	Only review

Classification and synthesis

The themes of the literature were identified based on water scarcity management in limited water resource areas. Management performance is assessed under four components: availability and demand, economic aspect, ecosystem, and governance. Finally, the JBI guideline was used to check the quality of systematic review report writing.

Quality assessment of review article

Each included paper was read by two researchers who independently scored them using the quality checklist devised and any disagreements were settled by discussion. Moreover, the quality assessment of reviewed studies was assessed by the Joanna Briggs Institute (JBI) critical appraisal checklist method. JBI assessed in 11 points of steps questions under "Yes/No"" and ""unclear/N.A."." In addition, it included only reviews, which scored ""Yes"" for at least 7 of 11 questions (63.6%) of the related questions.[9] Lastly, the quality assessment is satisfied when it has more than 63.6%.

RESULTS

Search outcomes

The initial search identified a total of 850 results appearing on databases of which 134 were from Scopus and 716 were from Science direct articles published from 2012 to 2023. After detecting duplicates, 199 were removed 651 articles remained. Abstracts and titles not reporting the outcome in relation to keywords were 440, then 211 were considered after screening. Moreover, 63 full-text articles were assessed from the inclusion and exclusion criteria of 211 papers. Finally, 63 papers were evaluated based on performance by scoring rubric. The search results were managed in Endnote reference software (Endnote X9) with the last 22 articles reported in this systematic review to classify and synthesize. The systematic review procedures are shown in Figure 1.

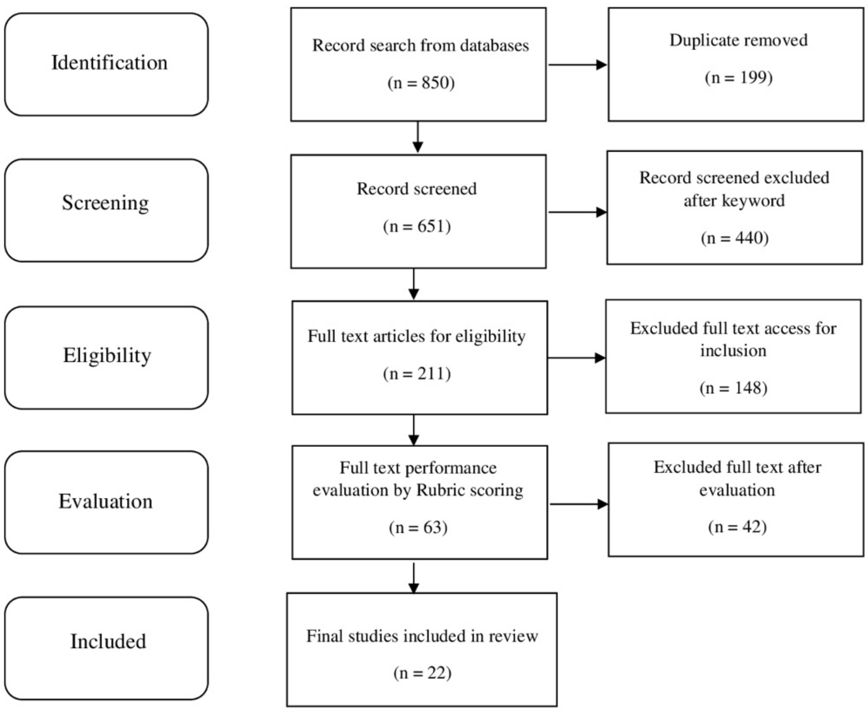

Figure 1: Search results and process of each stage of articles' selection

Outcomes on components influencing water scarcity management performance and its measurements

Twenty-two studies were selected from a systematic review of 850 papers from reliable sources, including ScienceDirect and Scopus databases. The review topic is identifying influencing components of water scarcity management performance. Most of them mentioned that water scarcity management always considers water supply and demand as the main components to meet human needs in their activities. In the past, water management had generally focused on using infrastructure and management in a passive or crisis approach due to various limitations such as knowledge, expertise, technology, etcetera. At present, the problem of climate variability, the need to develop water resources and the increasing water demand can create complicated issues in water management, especially in water-scarce areas. There have been many efforts to integrate knowledge on infrastructure and human resources development, planning and preparedness to become more proactive since 2004. The World Summit on Sustainable Development (WSSD) called for all countries to establish National Integrated Water Resources Management (IWRM). A process that promotes the coordinated development and management of water, land, and related resources, to maximize the resultant economic and social welfare equitably without compromising the sustainability of vital ecosystems.[41] IWRM is the starting concept to apply knowledge from various disciplines by diverse stakeholders to devise and implement efficient, equitable and sustainable solutions to water and development problems. Until ten years later, the water availability was compared to the demand for assessing water scarcity, the water balance method is helpful in a simple way.[36] Afterward, the water stress was characterized to assess the severity, and the water scarcity management could be improved more significantly with respect to human needs.[10,20] Afterward not only human demand was considered, but ecosystem referring to environmental water requirements was also added to the decision.[11,27] Some case studies tried adding water quality features related to human health to enhance management performance. When a global data set was made available for analysis, it was applied to other areas. Therefore, it is necessary to normalize an assessment for global comparability.[24] Moreover, water productivity which compares the worth of production was selected to be considered in water scarcity management for solving the conflict of interest among water use sectors.[27] Finally, all social, environmental and economic components are integrated to reach sustainable development following the SDGs; SDG 6 is proposed to ensure safe drinking water and sanitation for all. Participating countries have committed to systematic follow-up and review of progress toward the Goals and targets in the 2030 Agenda for Sustainable Development.[29] Thus, the evolution of water scarcity assessment components to improve water scarcity management performance is shown in Figure 2.

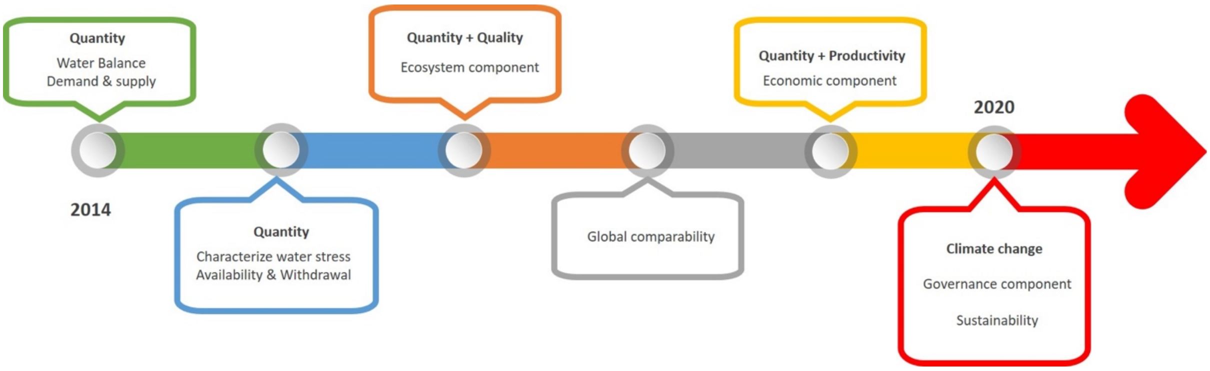

Figure 2: Evolution of water scarcity assessment components

Previous studies on water scarcity assessment primarily considered only water quantity based on water availability and demand. Some of them included environmental water requirements in their analyses such as considering the need for groundwater recharge in sustaining and maintaining ecosystems and good groundwater quality.[10] Only two studies dealt with water quantity and quality to improve water scarcity management in China.[11,12] Without considering the concentration of water contaminants and the quantity of water at the same time, it will be challenging to improve the problem of water environment contamination.[13] Moreover, some other studies consider the economic component of water productivity because the differences in water productivity values were seen as useful and valuable information to measure the worth of water and a fair approach to allocating water was provided.[33] Although, a large water quantity was delivered to the agricultural sector and produced low productivity than other sectors such as the industrial sector, a minor investment in agricultural production can affect national and global food security.[15] Therefore, the governance component was added in some studies to balance economic and social benefits to reduce social pressure and create well-being. Furthermore, the ongoing destruction and degradation of water ecosystems and aquifers have already led to social repercussions. Unsustainable consumption and production patterns are degrading ecosystems and reducing their ability to provide essential goods and services to humanity. All influencing components are categorized and shown in Table 3, and the conclusion of the main discovery results is shown in Table 4.

Table 3: Components related to water scarcity management performance

Component	Sub-component	Description
Availability & demand	Hydrological Water balance	Water scarcity can be assessed from the balance between water availability produced from the hydrological process and water demand quantity.
Economic	Productivity	The economic component which refers to productivity in a water-scarce area, could be considered for allocated optimization.
Ecosystem	Environment Climate change Water Quality	Ecosystems are controlled by the environment and affected by climate change, making uncertainty a resource. And poor water quality has been found to bring greater stress on water resources than freshwater consumption.
Governance	Policy Participation	The policy is adopted by governance action to improve management performance. Stakeholders will also support the sustainable management of natural resources in developing contexts with conflicting interests.

Availability and demand: Water availability and demand are the most influencing components of water scarcity management performance in scarcity areas considering the quantity of available water and consumption demand. WSI, AWARE, WSF, WaSSI, WQSI and WRSI are the recent tools that can assess water scarcity management from water availability and demand comparison. Focusing on WSI which refers to the ratio of water withdrawal and availability or WTA, many studies in China[16,17,18] especially, in the northern and eastern regions, and 25 watersheds in Thailand[19] considered the severity of scarcity in the agricultural regions. High WSI occurred in the central region of Thailand during the dry season because of the large areas of second rice cultivations and water competition among agriculture and other users if the irrigation water allocation is insufficient. Similarly, the industrial and agricultural sectors in Chile[20] have a high water consumption problem, mainly due to mining in the central and northern regions with limited water resources and China[21] has problems with the spatial WF per capita, which is affected by available water resources, population density, habits, etcetera.

The WF values were high in Xinjiang, Tibet, and Shanghai. Whereas, a negative value of WF per capita means the virtual water exports exceeded the entity water consumption. The maximum entity water consumption values were in Xinjiang, Ningxia and Tibet.[21] Both countries considered the scarcity under variation management of any policies and engineering practices. AWARE which refers to availability minus water demand or AMD, was completed in Thailand[22] to provide WULCA's AWARE CFs for the Thai watershed levels.

Thus, allowing the Thai government and the USA[23] to evaluate cooling technology choices quickly and the location of power plants contribute to regional and seasonal water stress based on quantifying the relative available water remaining per area.[24] Moreover, WSF calculated from WSI[20,17] or AWARE[22,23] multiplied by water consumption used in any sector was expressed in water equivalents to convince the potential environmental impacts of water use.[25] In USA[26], WaSSI was coupled with a hydrological model to improve water use performance in the irrigation sector and proposed to decrease direct water consumption. WQSI which can be expressed as the ratio of the blue water footprint to the blue water available had been done to estimate the WF in China at the provincial level and the impact of virtual water flows on the local water scarcity.[27] Lastly, the Water Accounting and Water Inventory assessment are essential to enhance water supply and demand management performance by driving the governance component to reach the sustainable development goal (SDG) in IWRM content. This method can also be a valuable tool for water footprint evaluation and agricultural product life cycle assessment that can help us improve the water demand-side efficiency.

***Economic*:** The productivity that is the sub-component of economics was considered in the economic component because producing a crop with a low WP (or IWP) in a water-scarce area can cause more severe impacts than producing a crop with a high WP in a water-rich area.[28] The water productivity defined as the ratio between crop financial returns or crop production to crop evapotranspiration, efficiently improved the consumptive part of irrigation needs in different crops and farm types in Peru.[14] Moreover, water productivity of a crop also was calculated as the ratio of irrigated crop yield to the sum of blue and green crop water requirements in the US.[26] In the same way, irrigation water productivity was analyzed based on climatic, soil and landform characteristics and was defined as the total production of each crop divided by the total irrigation water consumption.[17] The water scarcity assessment by WSF in China[18] and Thailand[22], also required crop production and crop yield data for the calculations. Finally, the water scarcity management in Peru[33] was required to achieve sustainability by following the SDGs (Sustainable Development Goals)[29] which are related to economic aspects or productivity from SDG 4 (quality education), SDG 8 (decent work and economic growth) and SDG 10 (reduced inequalities).

***Ecosystem*:** The ecosystem refers to environmental impact assessment, one of the components for reaching the sustainable development target. EWR is the ecological water requirement added in WSI, AWARE and BlWSI to assess water scarcity by considering the impact on the ecosystem. However, most studies of water scarcity assessment only considered water quantity and ignored water quality. Therefore, QQWYE[12] and QQE[11] considered quantity and quality because grey water or GW significantly stressed water resources more than freshwater consumption. Moreover, GWF had been selected to calculate the water scarcity in the industrial, domestic, and agricultural sectors in the Yangtze River Basin to express appropriate policies for each sub-region.[30] Similarly, WQASI was calculated by focusing on water quality to assess the water scarcity in China.[27] EPI which can reflect the degree of regional ecological environment pressure was calculated by using GEI. GEI is the carbon emission index and WRSI is the water resource stress index to develop a comprehensive index, REP (the resource–environment pressure, which describes the comprehensive impact of human activities on regional resources and environmental pressures[31]).[32]

Moreover, REP also considered the integrated factor of water, carbon, and ecological footprints in municipal or metropolitan water systems. For example, the case study in TOCC China indicated a high carbon footprint because there were many industrial structures caused by increasing urbanization and population.[32] For achieving sustainable development goals, SDGs had been assessed by the environmental impact of water scarcity referring to SDG 6 (clean water and sanitation) and SDG 11 (sustainable cities and communities) in Peru[33]. Likewise, WSC Index, created as an index to measure the full water-sensitive performance, underpinned SDGs for sustainable development as indicated in case studies in Australia, Asia, the Pacific and South Africa.[34] Finally, SDG 13 related to perceived impacts of extreme climate events, was also analyzed for scarcity assessment in Peru[33] on integrated land and water planning achieving the sustainable development goals.

***Governance*:** Governance is defined as all the processes of interaction through the laws, norms, policy, or language of a social organization.[35] It is related to the impact on people who are affected by the water scarcity in the region. Urban population growth affects natural resources through over-exploitation, weak environmental education and the lack of dialogue on improving the management of natural resources and sustainable development can be achieved by following SDG 4 (quality education), SDG 11 (sustainable cities and communities) and SDG 16 (peace, justice and strong institutions). It has been tested in some cities in Australia, Asia, the Pacific and South Africa[34] for the water sensitivity assessment of a municipal or metropolitan city, by setting self-improving targets and updating management responses to improve water sensitive practices. Similarly, in Peru[33], one of the critical innovations arising from the research is mapping environmental, economic, social, and governance challenges identified by key informant interviews and stakeholder workshops. The highly influenced actors that are private-public partnerships between local authorities, water supply services, and the agricultural and mining sectors generate synergies for the population in rural areas and counteract the effects of migration and its related environmental and social pressures. Stakeholder mapping exercises as in this study will also support the sustainable management of natural resources in developing contexts with conflicting interests. Hence economic development could be compromised based on Sustainable Development Goals (SDGs). Lastly, the governance component aims to enable adaptation and resilience between human resources and the ecosystem.

Table 4: The main discovery of water scarcity management component

Author (year)	Component	Main discovery
Mitra et al. (2014)	Availability & demand	Runoff and groundwater recharge were combined to estimate water requirements which were used to analyze the water budget at a local level to help planners for water resource use and conserve an over-exploited water resource to achieve sustainability.
Hybel, Godskesen and Rygaard (2015)	Availability & demand Ecosystem	The impact on freshwater resources is vital in assessing urban water systems and the development of an approach to get more site-specific and related estimations of environmental water requirements should be prioritized.
Aitken et al. (2016)	Availability & demand Ecosystem Governance	Water reduction strategies have a strongly positive impact on water scarcity and government agencies should provide updated information for better analysis of management relevance.

Author (year)	Component	Main discovery
Liu, Liu and Yang (2016)	Availability & demand Ecosystem	Only focusing on reducing water use may not help relieve water scarcity. Instead, consideration must be given to water pollution reduction and conservation encouragement.
Cai, Wang and Zhang (2017)	Availability & demand Ecosystem Governance	Virtual water flows intensified not only quantity-induced water scarcity but also quality-induced water scarcity.
Faramarzi et al. (2017)	Availability & demand Ecosystem Governance	The use of sector and local data rather than national or regional average statistics, as well as assessment of EFR, results in a more accurate accounting of water scarcity.
Boulay et al. (2018)	Availability & demand	The new method for assessing the impacts of water consumption is AWARE, which is reported relative to water consumption at the average global location.
Gheewala et al. (2018)	Availability & demand Ecosystem	An appropriate plan for water resource management is required to prevent water competition and severe stress in the watersheds, especially the cropping system and crop calendar.
Zhao et al. (2018)	Availability & demand	The relocation of production to regions and sectors should consider both water scarcity status and water productivity across regions.
Huang et al. (2019)	Availability & demand Economic Governance	The WP results can mislead policy decisions for water management and products should be traded from regions with high WPs to regions with low WPs.
Huang et al. (2020)	Availability & demand Economic Governance	It is critical to integrate socio-economic and environmental aspects to achieve sustainable agriculture development. By integrating food production and a water boundary, we illustrate the broader value of the safe and just operating space approach for sustainable development.
Huiping et al. (2019)	Availability & demand Ecosystem Governance	Infiltration coefficient, irrigation efficiency, water consumption of industrial unit output value and virtual water import are essential elements in the regional water resources system. Among the regulations, improving the infiltration coefficient has the most positive impact on alleviating water stress.
Lee et al. (2020)	Availability & demand Economic	The importance of strategically sitting power generation facilities and selecting cooling technologies to enhance the sustainability of the electric power sector should be considered.

Author (year)	Component	Main discovery
Rogers et al. (2020)	Availability & demand Ecosystem Economic Governance	A new tool to assess the water sensitivity of a municipal or metropolitan city by integrating many factors that could help city stakeholders assess improvements in their city's water sensitive performance and achieve SDG targets.
Salmoral et al. (2020)	Availability & demand Ecosystem Economic Governance	Cooperation between researchers and the national authority will be key to maximizing the decision making benefits by applying the knowledge to help identify options that are resilient to future water scarcity.
Salmoral et al. (2020)	Availability & demand Ecosystem Economic Governance	Shared visions between stakeholders were the need to promote adaptation in water and land management (SDG 6) due to perceived impacts of extreme climate events (SDG 13), urban population growth (SDG 11), and increased sectoral water demands which were identified as well as contradictory priorities relating to the sustainable management of natural resources.
T Marston et al. (2020)	Availability & demand Economic	Improving water productivity, supply sourcing, policies, and water-efficient technologies is an essential step for more economically and environmentally beneficial uses.
Cao et al. (2021)	Availability & demand Ecosystem Governance	Combining water quantity and water quality to assess the number of water resources is more accurate than calculating only water yield or quantity.
Chen et al. (2021)	Availability & demand Ecosystem	Water, carbon, and ecological footprints are the most significant integrated environmental footprint factors for evaluating the environmental impact and natural ecological carrying capacity.
Fu et al. (2021)	Availability & demand Ecosystem Governance	Grey water has been found to bring greater stress to the water supply than freshwater consumption.
Kaewmai et al. (2021)	Availability & demand Ecosystem Economic Governance	Adaptation plans, growing seasons and zoning of plantation crops in Thai watersheds can address the potential future impacts of water scarcity in the area.
Summers and Quinn (2021)	Availability & demand Ecosystem Economic Governance	WSF from AMD CF had different values when comparing WSF from the DTA method. However, the WSF comparison increased understanding which, combined with existing water policy and water law, can improve the freshwater environmental impact of the region through informed decision-making.

DISCUSSIONS

This systematic review shows that water scarcity management is not only the overview of water availability and demand but also associated with social, economic and environmental aspects in the limited water resource area connecting to sustainable development. Sustainable development must be understood as a type of economic development that ensures meeting the needs of present generations without compromising the ability of future generations to meet their requirements and applicable measures aimed at long intervals and long-term effects.[37] Conventional framework is considered a fundamental solution to balance supply and demand. When supply is higher than demand, water scarcity does not occur. In contrast, water is a limited resource and can vary depending on the climatic variation. Hence, the water balance between availability and demand is insufficient for sustainable decisions; additional components are needed to improve water scarcity management performance. The ecosystem component, referring to the supply side in terms of water quantity, depends on water availability and should be added to the management plan.

Moreover, the governance component which can help people arrive at adaptation and resilience should be considered as a measure on the demand side. Some previous studies involving management among various water use sectors (agricultural, industrial, and domestic) always were in conflict when they mentioned the productivity or financial benefit in the limited water resources area. Adding more components that follow IWRM framework will maximize the decision-making benefits. New initiatives must motivate co-operating stakeholder interest in the governance through natural resources that become key players. Otherwise, deciding to reduce their influence if their interests continue to conflict with the approaches. Therefore, the water scarcity management process is needed to identify the water source, water pathway, allocation, and end-users. The Water Accounting or Water Inventory Assessment approach can be a valuable tool to fulfill the water scarcity management and genuinely reflect the problem. It creates a holistic approach to remediation that can be proactive, prevent, correct and restore. Finally, it can enhance the water scarcity management performance to reach water security under a sustainability framework as shown in Figure 3.

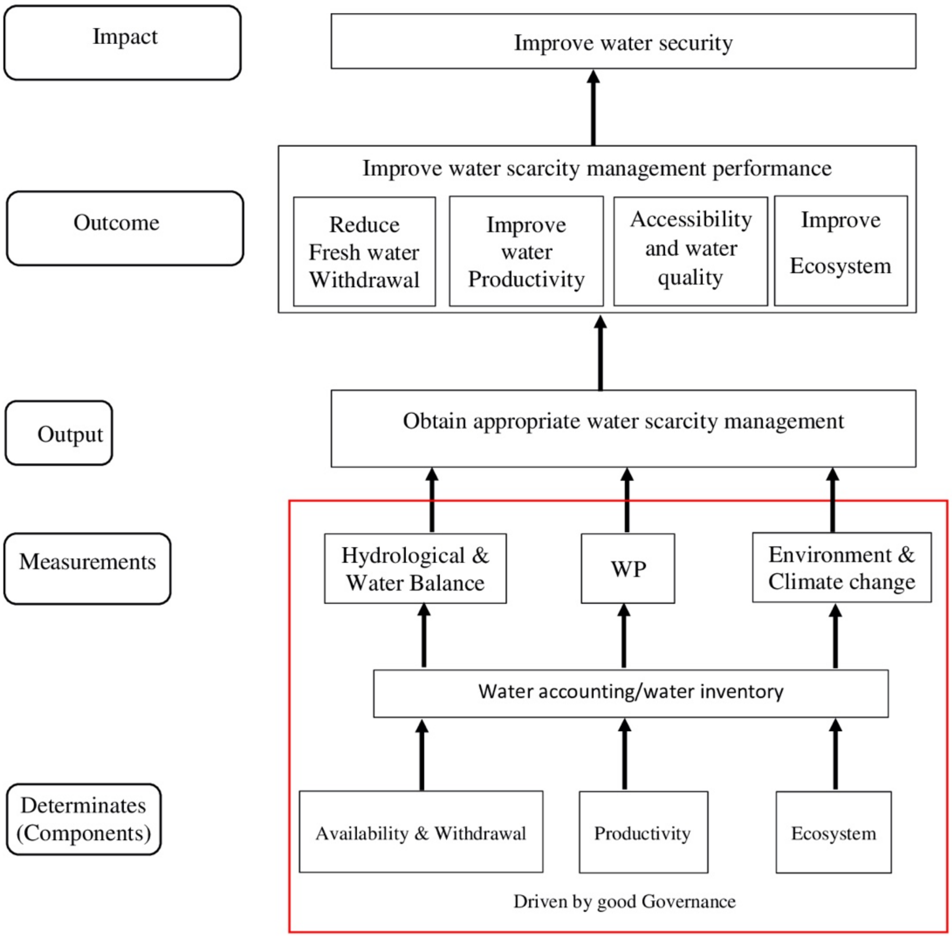

Figure 3: Re-define the water scarcity management in limited water resource areas under a sustainable management framework

CONCLUSIONS

Based on the literature review done in this study on water scarcity management in the last decade, it is found that in the previous studies, water availability and demand were only considered as the main factors in controlling the water supply-demand system. Such a consideration on water scarcity management is a type of crisis management that is only suitable for solving immediate problems. These studies have not mentioned the sustainability of ecosystems or environmental systems. Water quality is the one aspect that affects to water scarcity problem. Therefore, it could be considered for more information in future work. The present study's overall objective was water security with maximum economic benefit, social equity and environmental sustainability; integrated water resources management (IWRM) should be implemented to overcome the missing gaps in sustainability. Coordinated development and management of water resources, land areas, and related resources should be considered to maximize the resultant economic and social welfare equitably without compromising the sustainability of vital ecosystems.

Meanwhile, the increasing impacts of climate variability and climate changes and freshwater demand due to increasing population and related activities made water scarcity management even more severe and complicated. However, these components were mentioned in a few studies in the past and each component was separately analyzed. Consequently, the tool that can identify the source of water, water pathway, water allocation, and the connection between other related systems and end-users is needed to drive water scarcity management towards sustainability.

ABBREVIATIONS

NWFT: National Water, Food & Trade modeling; WaSSI: Water supply Stress Index; DFDI: Data Fusion-Based Drought Indices; SEAWAT: SEAWAT model; MCDM: Multi-criteria decision-making; WQSI: Water quantity scarcity Index; WQASI: Water quality scarcity Index; QQWYE: Water Quantity and Quality for Water Yield Equivalent; REP: Resource-Environment Pressure; EPI: Ecological Pressure Index ; GEI: Carbon Emission Index; WRSI: Water resources Stress Index; SEEA: the System of Environmental Economic Accounting; WFP: Water Footprint; WSI: Water Stress Index; SSP: the hared socioeconomic pathways; AWARE: Available Water Remaining; LMDI: Logarithmic Mean Divisia Index; GWF: Grey Water Footprint; SDI: Sustained Deficit Irrigation; LCIA: Life Cycle Impact Assessment; TETIS-VEG: Analyze the effectiveness of forest management model; WTA: Water Withdrawal-To-Availability; QQE: Quantity-Quality-EFR; EFR: Environmental Flow Requirement; WSC: Water Sensitive Cities; FEW: Food, Energy and Water; SDGs: Sustainable Development Goals; SCS-CN: US Soil Conservation Service Curve Number; WaSSI: Water Supply Stress Index; EWS: Economic Water Scarcity; WS: Water Stress indicators; WD: Water Dept; IWRM: Integrated Water Resources Management; INRM: Integrated Natural Resources Management; BlWSI: Blue Water Sustainability Index.

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