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Chapter 9

# Understanding Flood Risk Management in Asia: Concepts and Challenges

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Additional information is available at the end of the chapter

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**Abstract**

In this chapter, an attempt is made to review the behavior of flood in Asian region and mechanism of flood risk management adopted among Asian nations. Flood is the most frequent natural disaster at present and vulnerability is widespread across the globe. Though, Asian region is on a knife-edge. Distribution of natural disasters in Asia followed by economic damage and human killing is illustrated in this chapter. In addition, discourse of China, Pakistan, India, Bangladesh, Indonesia, Nepal, Vietnam, and Sri Lanka on flood risk management is examined. Flood risk management policies framed by these nations over the period of time are synthesized. Research and investment on forecasting, planning, preparedness, assessment, evaluation, and mitigation of flood risk are explained. This synthesis can present a pathway for better response and flood management for debated Asian countries through filling the identified policy gaps. This chapter also urges a need of holistic and inter-countries research and cross country analysis followed by increased funding for sustainable management of risk.

**Keywords:** floods, vulnerability, risk management, policy, research

## 1. Introduction

Overflowing of water in dry land is generally known as flood. Intergovernmental Panel for Climate Change explained that flood is the situation of water overflow or the excessive accumulation of water on specific areas which are not submerged usually. Flash floods, river floods, urban floods, coastal floods, and sewer floods are different forms of floods usually prevail subject to varying mechanism. Fundamentally, risk of flood may prevail anywhere.

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Flood can befall when riotous amount of water arches across a piece of land. The source of water may be river, lake, or the sea. If there is a hole in a defense built to hold water, it could also bring flood. Furthermore, flood may prevail pertinent to excessive rains and profligate melting of glaciers. Erratic weather patterns have become a prime reason behind flood occurrences as well. Researchers endorse precipitation as significant determinants of intermittent climate. Threshold for flood occurrence upsurges with annual rise in average rainfall.

Flood is an outcome of climatic changes (**Table 1** reflects climate change analysis of different countries) and influenced by climatic determinants vis-à-vis temperature patterns (fast melting of ice in case of rise in temperature, snow, soil freezing when temperature goes low) and precipitation (duration, intensity, frequency, timing, form-snow or rain) [1]. Brakenridge et al. [2] were of the view that chances of flooding increases if river is close to sea level. Floods

| Country | Impacts |
|---|---|
| Vietnam | Copsey et al. [4] presented that humans are in notice of climatic variations. Temperature is on continuous rise, and rainfall patterns are less predictable now. People residing around Central Coast and Red River Delta have discerned high intensity of extreme weather events. |
| Bangladesh | Cyclones and numerous floods hit Bangladesh since past due to ever increasing sea level. People are experiencing high temperatures, less rainfall and erraticness of weather as compared to last decade. Unpredictable weather is posing serious threats to loss of resources and livelihoods. Indian dams, urban growth, industry development and farming practices are surpassing impacts on climate [5]. |
| India | High temperature, less rainfall and erratic behavior of weather patterns are prominent in Indian states. Water shortage has become major concern for India as compared to other allied Asian nations. This acute shortage is directly or indirectly associated with climate change. Majority of Indians is feeling extreme weather patterns and on verge of climate-related risks [6]. |
| Sri Lanka | Sri Lanka is seriously vulnerable to enhanced intensity of floods, droughts, landslides, erratic rains, increased temperature and abrupt sea level rise. The vulnerability is in direct connection with climate change [7]. |
| Pakistan | About half (44%) of people in Pakistan have experienced climate change impacts. The percentage is much higher than any other Asian nation. Increased temperature, unpredictable rains, elevated extreme weather events and augmented infestation of pests and mosquitos are some outcomes from climatic severities. Inconsistent rain is affecting crops and access to water for drinking and irrigation is downsizing. Upwelling of pests and mosquitoes is affecting agriculture and health of humans and animals as well [8]. |
| Nepal | Nepal is fronting rise in temperature and less predictable rains. Likelihoods of floods and droughts have been increased in last decade. People are in agreement that climate is changing. These changes are bringing significant decline in farm productions. Human health is also vulnerable to adverse impacts of climate change [9]. |
| China | In China, people discerned upturn in temperature, erratic rains, and extreme weather events. One-fifth (20%) people perceived that impact of climate change is high, though the percentage is lower among all Asian nations. People from Nanchong and Sichuan provinces reported a wide increase in rainfall and an enormous fall in agricultural productivity [10]. |
| Indonesia | Plantation of trees and population of animals has decreased. People are of the view that climate has been changed. They believe that weather is hotter and less predictable now. Frequency, intensity, and patterns of rains have been transformed with sudden increase somewhere while abrupt decline in other areas [11]. |

**Table 1.** Climate change impact analysis in different Asian countries.

sway by basin drainage conditions like preexisting level of water in river followed by ice or snow cover, status and characteristics of soil (moisture contents in soil and permeability), existence of dams and reservoirs, and urbanization rate in the region. Hasty failures of impeding structures evolve floods, landslides, and compact conveyance channel of water [3]. Abiding rains, reckless melting of glaciers, and mounting temperature are widely debated flood risk sources. Consequently, each year, floods of varied magnitude and scale prevail in different parts of the world. Floods prevailed in India, China, and Pakistan in mid-2010 memorizes a damage of unprecedented scale. Colombia and Australia were reported victims to devastating flooding in the same year. Many other countries including Uganda, Namibia, Mozambique, South Africa, Mexico, Columbia, Brazil, United States, China, Korea, Pakistan, India, Thailand, Philippines, and Cambodia witnesses high material damage and causalities associated to floods [3]. In 2012, "killer floods," inducing more than 50 fatalities each, occurred in Madagascar, Niger, and Nigeria in Africa; Bangladesh, China, India, North and South Korea, the Philippines, and Russia in Asia; and Argentina, the United States, and Haiti in America.

## 2. Floods in Asia

Asia is on the verge of natural disasters and has witnessed numerous disasters with devastating impacts. During 2015, about 62.7% of total global disasters were recorded in Asian region. Approximately 167 natural disasters were recorded in Asia during 2015 which is far greater than the natural disasters (155) occurred during the period of 2005–2014. Among disasters, meteorological disasters appeared raised up to 30% as compared to period of 2005–2014. China, Indian, Philippines, Indonesia, and Pakistan were the countries major hit by natural disasters with average disasters of 45, 36, 21, 15, 10, and 10, respectively. On an average, these countries faced 55% of total natural disasters prevailed during 2015. More or less 69 million people were affected from reported disasters across the Asia. However, annual average of victims appeared lesser than average (158 million victims) during 2005–2014. It may be concluded that with the passage of time, frequency of natural disasters is on the rise, which may be more elevated in the forthcoming years.

A number of researchers [12–15] are in agreement that Bangladesh, China, and India are more vulnerable to natural disasters due to their geographical locations and extensive human and material losses could be anticipated. Bangladesh is the most flood prone country among allied Asian nations. Bhutan, Indonesia, Pakistan, Papua New Guinea, Sri Lanka, Thailand, Timor-Leste, Uzbekistan, and Vietnam were declared most vulnerable countries in Asian region by Asian Development Bank [16]. Ministry of Environment and Forest [17] reported that flooding is a usual and recurrent phenomenon in Bangladesh because of river overflows, poor drainage, and erratic monsoonal rains. Floods of 1987, 1988, and 1998 inundated more than 60% area of Bangladesh. Flood of 1998 in isolate caused 100 deaths and left 30 million people homeless.

India is collateral to Bangladesh in case of vulnerability to floods. Forecasting is in favor that by 2080, Mumbai city will be three time more vulnerable to floods [18]. During July, 2005, Mumbai city faced 944 mm of rain around 24 hours [19]. This flooding exhibited significant

| Years | Top 10 countries by number of natural disasters occurred (2006–2015) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| 2006 | China | US | India | Philippines | Indonesia | Afghanistan | Vietnam | Pakistan | Bangladesh | Romania |
| 2007 | US | China | India | Indonesia | Philippines | Pakistan | Japan | Mexico | Algeria | Haiti |
| 2008 | China | US | Philippines | Indonesia | India | Vietnam | Colombia | Kenya | Thailand | Australia |
| 2009 | Philippines | China | US | India | Indonesia | Brazil | Mexico | Vietnam | Bangladesh | Australia |
| 2010 | China | India | Philippines | US | Indonesia | Mexico | Russia | Australia | Vietnam | Pakistan |
| 2011 | Philippines | US | China | India | Indonesia | Mexico | Brazil | Nepal | Japan | Guatemala |
| 2012 | China | US | Philippines | Indonesia | Afghanistan | India | Russia | Japan | Bangladesh | Haiti |
| 2013 | China | US | Indonesia | Philippines | India | Vietnam | Japan | Brazil | Afghanistan | Bolivia |
| 2014 | China | US | India | Japan | Philippine | Indonesia | France | Mexico | Thailand | Nepal |
| 2015 | China | US | India | Philippine | Indonesia | Pakistan | Australia | Japan | Chile | Bangladesh |

Source: *Author compiled the data from "Annual disaster statistical review reports 2006–2015. Centre for Research on the Epidemiology of Disasters, Institute of Health and Society (IRSS), Université catholique de Louvain – Brussels, Belgium".*

**Table 2.** Top 10 countries by number of natural disasters occurred during 2006–2015 (10 years).

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loss on household level. China is on verge of acute and severe flooding in future as well. Monsoonal rains during 2011 cemented a destructive flood in Thailand and a huge loss of 45 billion USD was recorded. Economic growth sliced down to 1.5% from estimated growth of 3.5–4% in 2011. Similarly, 9% land area of Japan comprising 41% population and 65% economy support is vulnerable to floods [20]. Pakistan faced back to back floods in 2010 and 2011 authenticating wide losses. Brakenridge et al. [2] recorded 2000 instant fatalities in result of monsoonal flooding. Unpredictable nature of monsoonal rains is likely to increase in Bangladesh and China [21]. Peduzzi et al. [22] unveiled that Vietnam, Cambodia, and Bangladesh will remain on edge of flooding.

Centre for Research on the Epidemiology of Disasters (CRED), Institute of Health and Society (IRSS), Université catholique de Louvain—Brussels, Belgium published report entitled "Annual Disaster Statistical Review 2014; The numbers and trends" each year indicating natural disasters statistics. Data mentioned in **Table 2** are accumulated summary edited by author by consulting statistical reports from 2006–2015. Data reflect that from 2006–2015, each year, majority of countries are from Asia among top ten countries hit by natural disasters. China, India, Philippines, Bangladesh, Pakistan, and Nepal are Asian countries widely vulnerable to natural disasters.

**Figure 1** is illustrates the prevalence of natural disasters during 2000–2016 in Asia. Flood is the most prominent disaster with share of 41.27 in Asian region. During the period of 2000–2016, Asia faced more or less 2692 disasters (floods, earthquakes, landslides, extreme temperatures, storm, drought, wildfire, and epidemic). Storms posed one fourth (26.82%) share among disasters followed by 11.44% occurrence of earthquake. However, there is a significant gap between occurrence of flood and other disasters. Generally, it can be said that Asian region is more vulnerable to floods at present and in future as well. Distribution of floods in selective countries of Asian region is represented in **Table 3**.

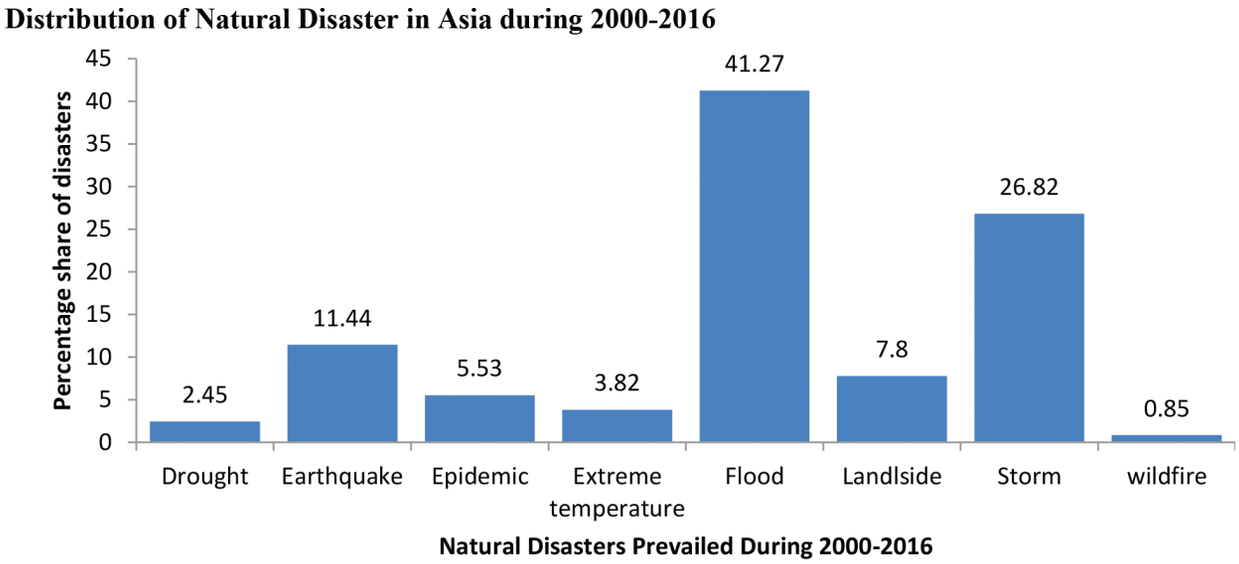



**Figure 1.** Distribution of natural disasters in Asia.

| Country | Number of floods | Total deaths | Total affected | Damage |
|---|---|---|---|---|
| Pakistan | 57 | 6584 | 46,001,293 | 18,707,148 |
| India | 148 | 23,592 | 293,642,535 | 42,294,347 |
| Bangladesh | 32 | 2764 | 72,706,135 | 3,014,000 |
| Sri Lanka | 31 | 211 | 309,071 | 2,000,000 |
| Indonesia | 109 | 3553 | 4,769,651 | 5,853,633 |
| China | 173 | 11,078 | 829,598,958 | 125,938,474 |
| Japan | 16 | 192 | 565,408 | 12,197,000 |
| Nepal | 23 | 2067 | 2,323,988 | 69,729 |
| Vietnam | 57 | 2612 | 17,474,738 | 3,123,502 |

**Table 3.** Total number of floods in some selective countries of Asia (2000–2016).

## 3. Asian discourse on flood risk reduction

Human security is of best entrust for the state governments across the world. Government bodies stay responsible for the planning and execution of public safety and vulnerability mitigation programs. Each country documents plans and strategies for sharing risk knowledge, prevention and mitigation, and preparedness. A brief overview of Asian countries' policies and intervention on flood risk management is discussed below. For a brief overview, extensive literature indicating policies, planning, programs, and outcomes was kept under debate. Cross-country comparison is documented, which could harness felt needs of future.

### 3.1. Pakistan

Pakistan lies in south Asian part and shares border with China, Afghanistan, India, and Iran. Geographically, Pakistan is on the verge of natural disasters. Pakistan witnesses occurrence of earthquakes in 2005 and 2013, floods in 2007, 2010, 2011, and 2012 costing damage of millions. However, floods are reported more devastated. Inadequate storage of water has been one of the prime reasons behind occurrence of floods in country. Efforts regarding water safety and security are scanty, regardless of constructions of dams for the storage, and water security is inevitable to mitigate floods. However, efforts regarding flood risks management are underway in form of different action since inception [23]. For substantial reduction of disasters losses and future security, country embarked National Disaster Management Commission (NDMC) and National Disaster Management Authority (NDMA) in 2006 and 2007 respectively with a vision to boost flood risk awareness, prevention and mitigation, and preparedness among masses. Authority was further devolved to province level with nomenclature of Provincial Disaster Management Authority (PDMA). Purpose of devolution was to implement action plan on grass root level. National Disaster Risk Reduction Policy (DRR) was formulated in 2013 to highlight and deliver comprehensive guiding agenda for addressing flood risk; which is increasing at pace. Policy acclaimed building positive outcomes across the

communities, but a number of experts negated the success and outcomes of the policy. DRR reflected partial success and usually narrated as a tale of contradictory perspectives. DRR revealed decisive weakness with the prevalence of back to back floods in 2010, 2011, and 2014. The occurrence of floods summarized poor performance of policy department and failure in achieving goals due to nonimplementation of proactive strategies. Usually, flood hit rural areas and rural poor communities paid a high cost for these disasters. This damage not only represented a poor implementation of policies but also cemented that "disasters are for the poor." Criticism made by Zeeshan and Khan [24] on sluggish early warning system authenticated the failure of policy. Early warning system has been practiced using radio and emergency flood risk announcements through loud speakers of Mosque. System in practice is so traditional and meager in effectiveness. Public was not trained about evacuation procedures and traditional information sharing system was not capable for this objective. Traditional approach was also not enough to make people aware about safe locations and places to dislocate. Inclusion of "Mass Media" in flood risk policy could harness noteworthy potential in disseminating flood risk and management awareness among community. On contrary, aspect is missing in policy [25]. Financial security of flood victims and migrants is another missing link in policy. The policy holds gaps concerning institutional vulnerability, resources gaps, and institutional coordination and collaboration to accomplish policy goals. Local knowledge and management activities on domestic level are not recognized by disaster reduction experts neither included in policy, which could be another productive step in flood risk management. It can be stated that Government of Pakistan is still struggling to lay plans in wake of catastrophe management [26]. Disasters management and implementation plans are insufficient to meet requirements of risk reduction. There has been no accountability framework for disaster management bodies in instance of poor performance in risk management [27].

Country is allowing natural disasters to occur with increased frequency despite of existence of disaster bodies is clear message of departmental failures. Prediction and forecasting about weather and raining patterns made by meteorological department are less reliable. Occurrence of disastrous drought in "Tharparker (a district in Baluchistan province)" followed by routine human deaths is a dent on performance of disaster management bodies.

Research in Pakistan on research on flood risk and their management is scanty. Research is not sufficient to disclose that how science and technology could be utilized to tackle societal decisions making in context of risk management. Incorporating research in policy formulation on flood risks could address the management of risks in better fashion. For the purpose, social sciences may be included in research agenda for better social overview and community perceptions on risk and their management. There is no database to reflect disaster statistics in Pakistan. Past experiences and research findings are not gathered in Pakistan. Social research in assessment and perception of community on different aspects (for example, about construction of dams) could unveil the felt needs.

### 3.2. India

India has faced a number of floods in the past and persists vulnerable to more disasters in future. Carnage exhibited by disasters urged Indian Government to design and implement

disaster management programs. "State disaster management plans" was the foremost policy documented by Indian Government. These plans inferred that all Indian states are obligatory to compile disaster management papers reflecting preparations outline, actions to minimize risk, and responses to cope with associated threats. State government in association with district governments execute rescue, disaster, relief, and rehabilitation functions with support of national government [28]. Regarding disaster management plans and strategies, Bahadur et al. [29] endorsed implemented programs condensed sound foundation for coordinating disaster management at state level and construct significant reduction in vulnerability of disasters. ICIMOD [30] revealed that coordination among departments (i.e. flood forecasting centers and central water commission, meteorological department and central relief commissioner) helped in saving numerous lives. National programs put more emphasize on human resource development. Preparation of flood risk maps on districts level has been in practice to enrich mitigation goals since the 1997 [30]. Government of India [31] has reported economic loss of approximately 100 million Indian rupees in 2009 due to floods.

Government of India [31] highlighted more focus of disaster reduction programs on safety and protection of vulnerable communities and strengthen coordination and partnerships with local communities to enhance flood risk mitigation. This aspect of policy posed reflection of true participatory approach. However, despite of sound planning, program showed partial success. Poor coordination with local communities, which was subject to extensive workload, and poorly transparent structure were the leading weaknesses. Feeble organizational cooperation between Brahmaputra Board, CWC, and Ganga Flood Control Commission put the working of these departments under criticism. Meager interdepartmental cooperation displayed deprived services followed by below-average effectiveness [32]. Failure in forming floodplain zoning in India raised quandaries, which appeared a barrier of flood management on national level. Floodplain zoning was the mandate of National Water Policy executed in 2012 [33]. Unfortunately, the objective was not met. Absence of enforcement mechanism and demarcation of zones were additional barriers in wake of flood risk management [32]. Findings of Government of India [34] report agreed poor governance behind sluggish implementation of integrated water resource management which was anticipated as leading flood management strategy.

Government of India launched National Disaster Management Authority in 2005 with responsibilities for constructing risk reduction policies and yearly plans. Das [35] agreed with success of NDMA in enhancing capacities and skills development of managerial and field staff. NDMA staff served the society through skill provision which was effective in managing disasters. Separate local as well as national level funds for disaster relief and mitigation activities assured the minimal pressure on public exchequer for embryonic disagreements [36]. Flood risk management in India is least discussed in research and literature. Studies and literature are mainly focused on risk assessment only, while flood insurance, structural control, and integrated management of flooding are least discussed.

### 3.3. Bangladesh

Bangladesh is also vulnerable to floods like collateral Asian nations. Flood prevailed during 1988 inundated 89,000 square kilometer area nationwide and 1517 human deaths were

recorded. After a decade, during 1988, another devastating flood hit Bangladesh and caused inundation on 100,000 square kilometers followed by 918 deaths. Numerous noteworthy floods have prevailed in different years like 1922, 1954, 1955, 1974, 1984, and 1987 with considerable losses [37]. About 70% land of Bangladesh stays exposed to flooding with likelihood of potential impacts on national economy [38, 39]. National Water Plan was implemented in 1980 with aim of balanced water use. In mid-nineties, Flood Action Plan was executed in Bangladesh. Later on, the plan gave origin to National Flood and Water Management Strategy in 1996 with recommendations of general public participation in environmental impact assessment at implementation phase of flood action plan. This action was kept mandatory for all water-related projects in future. National Water Policy was introduced in 1999 followed by subsequent emergence of National Water Management Plan in 2001 with vision to implement different courses of action for water conservation and management. Water-associated disaster management initiative further aided the foundation of Comprehensive Disaster Management Plan (CDMP) and Disaster Management Guidelines with involvement of different stakeholders for execution of different activities to strengthen disaster management capacity at local and national level. Planning of postdisaster rehabilitation and relief was major constituent of disaster management plans. Government of Bangladesh enjoyed smooth control of floods through water management groups, which were helpful in controlling water and allowing specific amount of flooding flow according to hydrology and land topography [40, 41]. Samuels et al. [42] endorsed the effective management water and land and trainings on natural resources management which resulted reduction in of river loads to keep embankments protected and easy carriage to the Bay of Bengal via amended capacity of rivers.

Bangladesh witnesses adoption of structural as well as nonstructural methods of flood prevention and management [39, 43]. Paula and Hossain [44] illustrated more preference of structural flood management techniques as compared to nonstructural technique of flood management. Despite structural methods of flood prevention not being economically conducive, they require huge investment and are not environmentally friendly [33, 45–48]. Over dependency on structural management techniques lead to internal drainage issues followed by siltation and waterlogging [49].

Government of Bangladesh integrated adaptation to climate change into legislation [50] for effective mitigation of floods. Intergovernmental panel for climate change (IPCC) has praised the effective policies of Bangladesh Government which resulted vital improvements in disaster management, reduction in flood fatalities, and enriched adaptive capacities at households' level [51]. This improvement was subject to increased coordination between concerned sectorial departments and concrete planning followed by practical implementation [52, 53]. Early warning system ensured local participation and produced promising outcomes regarding flood risk management [54].

Though efforts of Bangladesh government in managing floods appeared with some remarkable results, a number of policy gaps still persist. Huq and Bracken [55] opined that current flood relief regulatory framework of Bangladesh is only operative for response and relief during times of flooding which shows substantial gaps and sluggish necessities to uplift community adaptive capacities and tendencies to combat future vulnerabilities. Relief, rehabilitation,

and rescue operations effected by National Government are deficient in considering needs of communities [44]. National top-down approach of planning repeatedly failed to convey effective and in-time flood mitigation services [56–58]. Most of the efforts were framed for local participation, but community participation in practical was just at early state in flood-related projects rather than at implementation and execution phase [55]. Unnecessary extraction of upstream water particularly in dry season (November–May) usually paved the way to freshwater reduction and increased salinity level which affected agricultural production and other requirements [59]. Early warning system is not effective according to expectations [44]. Government of Bangladesh also evolves lack of coordination among departments, budgetary scrapes, and rigorous institutional frameworks which are suppressing the results of flood management measures.

Research institutions emphasizing on flood management possess serious gaps. Research in Bangladesh is mainly focused on concept of vulnerability and vulnerability to natural disasters [60–62]. Very few researches are so far carried out on geographic location, community cultural, socioeconomic, and political attributes to vulnerability [48, 63–65]. Assessment of community indigenous knowledge on coping of flooding is poorly addressed [39, 43, 66]. Moreover, fewer researches are conducted on assessment and evaluation of structural flood management techniques and embankments projects [67–69]. Shajahan and Reja [70] orated research gaps in flood mitigation activities and evaluation of flood management strategies and institutional management [38, 49]. General outlook entails that with the passage of time research on flood risk management is partially focused.

### 3.4. China

China is most vulnerable country of Asian region being exposed to disasters more often. According to the estimate, more than 200 million people every year are affected by disasters. Floods utterly distresses lives of people in China [71]. Economic loss per year is more than 100 billion yuan about a quarter of the entire world [72]. Flood occurrence frequency in China is greater than the average of world. This frequency of floods may predict more economic loss in future as well. For future security, Chinese Government is utilizing finest options to combat flood risks. Government of China introduced national integrated system to contest flood risks with integration of geographic information systems, remote sensing, global positioning system, and other techniques for assessment, monitoring, and evaluation of flood exposures. Integrated system reflected pivotal role in flood management and executed as key part of flood management system at National Flood Control Headquarters, China [73]. Forecasting, monitoring, evaluation, simulation, and analysis techniques hold potential to reduce floods [74–76], and China kept all the techniques under consideration. Ministry of Science and Technology China provided financial assistance and laid foundation of National Professional and Operational Integrated System in 1995 for evaluation and monitoring of stern natural disasters.

Forestation was most preferred initiative undertaken by China to mitigate floods. In last three decades, coverage of forests is elevated on consisted basis across the China, and reduction in Floods has been documented in this period. In 1998, China faced a flooding with precipitation

rate of equivalent to floods prevailed in 1980, 1983, and 2002; in these years, flooding was less serious. However, now situation is reversed, and floods have become severe, which is directly associated with destruction of forests and reduction in forest area. For instance, forest coverage in Yangtze River at current is 10% which was 30–40% in 1950s [77]. Wang et al. [78] reported that forest coverage reflected decline from 1970s to the end of 20th century. Deforestation is result of fulfillment of human needs and exploitation of natural resources in nonjudicious way. This deforestation leads contribution in poor management of floods and enhanced vulnerability of flood risks [79, 80].

China has elongated history regarding management of floods beginning with DaYu and Gun's flood management policy [81]. "Dujiangyan" was water conservation and flood management project implemented around 256 BC by state of Qin [82]. After the occurrence of flood in 1998, Government of China switched their course to adoption of structural as well as nonstructural approaches for management. Among structural approaches of flood management more or less 86,000 reservoirs have been constructed in past 5 decades (50 years) in China. These reservoirs posed momentous role in managing and mitigating flood risks and associated losses [83]. For the higher achievements in flood management, Chinese governments gathered allied departments under one umbrella to exert holistic action. For effective operation and management of floods, National Flood Control and Drought Defying Chief Headquarters of China has appointed Dalian University of Technology (DUT), Wuhan Hydroelectric University, and Hohai University to develop an integrated management system for flood control of reservoirs (IMSFCR) since 1998, with a duration of 5 years [83]. Moreover, number of initiatives were undertaken to conserve and manage water and water resources. Government implemented Water laws and regulations framed in succession with water sector since 1980s. Some noteworthy laws are Law of Flood Control (1997), Water Law (1998) later on revised in 2001, and Law of Soil and Water Conservation (1991). Some regulations were embarked in water sector of China as well, for instance, regulations of flood proofing, regulations of river course management, and guide to safety building of flood storage and detention basins. China has integrated wide network of technology in assessment and management of flood risk under flood control framework. For instance, Geographic Information System (GIS) is extensively adopted in regional disaster evaluation which exhibited useful outcomes [84–88]. ArcGIS technology also has been used by the Chinese government in mitigation of highway flood risk management [89]. These multiple initiatives are reflection of true zeal of Chinese government toward flood risk management.

### 3.5. Japan

Japan is another flood prone country of Asia. Extensive rains hit Japan more often in rainy as well as typhoon season which raises the precipitation level across the country. Annual precipitation is around 1500–1600 mm which is very high and fully capable to craft flood threats. Annual precipitation in main city Tokyo is much greater as compared to western countries. On pacific coast of Japan, annual precipitation of 50–60% is recorded from June–October in particular. This situation has caused number of floods in past and casted huge economic damage. In this context, Government of Japan formulated concrete policy to mitigate flood risks.

It is well noteworthy that in Japan about 70% of land is mountainous and covered with forests. Increased area of forests is usually a particular method to combat floods. Due to often occurrence of floods, Japanese utilize their indigenous knowledge to build flood management measures [90]. UNISDR [91] confirmed in connection of Hyogo Framework for Action (2005–2015) that "traditional and indigenous knowledge and cultural heritage" as one of the prime source of innovation, knowledge, and education to bring resilience at all levels.

Flood management history of Japan is extensive most probably came to inception during Yayoi period (300BC-AD 300); hence, Japan build refined and wide ranging disaster management plan. During 1960, efforts were made with focus on hydrologic function of "Green Dams" which acts upon the flow impeding potential of forests to reduce flood vulnerability. Less attention was paid on construction of concrete dams. It may be right to say that 70% mountainous area covered with forest laid foundation of "Green Dams" in country.

Current response system was initiated in short time, but this system enabled government to organize resources and comply in inclusive manner against the prevailed disasters to control damage [92, 93]. Ministry of Land, Infrastructure, and Transport (MLIT) of Japan is mainly responsible for the flood management policy in country at current. Currently, the ministry is managing 109 main river system covering greater than 70% of national land. Rests of the rivers of Japan are under control and management of municipal governments. Japanese Government propelled River Act in 1896. Under the act, each local government is accountable for flood control activities, management of rivers, hydrologic monitoring, and conductance of relevant studies for planning appropriate. Flood Fighting Act was recognized in 1949 with emphasize on systematic forecasting of flood and early warning system with collaboration of meteorological departments, healthy promotion of status and role of flood fighting brigades, and diffusion of flood hazard maps for rivers.

Japanese government has adopted structural as well as nonstructural measures to combat floods. Flood control dams, embankments, flood channels, and regulatory reservoirs were leading structural measures followed by nonstructural measures like forecasting of floods, early warning systems, land use regulations, and disasters and hazards maps adopted at national level. Unfortunately, despite of number of approaches, economic loss associated with floods is increasing due to socioeconomic development and condensed concentration of vastly prized assets. However, the number of deaths due to flood has been reduced significantly since 1960s [94].

### 3.6. Nepal

Nepal faced devastating floods in Tinao Basin, Koshi River, Tadi River Basin, Sunkoshi Basin, and in Kulekhani area in 1978, 1980, 1985, 1987, and 1993, respectively. The flood prevailed in Kulekhani area during 1993 alone caused 1336 deaths [95]. Floods prevailed in 1985, 1983, and 2004 damaged and destroyed large spheres of land terraces, farm areas, pastures lands, and orchards [96]. Therefore, Nepal is usually anticipated as vulnerable country to natural disasters, and huge proportion of GDP was lost annually in wake of natural disasters. Governmental of Nepal urged need of flood risk management and concentrated on Disaster

Risk Reduction Program with intention to identify, assess, and minimize disaster risk reduction [97–99]. This action facilitated sustainable development process in Nepal with reduction of adverse outcomes of natural disasters.

Disaster risk reduction programs were implemented among communities even in schools [100, 101]. Government of Nepal revised the vision and initiated Disaster Risk Reduction Campaign from 2006–2007. Under the campaign, risk reduction program was incorporated in educational curricula, and disaster management was disseminated on village level and districts level [102]. This integration raised the awareness level of community through involvement of instructors, teachers, and local youth clubs. A number of disaster education-related programs were initiated by government and nongovernment organizations [101, 103] on community level.

Nepali Government also launched National Plan for Disaster Reduction in 1996 in harmony of International Decade of Natural Disaster Reduction [104] to deal disasters on different stages. In 1999, an act named as "Local Self Governance Act" was launched which decentralized the responsibilities to lower level of politicoadministrative.

In 1996, the Government of Nepal (GoN) produced the National Action Plan for Disaster Risk Management [104] in accordance with the International Decade of Natural Disaster Reduction. This plan dealt with different stages of a disaster (pre, during and post) and was, in theory, supported by the 1999 Local Self Governance Act which advocated devolution of responsibilities to lower levels of the politicoadministrative pyramid. However, the impact of act appeared sluggish due to inadequate guidance and insufficient funds [105].

Hyogo Framework for Action (HFA) 2005–2015 documented pivotal significance in fostering agenda of disaster risk reduction [106]. The framework reflected a stimulus of change in field of disaster risk management. Disaster Management Policy and Act and the National Strategy for Disaster Risk Management (hereafter the National Strategy) were initiated in 2006 with aim of disaster risks management with improvement in institutional structures. Oxfam NGO funded both the initiatives. It is noteworthy that major funding of disaster programs was sponsored by NGOs. Similarly, Yoqi [107] presented rapid expansion of NGOs in Nepal. About 40,000 NGOs are registered by Social Welfare Council of Nepal. Heavy reliance on overseas aid and NGOs in absence of fully functioning government could raise issues and hinder disaster risks management policies [108–111]. Governance in Nepal is assumed meager which could be proven by the fact that none of the official mechanism to monitor transparency of NGOs registered under Social Welfare Council is in practice [108]. Jones et al. [112] argued sluggish political situation in Nepal, and progress of Nepal is stalled in framing a legislative context encouraging to effective disaster risk reduction measures. Insufficient public awareness, meager disaster preparedness, feeble governance, political instability, poor coordination among government institutions, agencies, and department followed by scanty financial assistance are notable factors hindering disaster risks reduction policies and measures [113, 114]. It can be said that Nepal is yet to understand the bond between disasters and development practices. Progress can be made only with the enhanced cooperation followed by effective policies to facilitate vulnerable in Nepal where each day about two persons die due to natural disasters [115].

### 3.7. Vietnam

Vietnam witnesses devastating flood in 1999 evolving economic damage of more than 200 USD, 547 human deaths and damaging 630,000 homes. Coastal flooding is foremost threat to Vietnam due to geographical location and socioeconomic absorption. The coastline is widespread over 3200 kilometers and 70% population is living there [116]. Since then, Vietnam is a flood prone country [117]. Greater observation and management are inevitable to combat vulnerability, and Vietnam government is harnessing different flood management approaches since inception in 1945. First order of Vietnam government (Order no. 70/SL) originated Central Committee for Dyke Maintenance for flood risk reduction, and later on, committee was replaced by Central Committee for Flood and Storm Control (CCFSC). Legislation was ensured, and hundreds of legal documents have been passed comprising laws, decisions, rules and regulations, and legal framework for effective control of floods [118, 119]. Despite of multiple documents, there has been no concrete and comprehensive law and policy on disaster management in Vietnam. For sustainable water resources management, Law in Water Resources was administered in 2012 followed by Law on Dykes (2006) and Ordinance on Flood and Storm Prevention and Control (2000) for flood management in Vietnam. Dykes in Vietnam adhere to dual purpose part, both for irrigation bank and drainage canal (Central Project Office, 2011); hence, law emphasizing on Dykes was of great worth. Ordinance on Flood and Storm Prevention and Control (2000) illustrated the need of further detailed and comprehensive legislation on flood management. This ordinance was replaced by the Law on Natural Disaster Prevention and Mitigation (LNDPM) in 2014. Government of Vietnam also brought a National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020 during 2009. This national strategy was particularly attentive upon integration of disaster management to socioeconomic position of community for effective response and preparedness to combat the disaster. The strategy also tends to raise public awareness.

Flood management strategies revealed inadequate success pertinent to several inefficiencies. Water Resource and Flood Storm Control Division Report (2011) reflected that inadequate funds allocation hindered flood management policies. Improved financial assistance and healthier observation could have enhanced the effectiveness [120], but it does not appear practical. In fact, existing flood management approaches remain failed in combating disasters. Defense system against floods was insufficient in recent incidences [121]. To take floods in account, early warning system could be strengthened [117, 120], which is meager at current. More focus on improving socioeconomic position of community through alleviating inequality and poverty [122, 123] is need of time. This phenomenon may bring a concept of integrated flood management approaches and holistic action [124] for sustainable management of flood risks in Vietnam.

### 3.8. Sri Lanka

Sri Lanka is a flood prone country of Asian region. The country has faced some noteworthy floods in 1989, 2006, and 2008 damaging huge areas and human killings. Flood is the often hazard faced by Sri Lanka [125]. In last four decades, floods were more often and

devastating for highest number of people [126]. However, Sri Lanka has implemented flood mitigation measures from the past. In late nineties, systematic forecasting programs were started in Sri Lanka [127]. Occurrence of Tsunami in 2004 urged government of Sri Lanka to precede tangible mitigation measures against the floods. Soon after Tsunami, Disaster Management Act, No. 13, was established in 2005 with aim of building institutional framework and national policy on disasters management [128]. National Council for Disaster Management (NCDM) is a high-level intern-ministerial body. Disaster Management Act leads to establishment of Disaster Management Center responsible for the implementation and coordinating national as well as subnational programs of disaster management. The country lingers to execute disaster reduction plans with assistance of nongovernmental agencies.

Among various initiatives regarding flood management in Sri Lanka, only two were found with success (Hazard Mapping Project by the National Building Research Organization [1991–1996] and Sri Lanka Urban Multi-Hazard Disaster Mitigation Project [1997–2003]). Incompetence in implementation of structural as well nonstructural measures against floods was significant reason behind poor performance of projects [129]. Local participation and adaptive capacities of local communities were not kept in consideration [130]. The research regarding assessment, planning, preparedness, and evaluation of floods and management techniques is scanty in Sri Lanka [130].

### 3.9. Indonesia

Indonesia is usually exposed to coastal and riverine flooding [131]. United Nations named Indonesia 38th "at risk" country in 2014. Bengawan Solo and Benanain River are the rivers more often vulnerable to flooding. In past decade, major floods prevailed during 2002, 2007, 2013, and 2014 costing billions of dollars economic damage [132–134]. To combat the vulnerability of floods, government of Indonesia launched different plans and approaches. For instance, in 2008, National Disaster Management Agency was inaugurated in Bahasa with aim to lessen floods. Government of Indonesia has implemented National Disaster Management Coordinating Board in 1979 which provided central coordination with support from 13 ministries of that time and armed forces. This board formulated flood management policy comprising rescue, mitigation, prevention, and reconstruction. Interagency disaster task force was also formulated at provincial, district, and subdistrict level. Flood risk management is also identified in law, 24/2007 and government regulation 21/2008.

Rivers of Indonesia are more often vulnerable to flooding. To combat the vulnerability of floods, government of Indonesia launched different plans. Indonesian Government administered National Disaster Management Plan (2010–2014) in 2012. The plan was more emphasized on flood policies, management strategies, and disaster risk reduction for 5 years span. National Development Planning agency ensured the implementation of plan [135], and technical protection measures were adapted to lower floods risks [136]. Success of flood management plan met with criticism. For instance, local communities were not having adequate environmental awareness to combat risk [137], which reflects that local participation in plan was scanty. Lack of coordination between departments, poor land using pattern and poor

awareness, and knowledge followed by forecasting of floods were some other debatable issues not discussed properly. Early warning and forecasting were also criticized by Shrestha et al. [138]. Marfai et al. [139] pointed a dire need of strong institutional linkage between different stakeholders for quick and effective disaster response. Literature on flood risk management in Indonesia is scanty. Flood management aspects are poorly debated and assessed through different research and evaluation techniques.

## 4. Conclusion

It is myth that Asia is most vulnerable region across the world, and this vulnerability may surpass with the passage of time. Climate of Asian region is already posing abrupt and abnormal variations which are backing the natural disasters. In response, across the region, efforts are in trend with support of concrete policies and huge investment for infrastructure. Each country is documenting viable policy according the topography and geographical location. But, still efforts are inadequate and disasters are occurring frequently. Somehow, killings are downfallen, but economic damage is inverse to killings. Hence, entire Asian region would have to rethink their policies and redefine their actions for sustainability.

Pakistan surely needs to redefine their disaster management policy by replacing "mosque microphone" lead early warning system with integrated modern media. Improving local knowledge on disaster management should be included in policy. Country would have to strengthen their weather forecasting system and water conservation and management. Structural measures (construction of dams) could be fostered. In past, poor storage capacity of water has also been the reason behind occurrence of floods. More research should be ensured on flood risk assessment and management. For the best outcome, country would have to add social research in policy formulation. Social research could embark feasibility, community perceptions, and actions in best entrust.

Disaster management plans of state level in India have been successful but there is need to strengthen inter-departmental coordination and initiation of accountability for those who are expressing poor performers. Floodplain zoning needs more emphasize for accomplishment. For quick and effective risk management, allocation of funds would have been increased. Flood risk management is least discussed in research, hence, more research should be conducted which could help policy makers and practitioners in engineering best models.

Bangladesh being one of the most flood prone regions formulated numerous policies and executed multiple initiatives to mitigate flood risk. Hence, the country would have to shift toward nonstructural measures as well. Bringing climate change into legislation proved remarkable success in flood management. But, current regulatory framework of Bangladesh is mainly operative for response and relief only during times of floods. Government would have to strengthen their framework prior occurrence of flood. For this purpose, weather forecasting

and early warning system should be empowered. Local participation should be ensured in policy formulation and planning. More research on different aspects of flood management could harness effective pathways. At present research in Bangladesh on flood management is meager.

Research on flood management is better in China, which is the most flood prone region of Asia. Deforestation has been found one of the major reasons of flooding in China. China would have to put emphasize on increased forestation. This is also nonstructural flood management measure.

Japan has been implementing structural as well as nonstructural measures for flood risk management. Increased forestation has been natural barrier against flood prevalence. However, socioeconomic development is still questionable, and the need is to strengthen socioeconomic condition of communities and enrich them with local indigenous knowledge to tackle floods. Increased focus on research regarding floods management could disclose existing gaps among communities in front.

Nepali Government has been rendering numerous policy efforts in managing floods. The strong aspect of policy was inclusion of disaster management in educational curriculum for the public awareness. Inadequate funds provisions and guidance on flood management were reported as hindering factor. Hence, government would have to sanction more funds and arrange community level trainings for the guidance of community on risk management.

Vietnam is a flood prone country, and several policies and approached were executed. However, still, there is no concrete and comprehensive policy documented on flood management in Vietnam. There is dire need of concrete policy followed by law and legislation on floods management. Inadequate financial assistance has been seen as constraining factor in flood management. Adequate funds provision and boosting early warning system which is already meager, could harness the better returns.

Despite of number of flood management approaches in Sri Lanka, only few (probably two) sowed successful outcomes. Country also remained unable to implement structural as well as nonstructural measures effectively. Moreover, local participation in planning, execution and management of flood management policy was ignored.

Indonesia was declared 38th "at risk" country, and multiple strategies and plans were initiated. Local participation in these strategies was scanty and environmental awareness among community was low. Lack of coordination among departments and poor forecasting of floods were reported major issues yet to be resolved by the government through effective policies.

To render sustainable management of floods across Asia, it is imperative to develop cross-country linkage and coordination in policy formulation and planning. Mutual financial assistance and technology sharing could support flood management initiatives. Asian countries would have to focus on cross country research on policies, assessment and mitigation of flood risks.

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