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Climate-water governance: a systematic analysis of the water sector resilience and adaptation to combat climate change in Pakistan

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Abstract

Climate change and water security have become the most challenging global issues of this era, especially for developing countries like Pakistan. Amid many hindrances, poor governance has been identified as one of the most pressing reasons for ineffective action to tackle multifaceted and integrative climate-water issues in Pakistan. This article, therefore, applied a systematic literature review methodology to examine the current climate-water governance archetype, including key areas, major elements, critical gaps, and potential strategy in Pakistan. This study found that key climate-water governance areas in Pakistan are: river basin and watershed management, agriculture and irrigation management, urban and domestic water issues, floods, droughts and disaster management, groundwater management, and transboundary management. Moreover, it is revealed that the major governance elements are political commitment and leadership, policy formulation and regulation, institutional capacity and coordination, stakeholder engagement, and resource management, technology, and infrastructure development. The article also discusses how Pakistan has not effectively employed most of the identified governance elements to tackle its climate-water problems, lacking mostly in political, policy, institutional, coordination, and infrastructure aspects. In conclusion, a four-dimensional governance strategy, encompassing leadership, policy, institutions, and stakeholders is proposed to improve water sector resilience and adaptation to combat climate change in Pakistan.

Keywords: Climate adaptation; Climate change; Climate governance; Policymaking; Resilience; Water governance

Highlights

- Poor governance is identified as the major reason for ineffective climate-water action in Pakistan.
- Leadership, policy, institutions, and stakeholders are key facets of climate-water governance.

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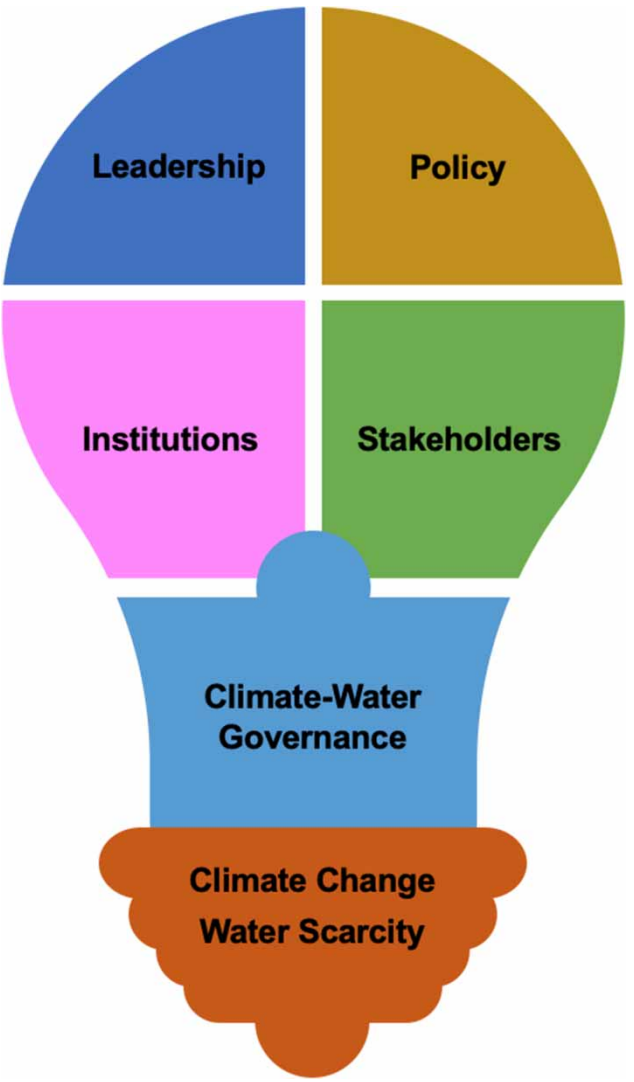
- Pakistan lacks political leadership, policy processes, institutional capacity, and stakeholder engagement.
- A four-dimensional strategy leadership-policy-institutions-stakeholders is needed to improve climate-water governance.

Graphical Abstract



Introduction

Climate change has become one of the most challenging global issues of this era. The Intergovernmental Panel on Climate Change (IPCC) and National Aeronautics and Space Administration have unequivocally publicised the anthropogenic reasons for climate change and its considerable consequent

impacts on global development (IPCC, 2018; NASA, 2019). Given the significant current and future repercussions of climate change, the 2020 Global Risks Report of the World Economic Forum has classified climate-related disasters as the topmost global risk (WEF, 2020). From the bushfire crisis in Australia to water scarcity issues in Asia and Africa, almost every extreme event has had links with climate change (Murakami *et al*., 2020). During the last two decades, these climate-linked events have had possibly the largest socio-economic impacts globally.

According to the 2020 Global Climate Risk Index, more than 12,000 climate change events have caused economic losses worth 3.54 trillion US dollars and resulted in over 500,000 deaths worldwide between 1999 and 2018 (Eckstein *et al*., 2019). Notably, most of these climate events are water-related, such as tsunamis, cyclones, floods, droughts, and unexpected precipitations. Increasingly, the connection between water and climate is becoming critical to address climate change and water security issues simultaneously (WWAP, 2020). Climate change – although a global issue – has enormous local repercussions, especially in developing countries such as Pakistan.

Pakistan, a low-income country in South Asia, is one of the most vulnerable countries to climate change (GOP, 2016; Eckstein *et al*., 2019). In the 2020 Global Climate Risk Index report, Pakistan ranks fifth in the list of the most climate-vulnerable countries in the world after Puerto Rico, Myanmar, Haiti, and the Philippines (Eckstein *et al*., 2019). Irrespective of a tiny (less than 1%) contribution to the global greenhouse gases account, climate change has caused Pakistan significant socio-economic damage, especially during the last two decades (GOP, 2016; Eckstein *et al*., 2019). For instance, during the period from 1999 to 2018, over 152 extreme weather events resulted in about 10,000 deaths and over 76 billion US dollars financial loss in Pakistan – nearly 500 fatalities and 3.8 billion US dollars economic loss every year (Eckstein *et al*., 2019). Notably, most of this damage has occurred due to water-related climate events, mostly floods and droughts. The massive floods from 2011 to 2014, for example, caused Pakistan an economic loss of 18 billion US dollars, destroyed standing crops covering about 4.3 million hectares (43,000 km^2), and damaged more than 3.5 million houses affecting about 38 million people (GOP, 2016). These climate-related events have significantly impacted the governance systems, especially of the water sector, in Pakistan.

Climate change has exposed the geographic, economic, social, and environmental vulnerabilities of the water sector in Pakistan (ADB, 2017; CIAT-World Bank, 2017; UNDP, 2017; Young *et al*., 2019). For instance, geographically, the country depends on a single river basin system for freshwater withdrawal to meet its water needs for agriculture, domestic and industrial sectors, as well as to attain its energy requirements. The Indus River Basin System (IRBS) – a complex hydrologic system – receives more than 70% of its water from the melting of glaciers located in the Hindu Kush Karakoram Himalaya (HKKH) (CIAT-World Bank, 2017). These glaciers have come under significant threat from global warming, melting rapidly at an annual rate of about 2.3%, making it one of the fastest glacier melting regions worldwide (GOP, 2016; CIAT-World Bank, 2017). This phenomenon causes significant unusual variability in river inflows between and within years, placing the country at a greater risk of water insecurity.

Furthermore, Pakistan's economic returns from its water resources are among the lowest in the world (Young *et al*., 2019). Although the country generates significant yearly economic benefits from its water resources, poor water resources management causes Pakistan an annual loss equal to around 4% (over 10 billion US dollars) of the gross domestic product (GDP) (Young *et al*., 2019). The major reasons for these economic damages are from poor governance of floods, droughts, low irrigation productivity, poor water supply and sanitation, and environmental degradation (FODP-WSTF, 2012; Young *et al*., 2019). Globally, Pakistan ranks as the 14th extreme water-stressed country in the world (Dormido, 2019).

Moreover, Pakistan falls in the medium-low category (scoring 50 points out of 100) for the implementation of Integrated Water Resources Management (IWMR) to monitor the SDG indicator 6.5.1 (UNEP, 2020). Overall, Pakistan's ranking regarding physical water availability and its management/governance is considerably low.

For the management of climate-water issues, Pakistan has historically relied upon structural, infrastructural and engineering solutions, thus generally ignoring the significance of good governance in addressing most of its natural resource problems (FODP-WSTF, 2012; Young *et al*., 2019). In general, governance systems have remained weak due to many internal and external political economy challenges and the intricacy of political and institutional matters. Recently, many studies have identified poor governance as one of the most pressing reasons for ineffective actions to combat climate change and water insecurity in Pakistan. Amongst many problems, the major governance challenges are political disinterest in issues like climate change and water management, absence of robust policies, lack of effective institutional frameworks, ineffective engagement of stakeholders, and poor service delivery (FODP-WSTF, 2012; Cooper, 2018; IUCN, 2018; Young *et al*., 2019). Overall, governance challenges have considerably worsened the evolving climate change and water security issues in Pakistan.

Notably, the latest literature contemplates climate change and water security as governance challenges more than technical or infrastructure issues. Most of the water scholars, policymakers, and practitioners concur that improving governance holds the key to addressing most of the climate-water issues (Araral & Wang, 2013; Neto *et al.,* 2018; Ozerol *et al*., 2018). For example, the World Water Development Report 2020 titled 'Climate Change and Water' argued about the robust connection between these two global issues. This report highlighted poor governance as one of the major reasons of mismanagement of these two critical global problems, leading to the lack of access to freshwater and climate mitigation and adaptation resources (WWAP, 2020). In the perspective of middle and low income countries, Sinharoy *et al.* (2019) argued that governance issues such as institutional and political barriers as well as lack of data are major hindrances in ensuring access to safe water and sanitation facilities to marginalised communities and low-priority economic sectors. In most of the developing countries, poor governance of natural resources like water have instigated a debate on economic water scarcity – when people lack access to water due to institutional, economic, and political issues (governance failures) besides the physical existence of resources.

During the last two decades, both the physical water scarcity (PWS) and economic water scarcity (EWS) concepts have been considerably debated globally in the wake of governance paradigm. In the most recent research, Rosa *et al*. (2020) defined agricultural EWS as the lack of economic or institutional capacity that hinders the use of renewable water to irrigate crops. The researchers further argued that better agricultural water governance can significantly help in the sustainable use of economically scare water resources to contribute to food and water security (Rosa *et al*., 2020). Similarly, Vallino *et al*. (2020) commented on the measurement of EWS and derived that better water governance through IWRM minimises EWS and higher water productivity. In general, poor governance of water and climate change has lead to EWS and PWS in developing countries like Pakistan, demanding considerable attention towards prevailing water-climate governance issues.

Notably, in developing countries like Pakistan, very little research has been carried out by scholars and policymakers about issues linked with climate change and water sector governance (ADB, 2017; Ebrahim, 2017; UNDP, 2017). Given the substantial vulnerability of the water sector to climate change, Pakistan needs to improve its climate-water governance systems. For this purpose, there is a dire need to assess the existing knowledge frontiers to explore climate-water governance issues and potential strategies for improving resilience and adaptation of the water sector to combat climate

change in Pakistan. This will implicitly help in identifying the major governance areas, core issues, and feasible strategies to improve climate-water governance in Pakistan.

In the context of the above-narrated challenges, the article will critically examine the current climate-water governance archetype in Pakistan to assess water sector resilience and adaptation to combat climate change. By applying the Systematic Literature Review (SLR) method, this paper will explicitly identify key governance areas, major governance elements, critical gaps, and a potential strategy to improve climate-water governance in Pakistan for building water sector resilience and adaptation to combat climate change.

Methods

This SLR aims to review the existing climate-water governance focussed literature for the identification of key governance areas; major elements and enabling factors; critical gaps and challenges; and potentially effective governance strategy in Pakistan. During recent years, various researchers have applied the SLR in reviewing different aspects of climate and water governance. For example, Ozerol *et al.* (2018) conducted the SLR to assess how water governance is conceptualised, contextually defined, and evaluated in different parts of the world. Similarly, Eckhardt *et al.* (2019) and Potts (2019) applied the SLR method to assess the governance issues for natural resource management. Another study (Brisbois & De Loë, 2015) examined the use of collaborative strategies for governing water resources using a formal systematic review. Broadly, there is an increasing trend in the SLR application for conducting a literature review to evaluate governance-related research frontiers. Based on the guidelines formulated by various prominent researchers, a distinct five-step approach has been followed for conducting the SLR that comprises of scoping; planning for SLR; searching or identification; screening and scanning; and presenting results and discussions (Ford *et al.*, 2011; Moher *et al.*, 2009; Ozerol *et al.*, 2018; Siddaway *et al.*, 2019; Xiao & Watson, 2019).

Initially, a preliminary literature search was carried out to assess the availability and breadth of literature regarding climate-water governance in Pakistan, during which it was found that no SLR had been conducted on this specific topic before. Based on this search, ten keywords and their related terms or words were identified from the literature (Table 1). A combination of the keywords was tested in

Table 1. List of keywords and associated terms for the SLR.

Keyword	Associated words/terms
Climate Change	Global Warming, Extreme Weather, Greenhouse Gases, Fossil Fuels, Carbon Dioxide, Sea Level Rise, Unexpected Weather, Climate Disasters
Governance	Government, Governing System, Institutions, Government Departments, Political System, Economy
Water	Precipitation, Surface Water, Groundwater, Irrigation, River, Sea, Aquifer
Sector	Field of Study, Systems, Aspect, Category, Economic Sectors, Sectoral Growth, Pathway
Adaptation	Adaptation Measures, Adaptation Strategies, Adaptive Systems, Adaptation Policies, Adaptation Planning, Adaptation Practices
Mitigation	Mitigation Planning, Mitigation Policies, Mitigation Strategies, Mitigation Measures
Resilience	Climate Resilience, Resilient Systems, Resilient Economies, Resilient Pathways
Sustainability	Sustainable Development, Sustainable Growth, Sustainable Policies, Sustainable Development Goals
Combat	Tackle, Counter, Fight, Control, Action, Act, Battle, Address
Pakistan	Punjab, Sindh, Khyber Pakhtunkhwa, Baluchistan, Gilgit-Baltistan

different databases (ProQuest and ScienceDirect) to develop string expressions. Testing a combination of search strings before commencing the full search can help in assessing the relevancy and suitability of the search string (O'Brien & Guckin, 2016). After reasonable trials of string testing, the following search string was formulated for searching the articles in the selected databases:

(*Climate Change OR Climate*) *AND* (*Governance OR Government*) *AND*

(*Water OR Precipitation*) *AND* (*Sector OR System*)

AND (*Resilience OR Adaptation*) *AND* (*Pakistan OR Punjab*)

The initial search resulted in a large volume (thousands) of articles, which was not realistically manageable, retrievable, and extractable. Therefore, for realistic and rational management of the SLR, inclusion and exclusion criteria were used for defining the boundaries of the search. The inclusion criteria included: peer-reviewed articles; scholarly journals; articles published between 2005 and February 2020; English language; electronic databases; and Pakistan specific (location). Books, thesis, book sections, and letters were excluded from the search results. For ensuring systematic and transparent record-keeping, separate filing and literature storage dossiers were developed using EndNote, Microsoft Word, and Microsoft Excel applications.

Four databases, ProQuest, ScienceDirect, Web of Science, and Scopus, were used to search a reasonable and manageable number of articles. After application of inclusion and exclusion criteria, a total of 568 articles were identified, including 267 in ProQuest, 59 in ScienceDirect, 240 in Scopus, and only two articles in the Web of Science database. Noticeably, it is found that a significant number of relevant studies that were reviewed during the scoping phase were not retrieved through database searches. It is noticed that these grey literature publications (policy, technical, and research studies) can significantly contribute to improving the quality of SLR (Lawrence *et al.*, 2015; Paez, 2018). They are authored by various international organisations like the United Nations Development Programme (UNDP), The World Bank, Asian Development Bank, Food and Agriculture Organisation of the United Nations, and many other national and global institutions are engaged in conducting research and development in Pakistan. These development partners and the researchers associated with these institutions have produced prominent reports (policy, technical, and research) related to climate and water governance aspects in Pakistan. Accordingly, 72 such publications, including policy papers, technical reports, and research and development studies were identified and included for screening.

In total, 640 articles/publications (568 from databases and 72 from the grey literature were identified for further screening and scanning. Following the rigorous screening and scanning process, 96 articles were selected for inclusion in the SLR based on their direct relevance with the study objectives, as shown in Figure 1.

Results and discussion

The articles included in this SLR were published between 2005 and February 2020, with almost 70% of reviewed articles (67 out of 96) published during the last six years (Figure 2). This increase coincides with a number of prominent events that occurred during the first half of the 2010s decade. This includes unprecedented floods from 2010 to 2014 that caused Pakistan significant social, economic, and

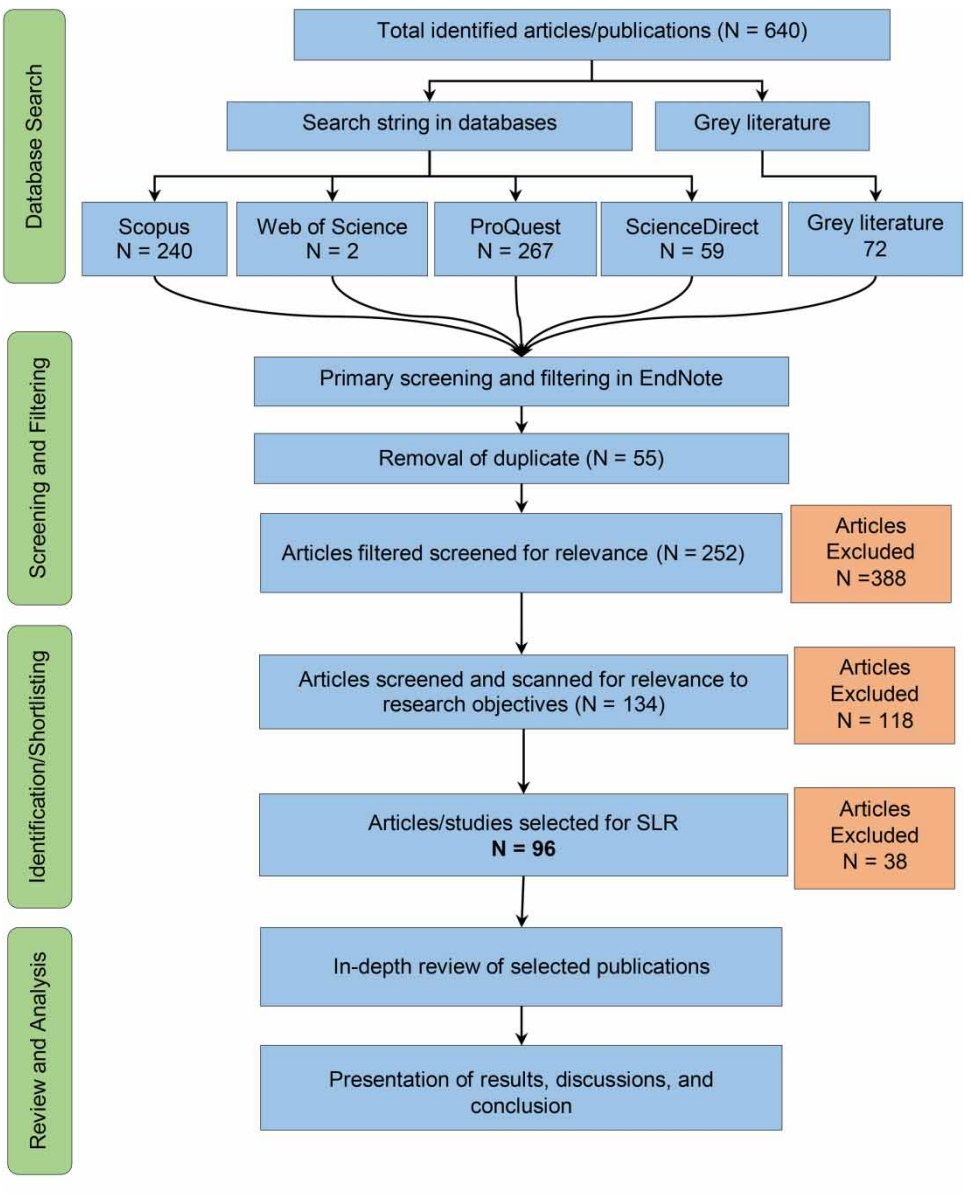


Fig. 1. PRISMA flow diagram of the SLR methodology.

ecological losses (GOP, 2016; Fahad & Wang, 2020). Later, as one of the governance responses to combat climate change, Pakistan formulated its first National climate change policy (NCCP) in 2012. These events have helped the creation of awareness among researchers and policymakers concerning climate change as an emerging global and national issue in Pakistan.

In 2015, the Paris Agreement played a pivotal role in mainstreaming climate change in governance-related matters globally and locally in Pakistan. Sheikh (2016) argued that the historic Paris treaty has

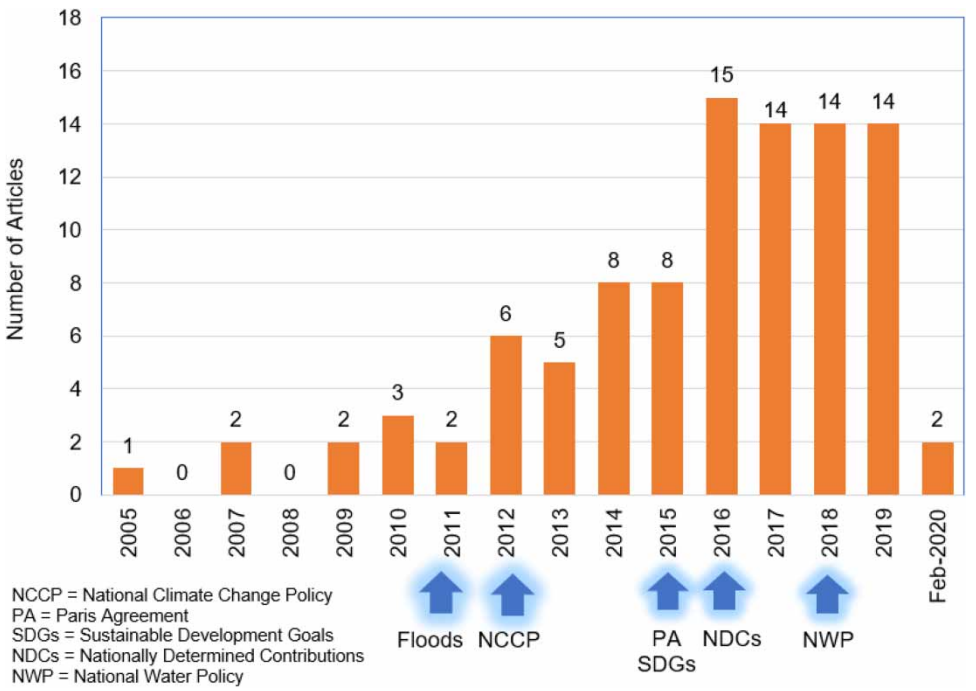


Fig. 2. Yearly trend of selected publications and related climate-water events.

considerably helped in raising climate awareness in Pakistan in almost all segments of society. After this global breakthrough, political parties started discussing the climate issue in parliament for its governance, technocrats started showing keen interest in climate-related challenges, and the media expanded its coverage on climate change and related problems (Sheikh, 2016). As a local response to the Paris Agreement, Pakistan submitted its Nationally Determined Contributions (NDCs) in 2016, envisaging various adaptation and mitigation measures to fight climate change. The localisation of climate governance in Pakistan – also called bottom-up climate governance – plausibly emerged after the Paris Climate Treaty.

Another global event that triggered climate awareness in Pakistan is probably the approval of Sustainable Development Goals (SDGs) that contained goals 6 (water) and 13 (climate) to address water and climate-related challenges with a significant linkage across all its 17 goals. The SDGs agenda offered scholars an opportunity to research inclusive development and governance reforms in addressing difficult problems like water insecurity and climate change. Lately, the approval of the National Water Policy (NWP) in 2018 can also be attributed to the increasing trend of climate and water governance-related research in Pakistan. Broadly, the national and global climate-water events that occurred during the last decade may have substantially contributed to the increased research (funding and interest) on governance-related issues focusing on water sector resilience and adaptation to combat climate change in Pakistan.

Key climate-water governance areas

Like many other countries, Pakistan is inherently a water-dependent country for many reasons. The country profoundly relies upon its water resources and climate conditions to produce food; generate

livelihoods; foster a healthy environment; meet its essential domestic needs; and contribute to the socio-economic growth through various other direct and indirect means (FODP-WSTF, 2012; Condon *et al.*, 2014; IUCN, 2018; Young *et al.*, 2019). Given the multifaceted and interdependent nature of climate and water issues, it is logically essential to categorise the major climate-water areas in Pakistan from a governance perspective. Out of 96 reviewed publications, almost one-quarter of articles (N = 23) focussed on agriculture water management, mainly on irrigation management. As shown in Table 2, other identified areas mainly include: river basin and watershed management (N = 13); urban and domestic water issues (N = 5); floods, droughts, and disaster management (N = 13); groundwater management (N = 5); trans-boundary challenges (N = 12). Notably, over one-quarter of studies (N = 25) did not fit into any of the major categories. The articles in this 'others' category focus on various water aspects, such as environmental management, ecological systems, coastal water management, and some studies have inclusively discussed policy, institutional, and governance-related challenges in Pakistan.

Almost 14% (N = 13) of studies focussed on the river basin and watershed management. Out of these 13 reviewed articles, 12 publications (Archer *et al.*, 2010; Qureshi, 2011; Laghari *et al.*, 2012; Rasul *et al.*, 2012; Zhu *et al.*, 2013; Condon *et al.*, 2014; Yang *et al.*, 2014; Karki *et al.* 2011; Salik *et al.*, 2016; Amin *et al.*, 2018; Asghar *et al.*, 2019; Wada *et al.*, 2019) examined the IRBS and its salient features for improving climate-water governance, whereas one article (Vaidya, 2015) analysed the HKKH, including the IRBS and nine other river basins. In general, most of these studies highlighted the significance of effective governance on a river basin or watershed scale to build resilience and embrace adaptation measures to minimise the impacts of climate change on the water sector in Pakistan.

Critically, Pakistan depends extensively on the IRBS for meeting its freshwater requirements. The IRBS is a widespread (spread over 5,896,000 km^2), complex, and highly climate-vulnerable hydrologic basin (Archer *et al.*, 2010; Zhu *et al.*, 2013; Yang *et al.*, 2014). The Indus River flows through almost the entire country, crossing over administrative or provincial boundaries, and is managed by various federal and provincial institutions. Intrinsically, the size and complexity of the IRBS makes it considerably challenging for researchers to carry out inclusive studies at a river basin scale, particularly to assess governance-related issues (Yang *et al.*, 2014). For instance, in the upper Indus Basin, glacial management is the main area of concern, whereas in the middle, building a climate-resilient infrastructure to manage floods and climate-adaptive irrigated agriculture are the priority areas, and in the lower Indus, environmental flows and ecosystem management are the challenging domains (Qureshi, 2011; Zhu *et al.*, 2013; Yang *et al.*, 2014; Rueff *et al.*, 2015; Asghar *et al.*, 2019). Given the significant vulnerability of the

Table 2. Categorisation of major climate-water governance areas retrieved from the literature.

Major governance areas	Number of publications (N)	Percentage of total
River Basin and Watershed Management	13	14
Agriculture and Irrigation Management	23	24
Urban and Domestic Water Issues	5	5
Floods, Droughts and Disaster Management	13	14
Groundwater Management	13	5
Transboundary Challenges	12	13
Others	25	26
Total	96	100

Indus Basin to climate change, integrated river basin management by ensuring climate resilience is perhaps the most significant governance area for sustainable management of the IRBS in Pakistan.

Almost one-quarter (N = 23) of the total reviewed studies focussed on issues related to agriculture and irrigation management. Notably, a large number of reviewed studies on agriculture/irrigation imply that this sector is vital for the socio-economic development of Pakistan. With an overall contribution of 19.5% to the national GDP, the agriculture sector employs over 42% of the labour force, provides the raw material for about 30% of its industry, and is the largest source of foreign exchange earnings in Pakistan (IUCN, 2018). In turn, agriculture uses around 88–92% of the available water resources to irrigate about 15 million hectares (150,000 km^2) spread across the country (Ringler & Anwar, 2013; Amir & Habib, 2015; IUCN, 2018). Within the agriculture sector, irrigation is the largest water consumer (over 98%) because Pakistan has a semi-arid climate and heavily depends on irrigating crops to produce food and fibre for its ballooning population (Ringler & Anwar, 2013; Piesse, 2015; Young *et al.*, 2019). However, agriculture is also the most climate-vulnerable sector of Pakistan (Piesse, 2015; CIAT-World Bank, 2017; IUCN, 2018).

For governance, agriculture and irrigation involve many facets, including many institutions working at the federal, provincial and local level; and multiple factors, such as water availability, requirement, allocation criterion, climate change, system efficiencies. These miscellaneous actors and multifaceted aspects make it significantly challenging to efficiently govern the irrigation water supplies (both surface and groundwater) all over the country. Given the critical significance of agriculture/irrigation, many researchers (Sultana *et al.*, 2009; Rahut & Ali, 2017; Gorst *et al.*, 2018; Mahmood *et al.*, 2019) have studied the negative impacts of climate change on the agriculture sector in Pakistan that accrued from the lack of climate resilience and adaptation strategies for sustaining crop productivity, food security, poverty, and rural development. Since the emergence of climate change, agriculture/irrigation management is perhaps the most researched area because of its critical significance in the political economy and overall sustainable development of the country. In general, agriculture water or irrigation management (resource, administration, and infrastructure) is one of the most critical governance areas in Pakistan to build resilience and adaptation to fight against climate change.

Among the reviewed publications, very few researchers studied urban and domestic water in Pakistan, irrespective of its paramount significance for governance and sustainability. Only five (N = 5) articles (Malik *et al.*, 2012; Shahid & Piracha, 2016; World Bank, 2018; Shahzad *et al.*, 2019; Shah *et al.*, 2020) studied the municipal water issues and their management under climate change. Broadly, most of these domestic water supply-related studies (for example, Shah *et al.* (2020) and World Bank (2018)) analysed the impacts of inadequate water supply and sanitation, and extreme weather events on residents in general and human health in particular. However, a relatively less number of studies (only five) on this considerably vital governance area may be either due to a single or combination of multiple factors, including: meagre share in overall water usage (compared with agriculture); insufficient data availability; less governance focus; and lack of academics on urban planning. In general, municipal water supply has remained a less noticeable research area in Pakistan. However, with the rising urbanisation and the global cognisance of Water, Sanitation and Hygiene (WASH) services, domestic water supply and sanitation facilities have become a significantly challenging governance area in Pakistan.

During recent years, floods, droughts, and disasters management have gained special attention from scholars. Out of the total reviewed articles, almost 14% (N = 13) of publications examined extreme weather events, their impacts on socio-economic development, and how these unprecedented events are managed in Pakistan. Notably, many of these studies (Ahmed, 2013; Salik *et al.*, 2015; Abbas

et al., 2016; Zaheer, 2016; Raza, 2017; Busby *et al.*, 2018; Memon *et al.*, 2018; Mukhtar, 2018; Jamshed *et al.*, 2019; Shah *et al.*, 2019) examined the current disaster management capacities – mainly institutional, technical, and financial capabilities – which are primarily linked with climate-water governance in Pakistan.

Noticeably, all 13 reviewed studies regarding disasters management were undertaken during the last seven years (after 2013). Critically, this increasing trend of research on extreme weather events and their management can be attributed to a number of prominent factors. For example, the occurrence of unprecedented floods from 2010 to 2014, and as a governance response, the establishment of national and provincial disaster management authorities during the early 2010s are probable reasons for this growing research interest on disaster management in Pakistan. Given the rising trend of unexpected climate events, disaster management has become a vibrant governance area in Pakistan – especially for floods and drought management.

Despite the paramount significance of groundwater in Pakistan, only five (N = 5) articles out of 96 reviewed publications analysed this highly critical climate-water governance area. These studies (Qureshi *et al.*, 2010; Basharat & Tariq, 2014; Steenbergen *et al.*, 2015; Aslam *et al.*, 2018; Memon *et al.,* 2019) highlighted the unsustainable exploitation of underground water and its consequences on socio-economic development in different regions of Pakistan. Although groundwater meets almost half of the agricultural water requirement and all domestic needs, it is the least regulated and researched area in Pakistan due to many institutional and operational constraints (Qureshi *et al.,* 2010; Steenbergen *et al.*, 2015). Unlike surface water, groundwater is a complex subject, being difficult to regulate, monitor, and manage in an already weak-governance environment of Pakistan (Qureshi *et al.*, 2010; Basharat & Tariq, 2014). Possibly, the convolutions involved in groundwater management as compared to surface water and the non-availability of quality data makes it unappealing for researchers and policymakers to investigate this highly important governance area. From a climate-water governance perspective, groundwater regulation and its sustainable management are perhaps the most critical areas for improving the governance of the water sector in Pakistan.

Since water and climate do not respect administrative or national boundaries, their transboundary management is one of the most challenging governance areas. In total, 12 publications (13%) examined the transboundary climate-water issues and allied conflicts. For example, Mustafa *et al.* (2017) commented on the Water Apportionment Accord (WAA) signed among the provinces in 1991 to regulate water-sharing among the provinces as per agreed water allocations in the Accord. Many researchers (for example Mustafa *et al.* (2017) and Anwar & Bhatti (2018)) discussed this Accord as a prominent governance tool by highlighting the implications of not considering climate change impacts on overall water availability in this water-sharing agreement.

At the regional level, few scholars (for instance Elalem & Pal (2015), Molden *et al.* (2017) and Vij *et al.* (2017)) examined regional collaboration on water issues and climate adaptation strategies. Notably, Pakistan is a major stakeholder of the HKKH, which is one of the vast glaciers of the world and a source of freshwater for over ten river basins, including the Indus Basin (Molden *et al.*, 2017). The HKKH covers an area of about 3.44 million km^2, encompassing around eight countries, including Pakistan, Nepal, Myanmar, India, China, Bhutan, Bangladesh, and Afghanistan (Elalem & Pal, 2015). These glaciers are considerably vulnerable to climate change due to an average increase in temperature, leading to their unforeseen rapid melting (Elalem & Pal, 2015; Molden *et al.*, 2017).

Pakistan receives most of its water from the IRBS shared by Pakistan (53%), India (34%), China (7%) and Afghanistan (6%) (FAO, 2011; Laghari *et al.*, 2012). However, Pakistan and India, being the major

shareholders, have a long and intricate history of transboundary issues (Kalair *et al*., 2019). Almost half of the reviewed transboundary climate-water related publications (for example Gazdar (2005), Zawahri (2009), Mustafa (2010), LEAD (2018), Sattar *et al*. (2018) and Kalair *et al*. (2019)) examined the historic Indus Water Treaty (IWT) signed in 1960 between Pakistan and India. Principally, this Treaty – a water partition agreement – entitles Pakistan to use waters of western rivers (the Indus, Jhelum, and Chenab), and India has water rights of eastern rivers (the Ravi, Sutlej and Beas) (Sattar *et al*., 2018; Kalair *et al*., 2019). Likewise, one article (Atef *et al*., 2019) discussed transboundary water governance between Pakistan and Afghanistan. Overall, the reviewed publications revealed that Pakistan's main transboundary challenges are the prolific implementation of the IWT with India and strengthening of regional coordination on HKH to protect rapidly melting glaciers and ecosystems that present snowballing challenges to all stakeholder countries.

Over one-quarter of the reviewed studies (N = 26) examined a broad range of governance issues and were, accordingly, placed under the 'others' category. For example, some scholars (Hussain & Sabri, 2014; Victor & Agamuthu, 2014; Hassan *et al*., 2015, 2017) studied the environmental governance challenges, such as environmental or ecological flows and ecosystems maintenance in Pakistan. Many publications (FODP-WSTF, 2012; Bisht, 2013; Mustafa *et al*., 2013; UNDP, 2017; Young *et al*., 2019) comprehensively analysed the water sector with a particular focus on climate change challenge, its implications, and adaptation strategies for better climate-water governance in Pakistan. Notably, Young *et al*. (2019), a World Bank-funded study, carried out an inclusive analysis of the entire water sector with a particular focus on the policy, institutional, and legal frameworks. Similarly, FODP-WSTF (2012) examined the water sector and recommended multiple social, economic, technical, and institutional reforms to improve water sector performance in Pakistan. Moreover, some researchers (for example Newberg (2016) and Cooper (2018)) analysed existing climate and water administrative systems in Pakistan. In general, a large number of publications in the 'others' category revealed a wide range of climate-water focussed issues and their inferences for effective governance in Pakistan.

Major climate-water governance elements and enabling factors

Globally, most of the government responses to managing water-related issues have remained surrounded predominantly by infrastructure and technical solutions. From the 1990s onwards, probably on the rise of sustainability paradigm, novel approaches such as governance and integration have emerged for managing the wicked problems of climate change and water scarcity (Grafton *et al*., 2019). For the elucidation of water governance, Kalair *et al*. (2019) argued that it is an integration of political, administrative, social, and economic aspects to manage water challenges. Moreover, OECD (2018) defined water governance as a set of political, administrative, and institutional policies, processes, and practices that enable decision making and their implementation after extensive consideration of stakeholders' concerns and holding the decision-makers accountable for water management. For climate governance, Climate Action Tracker presented a similar framework by integrating political, policy, and institutional processes as well as stakeholder engagement (CAT, 2019).

With time, different climate and water governance frameworks have emerged and been employed by researchers, for example Integrated Water Resources Management (GWP, 2000; Furlong *et al*., 2014); Organisation for Economic Co-operation and Development (OECD) Water Governance Framework (Neto *et al*., 2018); Water Governance Reform Framework (Grafton *et al*., 2019); Multilevel Governance Model for climate change adaptation and mitigation (Gregorio *et al*., 2019); Climate Action

Tracker – Climate Governance Assessment Framework (CAT 2019). With a broad concept of integration, almost all these frameworks incorporate political, policy, institutional, administrative processes, and stakeholder engagement as the key elements. Notably, the reviewed literature revealed similar aspects of climate-water governance in Pakistan.

From the in-depth analysis of reviewed publications, it is revealed that almost 10% (N = 10) of studies identified political commitment and leadership aspects of governance; about 20% (N = 19) emphasised on policy formulation and regulation; nearly 20% (N = 19) analysed institutional capacity and coordination factors; around 9% (N = 9) assessed stakeholder engagement; and nearly 41% (N = 39) of studies examined governance of resource management, technology, and infrastructure-related challenges, as shown in Figure 3.

Political commitment and leadership. From the reviewed studies, ten publications (10%) analysed the high-level political commitment and leadership for improving climate-water governance in Pakistan. Notably, most of these studies (for example Gazdar (2005), Zawahri (2009), Mustafa (2010) and LEAD (2018)) examined the transboundary, regional cooperation, and legal aspects of governance for ensuing hydro-politics and water cooperation between India and Pakistan. On the regional scale, some researchers (Hassan *et al*., 2017; Molden *et al*., 2017) underlined the significance of environmental and water diplomacy for regional prosperity. At the sub-national level, few publications (Akhter, 2015; Mustafa *et al*., 2017) highlighted the political implications of distrusted governance systems among the provinces regarding water distribution, usages, and infrastructure operation. From the reviewed literature it is found that the enabling factors to political commitment and leadership mainly entail promoting transboundary water-climate cooperation, enabling inter-provincial harmony, and making high-level decisions to facilitate water-climate governance in Pakistan (Gazdar, 2005; Zawahri, 2009; Mustafa, 2010; Mustafa *et al*., 2017; LEAD, 2018), as shown in Figure 4.

Given that water scarcity and climate change are global issues, various international forums require high-level decision making from national leadership to meet international obligations (for example,

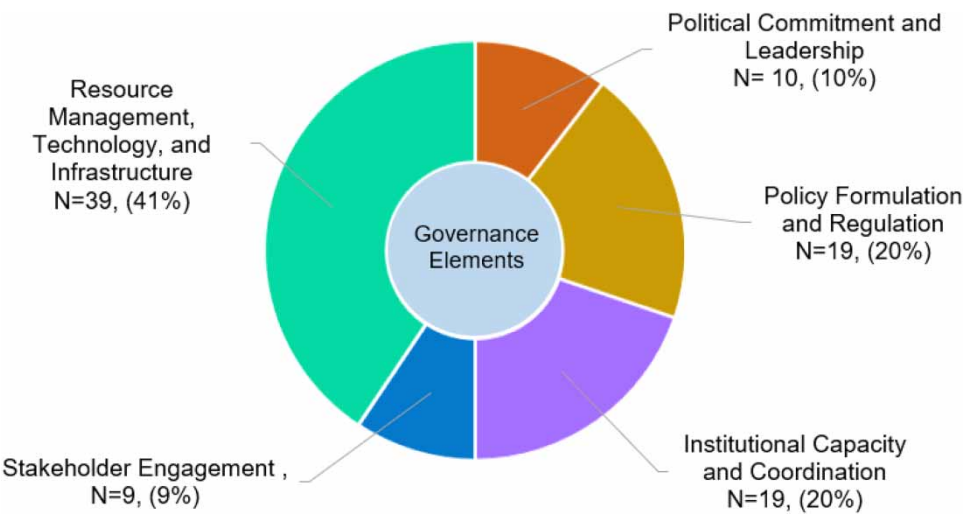


Fig. 3. Classification of major governance elements synthesised from reviewed publications.

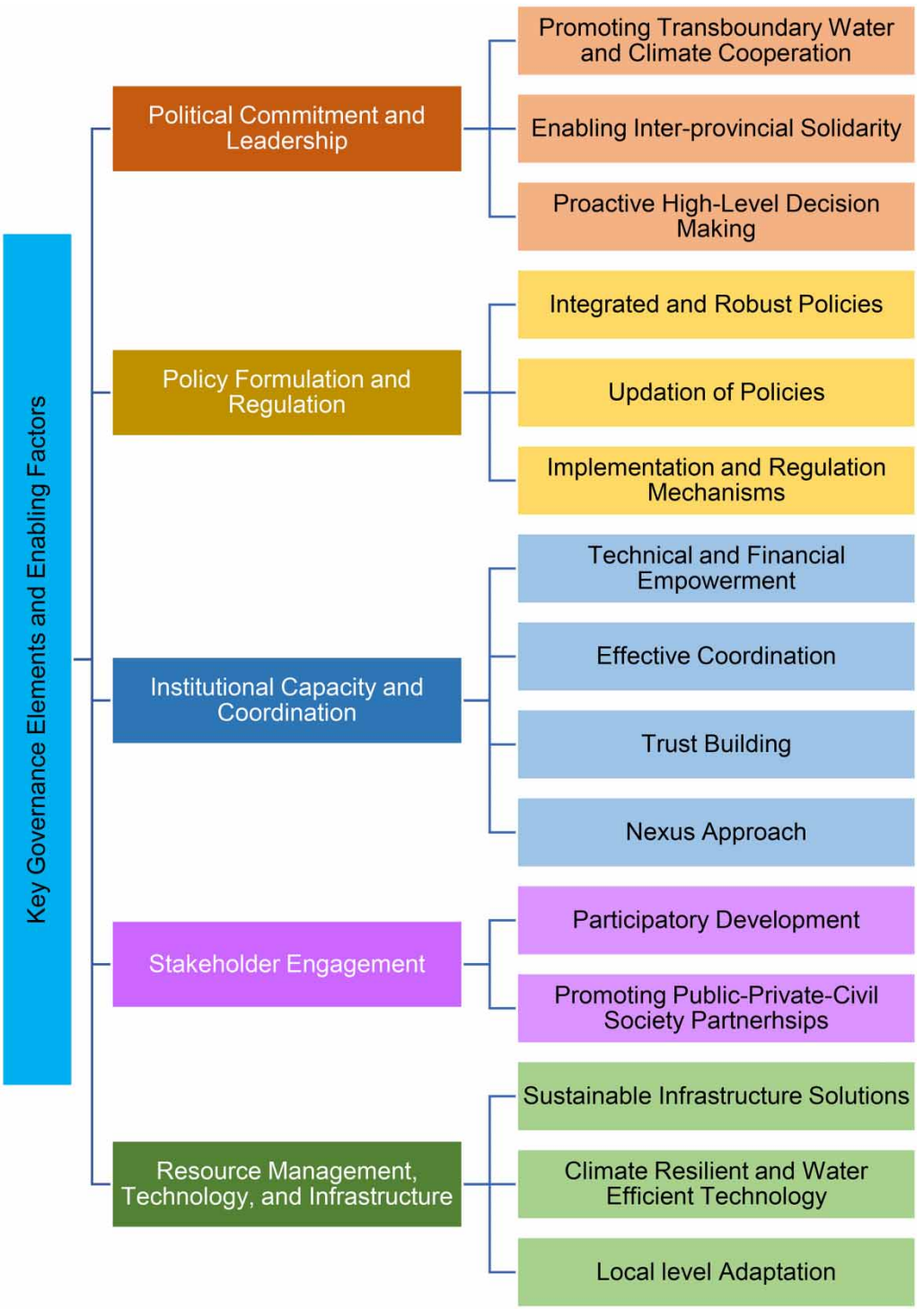


Fig. 4. Classification of major climate-water governance elements in Pakistan.

SDGs, NDCs, and the Paris Agreement), and even to formulate and achieve national policy goals for climate-water governance (Zawahri, 2009; Salik, 2017; Sattar *et al*., 2018). At the national level, creating inter-provincial solidarity for resolving sub-national level water disputes over water allocations and major development projects needs political harmony (Mustafa *et al*., 2017). Critically, transboundary water management (at local and basin scale) solidifies the need for visionary political leadership to upkeep a healthy and collaborative enabling environment for integrated and shared governance.

Policy formulation and regulation. Policy formulation and regulation have remained valuable governance tools to tackle wicked problems like water scarcity and climate change in Pakistan. From the reviewed publications, about 20% (N = 19) of studies featured the significance of policy formulation, regulation, and legal factors for better governance to tackle climate-water issues. These studies have addressed a wide range of climate and water policy formulation and regulations challenges. For instance, Hussain & Sabri (2014) analysed environmental policy; Khan *et al*. (2016) debated climate policy; Mumtaz (2018) evaluated Pakistan's NCCP; Salik, (2017) examined Pakistan's policy options after the Conference of Parties (COP) 21 and the SDGs approval; Mustafa *et al*. (2013) analysed the water policy perspectives; and Ahmed (2013) commented on Pakistan's disaster risk reduction and management policies. Regarding water regulations, Qureshi *et al*. (2010) stated that water regulations, especially for groundwater management, are weak in Pakistan, requiring robust regulatory frameworks and governance tools for sustainable management. Some research studies (for example Qamar *et al*. (2018)) analysed the water pricing policy and its implications on water governance in Pakistan.

Broadly, policymaking processes in Pakistan demand that a wide range of multifaceted issues encompassing water scarcity, sub-national water disputes, transboundary water management, groundwater regulation, low irrigation efficiency, ageing infrastructure, water pricing challenges, WASH issues, economic constraints, lack of institutional capacity, and environmental challenges are addressed (Mustafa *et al*., 2013; Khan *et al*., 2016; Young *et al*., 2019). However, the climate-water policy arena is significantly diverse, complicated and discounted. For example, the NCCP was approved in 2012, but there was no water policy at that time to integrate with for a cohesive response to tackle these integrative issues simultaneously. As recapitulated from the literature and shown in Figure 4, Pakistan's policy formulation and regulation processes need to articulate robust and integrated policies (climate-water integration), update existing policies to ensure the addition of unforeseen challenges, and formulate overarching implementation and regulation mechanisms (Mustafa *et al*., 2013; Khan *et al*., 2016; Salik, 2017).

Institutional capacity and coordination. Over one-fifth (N = 19) of the total reviewed publications highlighted the significance of institutional capacity and coordination arrangements for improving climate-water governance in Pakistan. Most of these studies have analysed the inter-institutional coordination mechanisms to fight against climate change. For example, many scholars (Abid *et al*., 2016; Gorst *et al*., 2018; Abid *et al*., 2019) have examined the role of institutions – especially agriculture development organisations – in the adaptation of climate-resilient practices by farmers for improving climate-water governance at the local level in Pakistan. Moreover, Cooper (2018) studied the existing governance hierarchy of water management institutions and evaluated institutional gaps in sustainable water management. Likewise, Iqbal & Khan, (2018) analysed the institutional arrangements at different governance tiers for the effective implementation of the climate policy in Pakistan.

The SLR revealed that within the institutional capacity and coordination arrangements domain, technical and financial empowerment of institutions, effective coordination and trust-building across and within institutions, and embracing nexus approaches are key enabling factors for improving climate-water governance in Pakistan (Yang *et al.*, 2014; Fan, 2016; Iqbal & Khan, 2018; Kalair *et al.*, 2019), as shown in Figure 4. Critically, effective coordination and nexus approach help in minimising trade-offs and maximising synergies among institutions and different sectors. In the complex and highly climate-vulnerable water sector of Pakistan, strengthening of institutional capacity in various areas is vital for improving governance. Notable capacity development areas are: leadership development; technical, financial, and technology empowerment; data, knowledge, and information generation; cross-institutional coordination for improving communication; and resolving conflicts are critical elements for improving climate-water governance. In general, institutional capacity and coordination are crucial elements for climate-water administration in Pakistan.

Stakeholder engagement. Stakeholder engagement is one of the most notable features of governance, especially for natural resources management. However, from the reviewed publications, only nine (N = 9) studies have discussed stakeholder collaboration. Most of these studies (Abbas *et al.*, 2016; Bott, 2016; Raza, 2017; Shah *et al.*, 2019, 2020) emphasised the active engagement of stakeholders through participatory development, including public and private institutions for disaster management and prevention of extreme weather events in Pakistan (Figure 4). Notably, few researchers (for example Wada *et al.* (2019)) examined water-energy-land nexus approach co-designed with the engagement of regional stakeholders (Pakistan, India, Afghanistan, and China) for achieving the SDGs in the Indus Basin.

Recently, with the emergence of inclusive development paradigm, active and object-oriented engagement of stakeholders at multiple levels has gained paramount significance for improving governance of natural resources. In Pakistan, stakeholder engagement is a complex domain as it comprehends many dimensions. For example, at the household level, community involvement, and building trust between stakeholders help in formulating adequate climate-resilient strategies to minimise flood-induced domestic vulnerability (Shah *et al.*, 2020). Moreover, the involvement of local communities in disaster management (before and after), decision-making processes, and drawing up local knowledge and expertise for development works, can help improve the governance (Raza, 2017). In the agriculture or irrigation sector, participatory engagement of the farming community in processes such as water allocations, system rehabilitation, irrigation management, promotion of efficient water management technologies, and climate-resilient practices is also indispensable for sustainable management of water resources and their governance. In general, stakeholder engagement is a vital element of almost every climate-water governance process for ensuring transparency and accountability essential for strengthening governance.

Resource management, technology, and infrastructure. Out of the 96 total reviewed publications, almost 41% (N = 39) of studies covered resource management, technology, and infrastructure-related issues. Critically, the large number of studies under this category is most probably due to the historical emphasis on infrastructure and technology for solving climate-water issues, thus generally ignoring the governance paradigm. Notably, many scholars (Sultana *et al.*, 2009; Ahmad *et al.*, 2017; Kirby *et al.*, 2017; Mahmood *et al.*, 2019; Shahzad *et al.*, 2019) have studied the importance of irrigation infrastructure and agronomic practices for climate change adaptation in the agriculture sector in Pakistan, whereas

various researchers (for example, Archer *et al*. (2010), Qureshi (2011), FODP-WSTF (2012), Laghari *et al*. (2012) and Young *et al*. (2019)) have not targeted any specific governance area but instead highlighted major water resources and climate change issues and options for their sustainable management under rapidly changing climate.

Among the reviewed publications, two notable studies (FODP-WSTF, 2012; Young *et al*., 2019) comprehensively analysed the water sector, considering existing governance architecture and proposed multiple actions (infrastructure, technical, institutional, and policy measures) to improve climate-water governance in Pakistan. Similarly, IUCN (2018) carried out a political economy analysis in the lower Indus Basin to analyse the political and economic aspects that influence agriculture water governance. Additionally, UNDP (2017) have examined the vulnerability of Pakistan's water sector to climate change and found significant knowledge and research gaps – mainly fewer scholars, less diverse research, low-quality data access, and lack of funding – which are essential factors in strengthening governance systems. On a technology front, many researchers (for example Rasul *et al*. (2012), Amin *et al*. (2018) and Asghar *et al*. (2019)) used computer models and technological options to evaluate different water management strategies under different climate change and socio-economic scenarios.

In Pakistan, though, water infrastructure varies from large reservoirs or dams to large and small-scale irrigation projects or an urban water supply scheme, with varying levels of governance issues and management requirements. During the last decade, many researchers (UNDP, 2017; Young *et al*., 2019) emphasised rehabilitation of the existing water infrastructure to make it climate-resilient and building new systems that are climate-smart. Moreover, the use of climate-resilient and water-efficient technologies can significantly help in improving water productivity under the changing climate. Besides, local level awareness and adaptation to climate change are critical enabling factors to assisting most vulnerable communities in making them adaptable to climate extremes. Along with 'soft' governance strategies, 'hard' infrastructure and technological solutions considerably assist in better climate-water management in Pakistan.

Climate-water governance gaps

Pakistan's water sector presents a complex picture of how water resources are managed, shared, and utilised by multiple stakeholders and at different hierarchical levels. During the last two decades, climate change has made the political economy of water governance more complicated and vulnerable in Pakistan. After the decades-long focus on infrastructure and technological fixes to water-related issues, many researchers have recently argued that Pakistan's water problems are mostly governance-related (FODP-WSTF, 2012; Ringler & Anwar, 2013; IUCN, 2018; Young *et al*., 2019).

Notably, poor water resources management (mostly governance) causes an annual economic loss equal to around 4% (over ten billion US dollars) of the GDP to Pakistan (Young *et al*., 2019). Almost 80% of drinking water supplies are bacterially polluted and unsafe for consumption in Pakistan (UNICEF, 2016), while one-third (about 30%) of total diseases and almost 40% of mortalities are connected to unsafe drinking water (Sleet, 2019). According to UNICEF, over 39,000 children die every year (almost 110 per day) due to WASH-related diseases in Pakistan (UNICEF, 2016). The impacts of climate change are even worse in Pakistan, with an annual economic loss of about 3.8 billion US dollars (Eckstein *et al*., 2019). Broadly, the major reason for these significant socio-economic damages is ineffective governance systems – mainly related to political, policy, institutional, stakeholder management, and infrastructure development.

Non-visionary political leadership. Primarily, the lack of high-level political commitment and visionary leadership has remained one of the significant reasons for the poor performance of climate and water sectors in Pakistan (FODP-WSTF, 2012; Mustafa *et al*., 2017; Young *et al*., 2019). A typical example of ineffective political leadership in Pakistan is the disagreement of political leadership (or parties) on the NWP, which was initially drafted in 1998 and finally approved in 2018 after almost two decades of wrangling and consultations (IUCN, 2018; Young *et al*., 2019). However, Pakistan showed proactive leadership in the approval of the NCCP in 2012; yet its implementation remained challenging in the absence of the NWP and an integrated framework to address both climate and water sector issues jointly. Another emblematic example of futile political leadership is inter-provincial water dispute, mainly the Kalabagh dam (hydropower and irrigation project). Despite the approval of this dam in the 1960s with significant socio-economic and environmental benefits, until today, this mega project remained disputed between the provinces (mainly Punjab and Sindh) due to provincial mistrust (Mustafa *et al*., 2017). Arguably, the main dispute on this dam is over benefit sharing and risk reduction that is not such a big issue to be resolved, provided national security prevail over short-term political benefits. In a politically unstable country like Pakistan, the solid commitment of high-level leadership is challenging to improve governance of the water sector, especially after the emergence of climate change.

For environmental awareness, national political leadership is futile in visualising the significance of water ecosystems. Annually, ecological degradation causes Pakistan approximately two billion US dollars of economic loss (Young *et al*., 2019). This financial loss is mainly attributed to the significant decline in biodiversity, estuarine fish stocks, coastal mangrove forests, and freshwater supplies (Salik *et al*., 2016). Unfortunately, the country is facing enormous damage due to the rapid decline of water-dependent ecosystems, which are critical for ensuring the sustainability of water resources.

Lack of robust and integrated policies. The political leadership has a strong correlation with the policy processes in Pakistan. Historically, water and climate policy have remained a federal subject in Pakistan. Until the 1990s, there were minimal efforts on water and climate policy in Pakistan (Young *et al*., 2019). However, after the emergence of climate change and its considerable negative impacts on water resources (Khan *et al*., 2016; UNDP, 2017), water and climate policy became notable governance elements in Pakistan, culminating in 2012, when Pakistan approved its first NCCP to tackle climate change. The NCCP discusses water as the most vulnerable resource to changing climate (GOP, 2012). The approval of the NCCP was indeed a notable intervention to tackle climate change in Pakistan. Still, it lacks identification of resources, monitoring and evaluation mechanisms, political and public opportunities, and stakeholder obligations (Mumtaz, 2018).

For the effectiveness of invoked climate policies, many researchers (for example, Iqbal & Khan (2018)) carried out a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis of the NCCP and its implementation framework, particularly concerning water sector adaptation strategies. This study found that proper identification of the institutional roles and responsibilities at different governmental tiers, along with ownership of the proposed water-related activities, riparian and transboundary water challenges, and climate diplomacy, are major elements missing in existing climate policy (Iqbal & Khan, 2018). Critically, the absence of the NWP was also the significant hurdle in the concrete implementation of the NCCP for building resilience and adaptation against climate change.

Notably, the water policy misses its synchronisation with climate policy. Approved in 2018, the NWP has not mentioned the NCCP and its provisions in policy manuscript. Although the NWP discusses the integrated approach for water resources management, it misses most of the critical governance elements.

Noticeably, the NWP has not a single mention of water governance, as the policy mostly engrossed around technical solutions for solving water challenges. Moreover, although the NWP stresses to formulate the groundwater regulatory framework, Pakistan currently has no framework for groundwater regulation, management, and development (Sattar *et al.*, 2018; Young *et al.*, 2019). Intrinsically, the non-existence of the groundwater regulatory framework is one of the major hindrances for ensuring better water governance in Pakistan.

Another aspect of groundwater regulation in Pakistan is the usage of water by the industrial sector. Most of the industries dispose of their industrial effluent (wastewater) into freshwater bodies without any treatment (World Bank, 2018; Young *et al.*, 2019). These industries discharge about 90% of untreated and toxic industrial waste into open drains (Mustafa *et al.*, 2013). This wastewater contaminates the fresh groundwater resources when it filters into aquifers. Moreover, there is no proper water pricing policy, as it (water) is mostly taken as a free infinite good (Qamar *et al.*, 2018). Broadly, Pakistan misses effective use of policy and regulatory instruments to improve water-climate governance, which then impacts institutional performance.

Weak institutions and linkages. Institutions are essential pillars of climate-water sectors in Pakistan. Both at the federal and provincial level, various institutions are involved in managing water and climate businesses. For climate governance, for example, the Ministry of Climate Change (MOCC) is responsible for articulating climate change policies, adaptation and mitigation action plans, and coordination mechanisms at local and global levels (Mumtaz, 2018). However, at the provincial level, there are no climate ministries or departments; instead, Environmental Protection Agencies (EPAs) are established to look after environmental sustainability (Young *et al.*, 2019). Furthermore, Pakistan has also established the National Disaster Management Authority (NDMA) and Provincial Disaster Management Authorities (PDMAs) for disaster management at federal and provincial levels, respectively (Ahmed, 2013).

For water resources governance, the Ministry of Water Resources (MOWR) is responsible for water resources development, management, and hydropower generation at the national or federal government level (Young *et al.*, 2019). Under the administrative control of the MOWR, the Water and Power Development Authority (WAPDA) – a leading national water institution – undertakes mainly the development and management of water resources as well as construction of water reservoirs or dams for irrigation water supplies and hydropower generation (FODP-WSTF, 2012). Another federally-managed institution of the Federal Flood Commission (FFC) operates under the MOWR, which is responsible for flood management (Young *et al.*, 2019). The Indus River System Authority (IRSA), another federal institution, looks after provincial interests to ensure that each province is receiving its share of surface water as per the WAA 1991 (Anwar & Bhatti, 2018). Also, Pakistan Council of Research in Water Resources (PCRWR) provides research-based policy guidance to the federal government regarding water-related issues (Young *et al.*, 2019). For dealing with transboundary water issues with India, the office of Indus Water Commissioner was established in the federal government to facilitate the implementation of the IWT smoothly (Sattar *et al.*, 2018).

Rainfall measurement and an early warning system are federal subjects with little expertise in provinces. Pakistan Metrological Department (PMD) monitors, analyses, interprets and communicates the rainfall data to provincial governments and other stakeholders (Young *et al.*, 2019). Moreover, Space and Upper Atmosphere Research Commission – a national space agency – also assists the federal government in weather monitoring (Young *et al.*, 2019). However, the provinces have currently no

institutional arrangements for weather monitoring and precipitation measurements. Generally, the NDMA and PDMAs rely on the data and information from the PMD about weather predictions regarding extreme weather events and early warning for disaster management – mostly floods.

At the provincial level, agriculture water management mostly dominates the traditional water governance hierarchy because of its largest share in total water usage. According to the 18th constitutional amendment, Provincial Irrigation Departments (PIDs) regulate and distribute the water diverted from the rivers by the WAPDA/MOWR through a network of canals, distributaries, and minor canals (FODP-WSTF, 2012), whereas Provincial Agriculture Departments (PADs), through its On Farm Water Management (OFWM) wings, are responsible for improvement/rehabilitation of tertiary level irrigation network (watercourses) at farm level and promotion of modern water management technologies, techniques and practices amongst the farmers for improving conveyance, application and water use efficiencies (FODP-WSTF, 2012; Young *et al*., 2019).

During the late 1990s, Pakistan introduced an irrigation management transfer model by establishing Provincial Irrigation and Drainage Authorities (PIDAs) to transfer irrigation service delivery to the farming community for addressing multiple technical and financial sustainability issues (FODP-WSTF, 2012). Under this reform, the water users (farmers) were involved in planning, management, and operation and maintenance of irrigation infrastructure through farmer organisations (FODP-WSTF, 2012). Many notable community-level institutions, like Area Water Boards (AWBs) and Farmer Organisations (FOs), were established under the PIDA mainly for agriculture water management at the canal level (Condon *et al*., 2014). At the watercourse (field) level, a community-based institution of Water Users Association (WUA) was established under the OFWM-WUA ordinance (GOPb, 2016). These farmer-led institutions are involved in irrigation-related technical and financial matters.

For domestic water use, mostly local governments administer the household water supply under the Local Government and Community Development Department (LG&CDD). In contrast, in major cities, Water and Sanitation Agencies (WASAs) are responsible for domestic water supply and sanitation (Cooper, 2018). Given a staggering number of climate-water managing institutions operating at the federal and provincial level, a significant lack of coordination, communication, capacity, and accountability exists among these institutions, leading to poor climate-water governance in Pakistan (FODP-WSTF, 2012; Mustafa *et al*., 2013; UNDP, 2017; Cooper, 2018; Young *et al*., 2019).

As shown in Figure 5, many environment/climate and water management institutions operate at the federal and provincial level in Pakistan, making the horizontal (within institutions) and vertical (among institutions) synchronisation highly challenging. Critically, the institutional responsibilities for several aspects of climate-water governance are abysmally delineated between federal and provincial level institutions, and amongst other allied entities at these levels (Young *et al*., 2019). This lack of clarity in institutional functions sometimes creates overlap in entrusted roles between and among federal and provincial institutions (IUCN, 2018; Young *et al*., 2019). For example, in Pakistan, many institutions claim groundwater management. However, substantial ambiguity persists over its management and regulation among the federal and provincial institutions. This uncertainty is perhaps mainly due to the non-existence of the regulatory framework. Possibly, the dwindling capacity of climate-water institutions further worsened by the duplication of institutional roles and responsibilities, leading to confusion and tension within organisations (Cooper, 2018; Young *et al*., 2019). Since responsibility is unclear and fragmented, so too is the accountability, which makes governance even more challenging.

Among the provinces, differences on water flows, allocations, and data sharing are prevalent, which creates mistrust among federal and provincial institutions (Mustafa *et al*., 2013, 2017; Anwar & Bhatti, 2018).

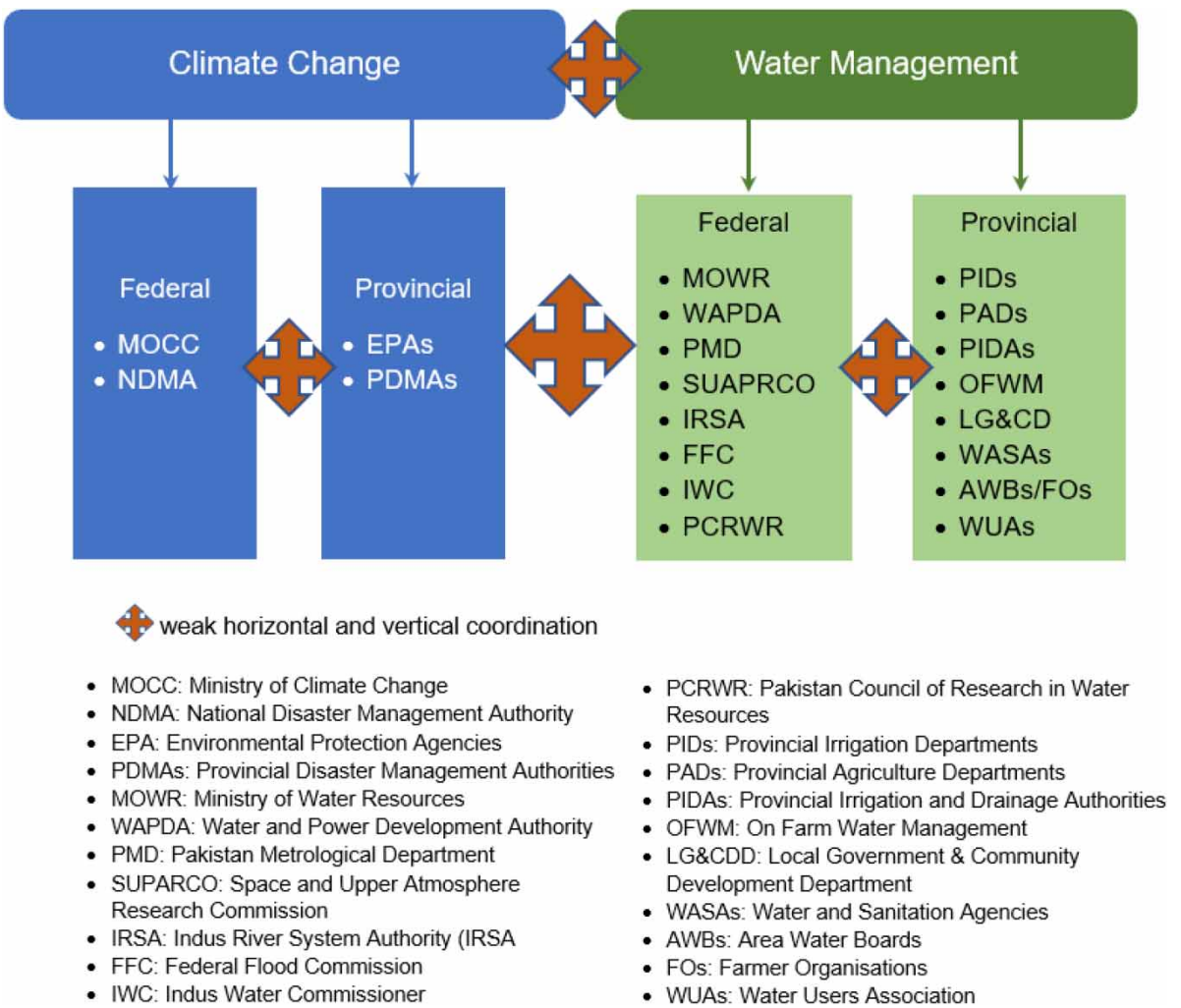


Fig. 5. Climate change and water management institutions and their linkages in Pakistan.

The non-existence of a standardised and reliable telemetric system for monitoring real-time water flows is one of the key reasons for mistrust among the institutions and provinces (Young *et al.*, 2019). Furthermore, the lack of institutional capacity of federal and provincial institutions in collecting, analysing, and communicating information hinders effective coordination amongst institutions (FODP-WSTF, 2012; UNDP, 2017; Young *et al.*, 2019). Similarly, technical and financial capacity gaps in existing disaster management practices and the lack of advanced early warning systems contribute to the weakening of governance systems (Mukhtar, 2018). Critically, the ineffective use of Information and Communication Technologies (ICT) to collect and analyse data, as well as its subsequent communication to stakeholders, is probably one of the main reasons for weak coordination. In general, institutional capacity and lack of coordination among institutions pose significant challenges to ensure effective climate-water governance in Pakistan.

Lack of stakeholder engagement. Equally, the engagement of stakeholders, mainly water users and managers, generally remained weak in Pakistan. Under the traditional government hierarchy, the status quo-oriented style of water-climate-environment management is most prevalent in Pakistan, in which vital policies and decisions are mostly made without effective consultations with the stakeholders (Mustafa *et al*., 2017; Alam & Lovett, 2019; Young *et al*., 2019). For example, most of the community engagement reforms, like the PIDA model (irrigation management transfer to the community), have not yielded the desired results. The key reasons for this unsuccessful implementation of such reforms are the lack of ownership and patronage by the government, internal disputes, capture of the reform by influential large landowners (farmers), and low performance of institutions who lead the reform (FODP-WSTF, 2012; IUCN, 2018; Young *et al*., 2019).

Stakeholder engagement for improving climate-water governance has many dimensions in Pakistan, such as data and information generation, resource planning, water allocation, system operations, infrastructure maintenance, and environmental management. Critically, the vigorous consultative process to engage water managers (institutions), water users (public and community), private sector, media, non-governmental organisations, and many other entities are either missing or not given proper consideration. For example, in the NCCP, although it mentions that all stakeholders were considerably consulted in policy formulation, it does not state who these stakeholders were, the consultative process, the level of engagement or stakeholder concerns and feedback (Mumtaz, 2018). However, Iqbal & Khan (2018) commented that the implementation framework of the NCCP encompasses a visible role of federal and provincial stakeholders. In general, the active engagement of stakeholders for improving climate and water governance is mostly missing in Pakistan.

Besides 'soft' governance measures, 'hard' infrastructure strategies are critical for strengthening governance in Pakistan. Historically, Pakistan has invested enormously in infrastructure rehabilitation and technological development (supply side) without much emphasis on governance elements (demand side) to improve the performance of the water sector. Developed over the decades, Pakistan's hydrological and irrigation infrastructure represents an assessed value of around 300 billion US dollars (Young *et al*., 2019). However, many of these irrigation and hydro-structures are aged and require rehabilitation and continuous maintenance to uphold their sustainability. Despite significant investment, large infrastructure gaps still exist in the climate-water sector in Pakistan. Water sector financing has remained below the recommended levels because infrastructure and technology-oriented reforms require enormous funding, particularly in large water reservoirs, public water supply schemes, institutional strengthening, disaster management, and irrigation projects (FODP-WSTF, 2012; Young *et al*., 2019).

Given the significant potential to enhance its per capita water storage capacity, Pakistan has not invested substantially on building large water storage infrastructure projects due to the lack of financing, among other sub-national disputes. Pakistan has only 30 days of water storage capacity (about 19.4 billion cubic meters) as compared to other countries, for example, India has 220 days, Egypt has 700 days, the USA has 900 days, and Australia has 1,000 days (FODP-WSTF, 2012; Mustafa *et al*., 2013). Notably, the lack of inter-provincial political consensus and massive financial requirements for building large water storage infrastructure projects remain a significant governance challenge in Pakistan. Moreover, telemetry and hydro-meteorological systems for flow monitoring of rivers and canals are not technologically advanced to provide reliable real-time information for better planning and governance (Young *et al*., 2019).

Similarly, Pakistan lacks climate financing for vigorously pursuing adaptation and mitigation activities. According to estimates provided in the NDCs, while submitting to the United Nations Framework

Convention on Climate Change (UNFCCC), Pakistan calculated an approximate requirement of about 40 billion US dollars for mitigation activities and around 7–14 billion US dollars annually for adaptation measures to meet the Paris Agreement targets (GOP, 2016). However, despite a considerable increase in funding for climate-related expenditure in national and provincial budgets during recent years, Pakistan still substantially lacks climate financing and needs to engage with global financial institutions – the Green Climate Fund (GCF) and Global Environment Facility (GEF) – to meet its NDCs estimated requirements for achieving the Paris Agreement targets.

Another significant governance issue, critical for financial sustainability, is the flat and low irrigation water pricing (one US dollar per year) – also called *Abiana* in the local language – and very low recovery rate of whatever is charged. Every year, the government disbursed 44 million US dollars as a subsidy for the maintenance of widespread irrigation infrastructure (Young *et al.*, 2019). Ideally, the water system (irrigation or urban supply) should be financially sustainable to generate at least the entire or a major portion of the maintenance cost, which is not the case in Pakistan (Qamar *et al.*, 2018). In general, infrastructure and technology-related water sector issues significantly affect the service delivery, and in turn, governance in Pakistan. At large, Pakistan has not employed major governance element gaps effectively for improving resilience and adaptation of the water sector to tackle climate change. Significant leadership policy, institutional, coordination, infrastructure gaps weakened climate-water governance in Pakistan.

Proposed climate-water governance strategy

A changeover from a traditional status-quo government mindset to governance paradigm is always challenging. With the emergence of sustainability and climate issues, the global focus is now largely shifted from reshaping conventional government approaches to embrace emerging governance strategies for tackling water security and climate change issues (Ozerol *et al.*, 2018). However, in developing countries like Pakistan, context-specific governance strategies are needed to be delineated for improving the management of climate-water sectors. The reviewed literature has emphasised several strategies to improve governance for building water sector resilience and adaptation to combat climate change in Pakistan. These governance elements mostly revolve around political, social, economic, institutional, coordination, and environmental dimensions. However, from the synthesis of the reviewed literature, a four-dimensional governance strategy, encompassing Leadership, Policy, Institutions, and Stakeholders (LPIS) is formulated. As shown in Figure 6, each element of the LPIS strategy covers critical enabling factors for improving climate-water governance in Pakistan.

Embracing visionary leadership. Given the integrative and multifaceted nature of climate-water issues, the role of leadership has become ever imperative globally to address these wicked problems. In developing countries like Pakistan, leadership is pivotal to address multiple governance problems confronting integration, regulation, coordination, trust-building, transboundary collaboration, and stakeholder engagement for tackling water-climate issues. However, as shown in the climate-water governance model (Figure 6), some of the most significant governance elements under leadership domain of the LPIS are challenging the status-quo, hydro-diplomacy, transboundary collaboration, and regional cooperation for climate and water. These challenges require a combination of political, institutional, and community leadership skills to bring improvements in governance systems at various levels (regional, transboundary, national and local).

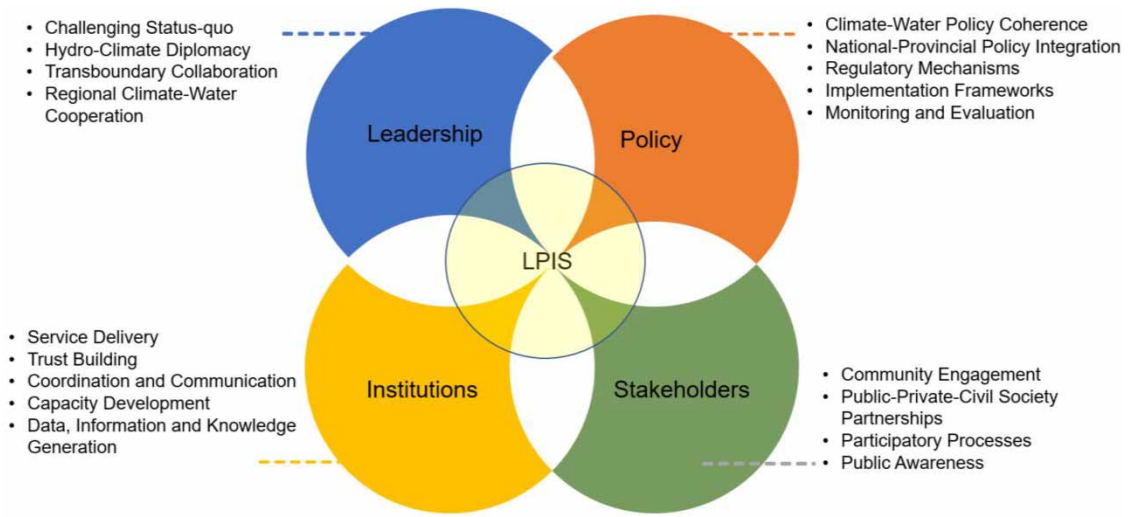


Fig. 6. Key elements and enabling factors of proposed climate-water governance strategy.

For challenging the status-quo and reforming the traditional approach, Pakistan needs visionary leadership (mostly political) that can comprehend the sustainability and governance paradigms and drive this novel change at various levels to address multifaceted climate-water problems. FODP-WSTF (2012) argued that political leadership and high-level commitment is instrumental in bringing reforms and improving governance in the water sector in Pakistan. Similarly, Cooper (2018) emphasised on institutional leadership, and Young *et al.* (2019) deliberated on community leadership for better water governance in Pakistan.

Given the geopolitical nature of climate-water issues, hydro-diplomacy is an evolving domain of water leadership, generally in Asia and particularly in Pakistan. For example, the country needs to advance its hydro-climate diplomacy and leadership skills at many global and regional diplomacy forums, such as the Conference of Parties (COP), SDGs, UNFCCC, GCF, GEF, and other similar organisations (Gazdar, 2005; Mustafa, 2010; Salik, 2017). Notably, the current Prime Minister Imran Khan-led government in Pakistan has showcased climate leadership, as the country has implemented a billion tree project recognised by global leaders at the World Economic Forum (Khan, 2018), and was recently elected as co-chair of the GCF (Dawn, 2019). However, the continuity of such efforts is critical for building resilience and adaptation to combat climate change. At the regional level, collaborative leadership is required to actively participate in agendas on sustainable management of the HKKH (Elalem & Pal, 2015; Molden *et al.*, 2017). Nevertheless, for regional cooperation to succeed, tangible efforts and sincere support from all shareholders is a prerequisite.

For sustainable management of the IBRS, effective transboundary collaboration can play a game-changing role in improving climate-water governance. Intrinsically, the IWT provides a commendable opportunity to the leadership of both Pakistan and India to strengthen transboundary water cooperation, build climate-water partnerships, and develop a robust information-sharing mechanism for sustainable climate-water management. Critically, given the significant impacts of climate change on transboundary water and so on the IWT (signed in 1960 without environmental consideration), it is timely to revisit this Treaty to incorporate climate change implications. However, under current political circumstances and

hostile environment, this is not likely to happen soon which will probably have severe negative consequences on future generations.

Within national boundaries, although a provincial water allocation agreement in the form of WAA 1991 exists, national leadership needs to collaborate effectively for solving provincial disputes regarding water allocations and mega hydropower (dam) projects (Mustafa *et al.*, 2017). After building trust among provinces, the WAA 1991 requires its upgrading to include missing climate change and environmental implications (Salik *et al.*, 2016; Anwar & Bhatti, 2018). Nevertheless, such deliberations are perhaps not possible without visionary leadership and solid political commitment. Broadly, leadership is crucial for improving climate-water governance in Pakistan to break the status-quo, display hydro-diplomacy skills, address transboundary disputes, and resolve inter-provincial disagreements.

Robust policy frameworks. The policy is one of the most critical features of any governance strategy. For instance, policy-related processes are at the forefront of both the Climate Action Tracker-Climate Governance Assessment Framework and the OECD-Water Governance Framework (OECD, 2015; CAT, 2019). However, in Pakistan, climate and water policymaking is inherently a complex domain that is meticulously linked with various other socio-economic sectors, including agriculture, food, health, energy, poverty, environment, and regional development (Mustafa *et al.*, 2013; Ringler & Anwar, 2013; UNDP, 2017; Mumtaz, 2018; Young *et al.*, 2019). As synthesised from reviewed literature, Pakistan's climate-water policy landscape encompasses five critical areas for improving governance (Figure 6). First, the coherence in water and climate, as well as other related policies (agriculture, urban development, environment, food, health, energy), is critical for inclusive governance. For example, many researchers (Fan, 2016; Kalair *et al.*, 2019; Wada *et al.*, 2019) emphasised policy coherence and the nexus approach to combat water-climate issues. Since there are no provincial climate policies, the development and effective implementation of such policies in coherence with the NCCP and NWP and other related sectoral strategies can significantly help in achieving intended climate-water policy objectives.

Moreover, given the complexity of climate-water issues, the policy frameworks need to consider structural vulnerabilities through building societal, political, economic, institutional or regional collaborations for improving governance rather than just targeting general (mostly infrastructure and technology) development strategies. Moreover, the policymaking process needs to embark upon robust regulatory and legal frameworks, implementation strategies, and monitoring and evaluation (M&E) mechanism, with clear roles and responsibilities of governing institutions for sustainable management of climate-water resources, in particular, for groundwater regulation, water pricing, irrigation and municipal water service delivery and local climate adaptation (Qureshi *et al.*, 2010; Qamar *et al.*, 2018; World Bank, 2018; Memon *et al.*, 2019; Young *et al.*, 2019). More specifically, the existing NWP and NCCP require a comprehensive and cohesive implementation framework by underlining concrete actions, institutional arrangements, and M&E mechanism to implement envisaged activities tracked through a robust accountable framework (Mumtaz, 2018; Young *et al.*, 2019). Broadly, a rigorous policymaking process and greater policy coherence across multiple sectors and actors are essential for building climate resilience and adaptation of the water sector to strengthen governance in Pakistan.

Strong and connected institutions. Institutions play a pivotal role in the effective implementation of governance frameworks. Governance generally depends on how efficiently institutions deliver the intended services and are held accountable for this service provision. As the institutional architecture

in Pakistan is widespread with several climate and water institutions working at the federal, provincial, and local levels, the reviewed literature revealed many institutional functions to be transformed for ensuring better climate-water governance. However, the critical governance-enabling factors mainly include service delivery, building trust among and within sectors and actors, improving coordination and communication, capacity development, and data, information and knowledge generation (Figure 6).

Service delivery is the most critical governance function in Pakistan. Irrigation, WASH, and disaster management are priority services provided by public institutions. For reshaping service provision, institutional strengthening of ministries, departments and sub-ordinate organisations – the MOCC, MOWR, WAPDA, IRSA, NDMA, and PMD at the federal level, and PIDs, PADs, WASAs, PDMAs, EPDs, and LG&CDD at the provincial level – will significantly help in improving governance of climate and water sectors in Pakistan (Cooper, 2018; IUCN, 2018; Young *et al.*, 2019). The services provided by these institutions need reform through embarking upon an integrated approach that may embrace climate-resilient infrastructure, modern technology, capacity development, building partnerships, technical and financial empowerment, and assuring accountability (FODP-WSTF, 2012; World Bank, 2018; Young *et al.*, 2019).

Given Pakistan's complex climate-water institutional landscape, effective coordination and reliable communication are essential elements for shared and multilevel governance. For example, effective coordination among all stakeholders at multiple levels is crucial – among relevant ministries and departments working at federal, provincial, and local governments, civil society, global development partners, external support agencies, research institutions, private sector, and the community organisations, and even the transboundary collaboration (Zawahri, 2009; Karki *et al.*, 2011; Cooper, 2018; Young *et al.*, 2019). The coordination functions of governance generally encompass information sharing, integrated planning, collaborative decision making, and constructive dialogue. Notably, the use of ICT can considerably help in building institutional coordination and fast-track communication to improve collaborative water governance in Pakistan.

As climate and water do not respect administrative boundaries, trust among resource users and managers is a critical factor for their sustainable management. Trust-building is mainly linked with political and organisational aspects, including transparency in operations and disclosure of information; standardised and reliable water allocation and monitoring system; and level of inter-provincial and inter-institutional collaborative dialogue (Yang *et al.*, 2014; UNDP, 2017). For improving climate-water governance, Pakistan needs to build trust and harmony between and among water users and water managers.

Data, information and knowledge generation systems have become crucial for the sustainable and efficient operation of governance systems. Pakistan needs to fully recognise the significance of data and information management and the use of ICT for water resources management. Notably, the NWP emphasises the development of robust water sector information systems by upgrading collection, processing, archiving and retrieval capabilities (GOP, 2018). Accordingly, a state of the art telemetry system and a reliable early warning system can help to predict the extreme weather events, facilitate better disaster management, and contribute in trust-building (FODP-WSTF, 2012; Young *et al.*, 2019). This will then assist in quality planning, implementation, M&E, and sustainable regulation of climate-water resources.

Institutional capacity development is also an essential component of governance strategies. In Pakistan, it entails capacity building of all stakeholders, including public institutions, private organisations, community, and civil society. It enables water managers and water users to upgrade their skills – mainly in leadership, planning, implementation, regulation, monitoring, evaluation, and coordination aspects –

to govern climate-water resources sustainably. Under multifaceted climate-water challenges, capacity development is essential in various aspects, such as climate-resilient infrastructure development, climate-smart adaptation strategies, integrated water resources management, conflict resolutions, water leadership, effective service delivery, and various other governance-related capabilities (Karki *et al.*, 2011; Xu & Grumbine, 2014; UNDP, 2017).

Stakeholder engagement. Water and climate intersect across sectors, places, and people, as well as terrestrial and temporal scales (OECD, 2015). In Pakistan, climate-water resources encompass a plethora of public, private, community, civil society, and non-profit stakeholders in various development processes, including policy, decision-making, implementation, and project cycles. Hence, stakeholders are central elements of the participatory governance process globally, and it is no different in Pakistan. Apart from top-level commitment and involvement of the government, the active engagement of non-state stakeholders is critical for finding sustainable solutions of climate-water problems. From the amalgamation of reviewed studies, it is found that major governance functions for stakeholder engagement in Pakistan are public-private-civil society partnerships, community engagement, public awareness, and participatory processes (Figure 6).

In Pakistan, the level of stakeholder involvement generally varies from either just informing or consulting, being actively involved in the process, collaborating as an implementing partner, technically and financially supporting the project, or a combination of any of these engagement levels. Under the participatory governance approach, effective community participation is vital for bringing a paradigm shift from the current bureaucratic top-down development approach to a community-driven bottom-up governance strategy in Pakistan. This type of stakeholder engagement facilitates public-private-civil society partnerships, greater public awareness, and encourages participatory processes to improve governance.

Overall, the proposed LPIS framework/strategy for improving climate-water governance encompasses most of the critical governance elements and enabling factors emphasised in prominent climate-water governance frameworks including Integrated Water Resources Management (GWP, 2000; Furlong *et al.*, 2014); OECD Water Governance Framework (Neto *et al.*, 2018), Climate Action Tracker-Climate Governance Assessment Framework (CAT 2019), Water Governance Reform Framework (Grafton *et al.*, 2019), and Multilevel Governance Model for climate change adaptation and mitigation (Gregorio *et al.*, 2019). As a whole, the LPIS framework can potentially help in bringing a much-needed change-over from a traditional status quo-oriented government to an integrated and shared governance approach for building water sector resilience and adaptation to combat climate change in Pakistan.

Conclusions and recommendations

Climate change and water security are the most challenging global issues of this era. These intricately linked problems have caused significant socio-economic damage during the last two decades, and mostly in developing countries like Pakistan. For tackling the water-related extreme weather events, Pakistan has historically relied upon structural and engineering solutions, thus generally ignoring good governance principles. Poor governance has lately been identified as one of the most pressing reasons for ineffective actions to combat climate change and water insecurity in Pakistan. However, significant research and a knowledge gap exist for the identification of critical areas and elements of climate-water governance, and how effectively these elements are employed in Pakistan.

For bridging the knowledge gap, this article applied the SLR method to critically analyse the current climate-water governance archetype in Pakistan. In total, 96 publications were selected and reviewed to identify key areas, major elements, critical gaps and potential strategy for climate-water governance in Pakistan. The results revealed a significant increase in climate-water related publications during the last decade coinciding with various events, such as floods from 2010 to 2014, the NCCP in 2012, the Paris Agreement in 2015, and the NWP in 2018. The main conclusions drawn from the study are:

- The study revealed that major climate-water governance areas identified from SLR are: river basin and watershed management; agriculture and irrigation management; urban and domestic water issues; floods, droughts and disaster management; groundwater management; and transboundary challenges. However, some publications also emphasised environmental management, ecological systems, coastal water management, and few studies have discussed general policy, institutional, and governance-related challenges.
- Key climate-water governance elements identified from the reviewed publications are: (i) political commitment and leadership; (ii) policy formulation and regulation; (iii) institutional capacity and coordination; (iv) stakeholder engagement; and (v) resource management, technology, and infrastructure.
- It is found that Pakistan has not effectively employed these identified governance elements to tackle climate-water issues. Critical governance gaps are the futile political leadership; ineffective policymaking; weak institutions and coordination arrangements; lack of stakeholder engagement; and, less focus on infrastructure and technological development.
- A four-dimensional governance strategy, encompassing Leadership, Policy, Institutions, and Stakeholders (LPIS), is proposed to improve existing governance systems for building water sector resilience and adaptation to combat climate change in Pakistan. This framework mostly embraces social, economic, institutional, political and environmental aspects. The LPIS strategy mainly entails embracing visionary leadership, policy coherence and integration, institutional strengthening, and stakeholder engagement. This framework can potentially help in bringing a much-needed changeover from a traditional status quo-oriented government to the integrated and shared governance approach for building water sector resilience and adaptation to combat climate change in Pakistan.

For future research, the application of notable governance models, such as the OECD-Water Governance Framework and the Climate Action Tracker Climate Governance Assessment Framework, can significantly help in assessing the actual status of water and climate governance in Pakistan. The research recommends that critical evaluation of the current political economy of climate and water governance in Pakistan would be useful for future planning. Furthermore, the researchers and policymakers need to assimilate the governance aspects in the future infrastructure and technology-oriented projects for improving climate-water governance in Pakistan.

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Data availability statement

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

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