INSTITUTIONAL AND GOVERNANCE DIMENSIONS OF FLOOD RISK MANAGEMENT

A FLOOD FOOTPRINT AND ACCOUNTABILITY MECHANISM

Rabindra P. Osti

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ABBREVIATIONS

ADB	–	Asian Development Bank
DRM	–	disaster risk management
FERM	–	flood and environmental risk management
FFAM	–	flood footprint and accountability mechanism
FRMP	–	flood risk management plan
GIS	–	geographic information system
IFRM	–	integrated flood risk management
IWRM	–	integrated water resources management
MRC	–	Mekong River Commission
MWR	–	Ministry of Water Resources
PRC	–	People's Republic of China
RBC	–	river basin committee
RBO	–	river basin organization

ABSTRACT

Best practice in the management of floods has advanced to place greater emphasis on a joint flood and environmental risk management (FERM), which utilizes measures that recover the natural flood mitigation function of floodplains and wetlands and acknowledges the importance of the flood (water)–waste (environment)–biological ecosystem nexus. A challenge in the preparation of FERM projects is having a cross-sector planning approach that is sufficiently holistic to sustain project benefits.

This working paper proposes a concept of flood footprint—i.e., the potential impacts of floods on different sectors—and accountability as a mechanism to guide the institutional arrangements and administrative procedures needed to coordinate project activities within the flood risk zones and in adjoining areas by appropriate spatial planning at river basin scale.

The paper also discusses a study in the Longxi River basin, which demonstrates how technical tools (e.g., flood risk and/or hazard mapping, river basin model) could be used to assess the probable change in flood footprint from different scenarios of flood risk management. The flood footprint and accountability mechanism model used in the trial study not only produces improved outcomes and secures more sustainable project benefits, but it can also provide a framework useful to support initiatives of other countries.

I. INTRODUCTION

The traditional approach to mitigating floods in the 20th century focused on structural works that modified the flood hazard—i.e., engineering works such as levees and/or dikes, reservoirs for storage of floodwaters, and diversion channels.¹ The philosophy of that approach was captured in the widespread use of the term flood control. In the latter part of the 20th century, the importance of nonstructural measures in the mitigation of flood impacts gained greater recognition, producing a paradigm shift in philosophy from flood control to integrated flood risk management (IFRM). This acknowledges that engineering methods were limited in their capacity to control the forces of nature. Natural disasters, such as floods, could not be completely tamed, and it would inevitably be necessary to manage the residual risk after structural flood mitigation works were implemented; hence, the adoption of the term flood risk management. IFRM further acknowledges that nonstructural measures had a crucial role to play in the management of the residual risk, and that flood risk management required integration of structural and nonstructural measures. Integration also referred to the need to spatially integrate flood risk management measures at river basin scale.² In the early 21st century, approaches have advanced to place more emphasis on the joint management of flood risk and environmental risk. There is a preference for measures that utilize or recover the natural flood mitigation function of floodplains and wetlands.³ The term “green flood risk management measures” was introduced in this regard,⁴ and the further updated approach has been referred to as flood and environmental risk management (FERM).⁵ The importance of the nexus between flood risk management, ecological sustainability, and environmental water quality is properly acknowledged and accounted for in FERM. In a broader context, as illustrated in Figure 1, FERM overlaps and is part of integrated water resources management (IWRM), integrated river basin management, and, more generally, disaster risk management.

In developing countries, the shift to these new approaches of flood risk management has been slower, constrained by more limited funding, resources, and technical skills; weak governance; and other factors like limited access to hydrological data and forecasting. Beyond these unavoidable constraints, there have been lack of inertia and reluctance by responsible agencies to embrace new approaches, and insufficient initiative by many governments to provide impetus for change. An outdated approach of channeling available funds exclusively to expenditure on structural flood protection works persists.

¹ Early examples of this approach were found in the United States (US) beginning with works in the Mississippi River basin after the major 1927 flood (G. Galloway. Undated. USA: Flood Management–Mississippi River. World Meteorological Organization/Global Water Partnership Associated Programme on Flood Management), and in the People’s Republic of China in works implemented during the second half of the 20th century along the Yangtze, Yellow, and other major rivers (Y. Kobayashi and J. W. Porter. 2012. *Flood Risk Management in the People’s Republic of China: Learning to Live with Flood Risk*. Manila: Asian Development Bank [ADB]).

² Y. Kobayashi and J. W. Porter. 2012. *Flood Risk Management in the People’s Republic of China: Learning to Live with Flood Risk*. Manila: ADB; and P. Sayers, Y. Li, G. Galloway, E. Penning-Rowsell, F. Shen, K. Wen, Y. Chen, and T. Le Quesne. 2013. *Flood Risk Management: A Strategic Approach*. Manila: ADB.

³ For example, European Environmental Agency. 2017. *Green Infrastructure and Flood Management: Promoting Cost-Efficient Flood Risk Reduction via Green Infrastructure Solutions*. EEA Report No.14. Luxembourg.

⁴ F. Klijn, N. Asselman, and D. Wagenaar. 2018. Room for Rivers: Risk Reduction by Enhancing the Flood Conveyance Capacity of The Netherlands’ Large Rivers. *Geosciences*. 8 (6). p. 224.

⁵ FERM is a new concept recognizing the close connection between managing flood risk and managing risks to the physical environment and biological ecosystems. The concept aims to address the inextricably intertwined nexus between flood (water), waste (environment), and biological ecosystem by applying both structural and nonstructural solutions and taking into consideration urban–rural and upstream–downstream linkages in development planning and project implementation. The nexus approach assimilates multisector targets, provides more economical and cost-efficient development goals, and lessens the risk of applied interventions undermining one another (R. Osti. 2018. *Integrating Flood and Environmental Risk Management: Principles and Practices*. East Asia Working Paper Series. No. 15. Manila: ADB.).

Important is to highlight the benefits of integrated approaches and the potential of nonstructural and structural solutions in tandem.

One consequence of the outdated flood control approach and the lack of integration of flood management works is often a failure to sustain project benefits. Subsequent engineering works, which may or may not be directly related to the objectives of flood management, may undermine or erode the achievements of previous projects. This is since their impacts can be locally or spatially transferred to other locations within a river basin. There are almost limitless ways in which this type of inadvertent adverse impact on flood risk can occur. A good example that is easily visualized is the subsequent construction of a rail or road bridge over a river downstream of established flood protection works that raises flood levels upstream and compromises the capacity of existing flood protection measures. Unfortunately, this kind of problem is quite common.⁶

It demonstrates the need for institutional arrangements and administrative procedures to coordinate project activities within flood risk zones, and in adjoining areas, and preferably with proper spatial planning at river basin scale. The arrangements and procedures should endeavor to avoid inadvertent adverse changes to flood risk (or environmental risk); or, if adverse changes are unavoidable and the case for new works is compelling, ensure that countermeasures are included in the proposed project to minimize and/or compensate for these changes to flood and environmental risk in the basin. As projects

⁶ A classic case is that of the Mississippi River in the US, noted later in this report, where early focus on engineering measures such as levees and/or dykes subsequently aggravated flood risk and prompted subsequent changes in policy and approach.

that can produce inadvertent adverse changes to flood risk are not limited to those within the water resources sector, a cross-sector approach is necessary for effective project coordination.

In advanced countries, institutions have evolved to meet these needs, although coordination is generally imperfect.⁷ In developing countries, much more must be done to transform existing institutional functions to improve cross-sector project coordination and spatially integrate flood risk management in a river basin scale with due consideration of spatial planning. This paper considers impediments and opportunities related to this objective, and it proposes a concept of flood footprint and accountability as mechanism to guide the desired change and improve the practice of IFRM. It includes a brief international review of how these issues are tackled in selected national and international jurisdictions, and uses a study in the People's Republic of China to suggest a new direction of applying the tools of flood footprint and accountability.

II. INTEGRATED WATER RESOURCES MANAGEMENT AND DISASTER RISK MANAGEMENT

Flood risk management (FRM) is a subset of integrated water resources management (IWRM) and is also a part of climate change adaptation (CCA) and disaster risk management (DRM). In practice, DRM tends to maximize efforts and investments in favor of flood risk mitigation, while IWRM tends to optimize water resources to maximize their benefits in a wide variety of sectors and subsectors. As shown in Figure 1, there is a common space where all principles under FRM, DRM, and CCA can be applied, which is called the win-win space. To maximize the use of the win-win space in FRM practice, flood and environmental risk management (FERM) was introduced with the provision that any measures under any of the nexus elements—i.e., flood, waste (environment), and ecosystem—are expected to mitigate flood risk but also to improve the water quality and help preserve ecosystem at the same time (footnote 5). However, FERM covers only the environment dimension of solutions. The problems in a river basin are more complex as many sectors interact with flood risk and vice versa—e.g., the transport sector, especially its roads and highways projects, can easily alter the flood risk situation.

As the Global Water Forum (2013) cautions, IWRM is not a prescriptive method for how water should be managed but is a general framework in which decisions can be made collaboratively regarding the goals of water management and the coordination of multiple instruments to achieve these goals.⁸ Among others, the three key goals of IWRM include (i) equitable allocation of water to competing water uses, (ii) the maintenance of water quality suited to these uses, and (iii) the conservation of water and related natural resources. FERM can affect any or all of these three IWRM goals, and so can be regarded as a subset within IWRM. Importantly, it also relies on the outcome of a strategic vision and development plan to consider compounded impacts of development on flood risk.

The United Nations Office for Disaster Risk Reduction summarizes the principles of DRM as prevention, preparedness, response, and recovery aimed at reducing risks and enhancing community resilience by means of preventive measures to modify the hazards; better planning to reduce exposure to hazards; improved preparedness and early warning to lessen vulnerability; and effective procedures for emergency response and post-disaster recovery.⁹ While IWRM supports the equitable distribution of water among

⁷ For example, the European Union (EU) has mandatory guidelines for flood risk management and environmental management: the EU Floods Directive and the EU Water Framework Directive. Both require integrated management at river basin scale.

⁸ C. White. 2013. Integrated Water Resources Management: What is it and why is it used? *Global Water Forum*. 10 June.

⁹ United Nations Office for Disaster Risk Reduction. What is Disaster Risk Reduction?

uses and users, with respect to flood disasters, DRR relates to reducing flood risks by any means that mitigate the potential impacts.

A simple conventional example is that the required water storage capacity of the reservoir for flood management (tendency to keep more empty space) and for agricultural or energy production (tendency to occupy more space) often contradict, and additional measures are usually required to optimize the benefits or address both extreme needs. Therefore, there can be conflicting objectives between IWRM and DRR practices when dealing with flood risks that often cause dilemmas for policy makers and practitioners.

As for flood management, FERM promotes nature-based solutions and is appropriate within IWRM, DRM, and integrated river basin management. FERM recognizes the flood (water)–waste (environment)–biological ecosystem nexus and synergizes the linkages that exist between flood mitigation, waste management, and ecological conservation at both local and river basin scales. Therefore, FERM provides an important connection between IWRM and DRM (footnote 5). As discussed above, FERM alone cannot solve the complex flood risk and associated problems at a river basin scale. As a step forward, the flood footprint and accountability mechanism (FFAM) has been introduced as a next level solution. FFAM is a tool to conduct a spatial planning at river basin scale, which will help establish a regulatory framework with monitoring and evaluation provisions. In this paper, FFAM will be discussed.

III. FLOOD FOOTPRINT

Flood footprint is defined as the potential impacts of floods on different sectors and vice versa. It can be classified as (i) progressive or forward flood footprint, which is the impact of floods on different sectors; (ii) reverse or backward flood footprint, which is the impact of sector developments on flood risk; and (iii) spatial flood footprint, which is the forward or backward flood footprints in spatial scales (i.e., at local, river basin, or beyond). Forward flood footprint refers to the magnitude and/or effect of a flood event not only on the physical environment (embracing both natural and built environments, and both water quantity and water quality) but also on the ecosystems, the economy, and the functioning of affected communities, including the health and well-being of members of these communities. It therefore includes physical environment, ecological, economic, and social footprints related to a flood event at both local and entire river basin scales, sometimes even extending outside the basin boundary. This multidimensional aspect of flood footprint is illustrated in Figure 2. Backward flood footprint, on the other hand, denotes the impact of these elements on the flood risk situation (Figure 3).

The schematic diagram in Figure 4 shows flood footprints in a spatial scale, importantly in a transboundary river basin, using Longxi River basin of the People's Republic of China (PRC) as example. Longxi River basin is a sub-basin of Yangtze River that covers three administrative boundaries: Liangping District in the most upstream, Dianjiang County in the middle, and Changshou District in the lower part of the river basin. As an illustration, a dam constructed in Dianjiang County could inundate the area in Liangping District. Similarly, a highway constructed in Changshou District could inundate the area in Dianjiang County. Flood control dikes constructed in Dianjiang County could protect Dianjiang from flooding but could exacerbate flooding in Changshou District. Likewise, the highway constructed in Changshou District could not only inundate the Dianjiang County but could also overshadow the investment in flood control dikes. Both backward and spatial flood footprints are visible in Figure 4.

Flood footprint can either be (i) direct, which is the direct impact of flood on sectors or the impact of sectors on flood risk, or (ii) indirect, which is the impact of flood on any sectors transferred through

Figure 2: Flood Footprint Dimensions

Source: Asian Development Bank.

Figure 3: Backward Flood Footprint

Source: Asian Development Bank.

Figure 4: Spatial Flood Footprints—A Schematic Diagram

Note: The diagram is not drawn to scale or shape, but is sketched merely for demonstration purposes.

Source: Asian Development Bank.

another sector (Figures 2 and 3). It can also be positive or negative depending on the decrease or increase in flood risk. Many flood risk management projects themselves inadvertently affect the footprint of floods, either positively or negatively, in any locality within the river basin. These projects alter how floods interact with the physical environment, ecosystems, communities, and the economy.

In some projects, changes to the flood footprint are intentional; these are flood risk management projects that aim to mitigate flood risk. In many other projects, changes to the flood footprint are secondary consequences; these are projects with primary objectives other than flood risk management that require physical interventions that inadvertently modify flood footprints. Infrastructure projects and land development projects are examples of types of projects that can inadvertently modify flood footprints. Because many governments employ a sector-based approach for infrastructure development, they often conduct flood risk mitigation activities in isolation from other sector development and without adequate spatial planning. In a short timeframe, such investments in flood management can either become far inadequate or grossly excessive.

This paper recommends that, during the development planning and individual project preparation, every proposed development project requires an assessment of the change in flood footprint, if the project is implemented. Preferably, because of potential transfer of effects of interventions upstream–downstream, left bank–right bank, etc., assessments should extend to river basin scale. A preliminary investigation will reveal whether the change in flood footprint is likely to be negligible. Otherwise, more rigorous investigation and analysis are required to determine the effects on flood footprint and their magnitudes, and measures to mitigate or compensate for these effects must then be considered during

project feasibility and design. This concept promotes the mainstreaming of flood risk management into development projects, which ensures that sector developments are protected from floods; but, at the same time, better planning and design of those sector interventions can also reduce the flood risk in the entire river basin. It also suggests that the current practice of flood risk management focusing at any particular location should be viewed from a spatial planning perspective because the ultimate flood damage in the basin induced by such local practice could surpass the damage mitigated for any specific area. In many developing countries, these provisions are not met due to the lack of enabling environment including policy guidelines, institutional framework, and technical capacity.

Preliminary investigations of flood footprints are greatly facilitated by flood hazard mapping. This shows the physical footprint of floods and can be used in a dynamic sense to examine how that physical flood footprint will change if proposed interventions are implemented. As noted elsewhere, changes in environmental, social, and economic footprints of floods are derived from changes in the physical footprint that flood hazard mapping can identify.

Programs for comprehensive flood hazard mapping are being implemented in many developed countries, particularly in Europe (e.g., France, Germany, and Sweden). In developing countries, availability of flood hazard mapping is often very limited. Typically, in developing countries, flood hazard mapping is only available where it has been undertaken as a requirement for other projects, but not for development planning purposes. The PRC is one exception, where a program for comprehensive flood hazard mapping has been initiated. Nonetheless, the objective of achieving comprehensive coverage is formidable in such a large country, and much remains to be done.

In the absence of available flood hazard maps, and if preliminary investigation indicates that a change to flood footprint by a proposed project or plan is potentially significant, flood hazard mapping would generally need to be undertaken as part of the more rigorous subsequent investigations to determine the change in flood footprint. The basic capacity of authorities, mainly the river basin organizations, on river basin modelling including flood risk mapping is essential for flood footprint analysis, together with their engagement on river basin development planning. However, very few developing countries have adopted the river basin authorities into their institutional system. It is very rare that such authorities have a mandate to coordinate the sector development in the river basins and, therefore, have decision-making power on overall river basin planning (even if such spatial planning provision exists in the development planning process).

To be practical, effective regulation of development projects is essential to support the vital linkage between flood footprint and accountability. Institutional mechanisms are necessary to ensure that assessments of change in flood footprint are included in development approval processes. Government agencies need to have the powers and resources required to monitor developments under their jurisdiction and enforce development regulations. These are difficult to accomplish, even in more advanced countries, and are much more difficult in developing countries where weak governance and limited resources pose greater constraints.

Regulation of development often falls within the mandate of local governments. Generally, the spatial boundaries of flood footprints are dominated by hydrology, and the natural units for determination of flood footprints are river basins.¹⁰ The spatial boundaries of local government jurisdictions and river

¹⁰ Economic and social effects that are part of the flood footprint of a project may not be limited to the river basin in which the project is to be implemented.

basins rarely match, which present an additional obstacle to effective coordination of development regulation at river basin scale. Around the globe, many river basin authorities have been established to address this problem of coordination at river basin scale, with varying success.

IV. FLOOD FOOTPRINT AND ITS ASSESSMENT

Although storms and floods are natural features of meteorological and hydrological regimes, they can disrupt the normal social and economic functioning of communities as well as deliver shocks to the ecological balance of the ecosystems. The capacity of ecosystems to recover may be compromised, particularly if these ecosystems are already damaged or modified either by human activities or by climate change. In the planning and preparation of development projects that modify the physical environment, proponents and managers of these projects have the responsibility to protect the flood resilience of both communities and the ecosystems.

A. Physical Flood Footprint

The footprint on the physical environment includes the effects on buildings, private property, agriculture, wetlands, public infrastructure, sediment transport and deposition, water quality, and so forth. The physical impacts of floods are very familiar because of the direct damages they cause. Structural and material damages occur to buildings such as homes, commercial and industrial premises, public buildings like schools and hospitals, farm machinery sheds, etc. Structural and functional damages can occur to public infrastructure such as bridges, roads, railways, water and wastewater treatment plants, water management and flood protection works, hydropower facilities, dams and weirs, etc. Physical change can also occur to waterway or stream morphology, as sediments are deposited in river beds or eroded from the beds or banks of waterways. Avulsions are possible, in which lasting changes in stream paths occur through floodplains or deltas. Agricultural land in floodplains may either benefit from deposition of fertile silt or be degraded by topsoil erosion. Wetlands are susceptible to similar effects. Drainage works may reduce local flooding but have potential to aggravate flooding downstream.

The physical flood footprint also covers changes to water quality during floods that may arise from project interventions. As examples, sewerage and/or drainage works, and solid waste disposal projects that deter disposal of wastes in waterways or on flood-prone riparian land, or remove instream contaminants from waterways, or improve the quality of effluents at outfalls will have a physical–chemical impact downstream. These changes will be directly linked to social and ecological effects, and may also be indirectly linked to economic flood footprint.

Clearly there is a close association between the physical flood footprint as described above, and the economic, social, and ecological footprints of a flood. The physical changes are the intermediary to the other changes of concern.

B. Ecological Flood Footprint

The ecological dimension of flood footprint refers to impacts on ecosystems due to changed flood regimes caused by project interventions. Most direct impacts occur to aquatic and riparian environments because these are most sensitive to changes in hydrological regimes—i.e., wetting and drying cycles, severity and frequency of floods (and droughts), and water quality. These environments include streams, lakes, wetlands, estuaries, and floodplains. Affected ecosystems generally extend beyond the spatial limits of these environments. There are biosystems that only partly rely upon these aquatic and

riparian environments, and partly rely on terrestrial environments not susceptible to flooding. In other words, certain species of fauna may lead parts of their lives within environments dependent on regular or irregular inundations, but other parts of their lives hunting or foraging outside these environments. The spatial limits of flood footprint on ecosystems therefore often extend beyond the spatial limits of aquatic and riparian environments.

Any change to flooding regimes caused by project interventions will cause change to aquatic and riparian environments—in the case of riparian environments, firstly by changing the species composition of the vegetation, followed by repercussions all along the food chain. In addition to being sources of food, plants provide shelter, refuge, and breeding habitat for many birds and animals. Floods cause a domino effect. The ecosystem can often bounce back from short duration flood; but, severe and prolonged flood means flora and fauna die, undermining biodiversity which many never recover. Local people may likewise be disadvantaged by changes to the natural ecosystems, particularly in rural communities that utilize natural resources for food, fiber, tools, utensils, etc. Aquatic environments are sensitive to changes in water quality and suspended sediment concentrations. Moreover, life cycles of aquatic creatures can be seriously disrupted by changes in seasonal availability of water, temperature of water releases in regulated river systems, etc.

C. Social Flood Footprint

The social dimension of flood footprint is closely associated with the economic dimension, and the combined effect is often referred to as socioeconomic. Social impacts of floods derive from the economic and physical hardships imposed when dwellings are damaged or destroyed, belongings are lost, and means of livelihood are disrupted (especially in the case of shopkeepers, farmers, or fisherfolk). Loss of life, injury, or illness caused by contaminated water or water-borne disease vectors can compound social stress and prolong hardship through loss of family income. Emotional trauma or depression may ensue.

Whereas economic damages are typically greatest in more affluent communities where the value of assets and enterprises are much higher, the greatest social impacts and personal hardships afflict the poor. Poor communities have little or no spare financial capacity to support post-flood recovery, and rely more on the government or international development agencies for support. In poorer developing countries, provincial or national governments also have limited financial capacity, or weak governance may impair or delay delivery of aid. Those least able to fend for themselves are left at greatest risk. Recovery may be extremely difficult and prolonged for those in poverty, and the recurrence of floods in high-hazard areas can impose a vicious cycle of poverty almost impossible to escape.

D. Economic Flood Footprint

The economic component of flood footprint includes the cost of direct damages to assets and infrastructure, which must be repaired or replaced—e.g., damage to or loss of buildings, private property and belongings, agricultural crops, livestock, and public infrastructure. It also includes indirect damages, which take into account losses to the economic production of goods and services, such as:

- (i) interruptions to commerce due to disruption of access and supply to premises and production facilities, forced closure for clean-up and repairs, or labor shortage due to injuries or illness caused by floods;
- (ii) reduced sales for retail and wholesale businesses resulting from temporarily depressed economic conditions and personal spending constraints within the affected community;
- (iii) disruption to supply chains;

- (iv) shortages of materials and other means of secondary production; and
- (v) ongoing costs to primary producers forced to import fodder and other production inputs.

In certain circumstances, indirect damages can cost more than direct damages.

The economic repercussions of a flood can extend well beyond the immediate region impacted. For example, remote communities in Australia¹¹ or in Mozambique¹² have historically been cut off by floods for several weeks and obliged to bring in supplies by air, a major cost to state or national finances. Roads and railways may take months to repair, and truck convoys may be forced to add hundreds of kilometers to supply routes to service affected areas. Effects can even extend beyond the provincial or national scale. After the 2011 floods in Thailand, for example, large stockpiles of new cars intended for export parked in factory yards were lost and car production facilities were badly damaged, disrupting production for months and causing major loss to export income.¹³ Factories producing computer hard drives in Thailand were badly flooded, causing serious and protracted shortages in the global supply chain.¹⁴ Losses were incurred by computer manufacturers in the Republic of Korea and Japan due to the temporary disruption of supplies from Thailand.

Economic effects of floods are also typically more persistent in areas with higher risk of flooding. Where there is greater probability of flooding, entrepreneurs are more reluctant to invest, economic conditions may stagnate, and progress may be impeded. These types of loss of opportunity should also be debited to the ledger of economic losses.

V. LINKAGE OF FLOOD FOOTPRINT AND ACCOUNTABILITY

Changes made in the flood footprint by physical infrastructure in a river basin should be duly accounted for, such as shown in Figure 4. In the schematic diagram, the highway in Changshou District is accountable for the inundation in Dianjiang County, which means the implementer (probably the Dianjiang County Government or the National Highway Authority) is accountable for the increase in flood risk in Dianjiang County. In other words, project proponents, project managers, and development regulators are all accountable for the physical, ecological, economic, and social impacts of changes made in the flood footprint both in local and river basin scales. This accountability rarely occurs in practice, including projects with primary objectives for flood risk management, or in some cross-sector projects with flood risk management explicit as one of several project objectives. Even with these projects, the gains sought in the management of flood risk can be undermined by subsequent projects that do not explicitly account for changes in flood footprint. What is required is a systematic approach that accounts for flood footprint at every stage of development in any part of the river basin, from project preparation, through feasibility and design studies, post-implementation during project monitoring and evaluation, and procedures administered by government that secure the flood risk benefits gained in a coordinated manner.

¹¹ B. Wark. 2012. Carnarvon Flood Mitigation Works. Australian National Committee on Large Dams.

¹² Southern African Research and Documentation Centre. 2000. Mozambique—Natural Disasters—Floods. *ReliefWeb*. 31 May; and World Bank. 2000. Mozambique: A Preliminary Assessment of Damage from the Flood and Cyclone Emergency of February–March 2000. 27 March.

¹³ M. Haraguchi and U. Lall. 2015. Flood Risks and Impacts: A Case Study of Thailand's Floods in 2011 and Research Questions for Supply Chain Decision Making. *International Journal of Disaster Risk Reduction*. 14 (3). pp. 256–272.

¹⁴ T. Fuller. 2011. Thailand Flooding Cripples Hard-Drive Suppliers. *The New York Times*. 6 November; and C. Johnson. 2011. Inside WD's Flooded Thai Factory. *Forbes*. 28 October.

A. Technical Foundation for Flood Footprint and Accountability Mechanism

Technical tools necessary to support the accountability for project effects on flood footprint are available. Key tools suited to this purpose include flood hazard mapping (Box 1) and flood risk mapping (Box 2).

Although coverage in most developed countries remains incomplete, flood hazard mapping and/or flood risk mapping are widely available for many river basins. In developing countries, flood hazard mapping and/or flood risk mapping are generally unavailable, and that is an obstacle to making projects readily accountable for their effect on flood footprint. In the absence of existing mapping to support accountability, it is desirable to undertake flood hazard or flood risk mapping for specific project due diligence in order to assess changes in flood footprint. This, however, can lead to inefficiency, inconsistency, and duplication of effort if, instead of mapping an entire river basin as one task, separate projects undertake mapping for different parts of the river basin.

Another technical tool to support project accountability for flood footprint is the preparation of dynamic river basin model in a geographic information system (GIS) platform. The model is interactive and can illustrate the changes in flood hazard extent and severity at any part of the river basin caused by any proposed intervention. The user can populate or draw the intervention interactively on the map, with hydraulic properties, if needed, to see such changes. Although this is a coarse screening of flood footprint, a detailed analysis may be required to trigger the accountability mechanism. This model will also develop a river basin atlas, which will serve as a river basin communication tool, particularly with policy makers.

Box 1: Flood Hazard Mapping

Flood hazard mapping is an output of technical analyses, which include (i) flood frequency analysis, to estimate the probabilities of floods exceeding nominated flow thresholds; and (ii) hydraulic model analysis, to determine the spatial extents of inundation for floods of different magnitudes (design floods or planning floods).^a Flood hazard mapping can also be conducted to evaluate the physical flood footprint of any sector interventions in any part of the river basin, for which a dynamic river basin flood hazard modelling is required.

Hydraulic model analysis requires information on surface elevations and surface cover (land use and vegetation), especially in floodplains. Data on surface cover is readily available from satellite remote sensing, although limited ground-truthing may be necessary. To date, the accuracy of surface elevations available from satellite remote sensing is not always adequate for the reliable creation of Digital Elevation Models (DEMs). But other methods are available, including aerial laser scanning or Laser Imaging Detection and Ranging (LIDAR)—although, these can be expensive for large areas. Undoubtedly, the accuracy available from commercially available or freely available satellite remote sensing will improve in the future and simplify the creation of DEMs. Hydrographic data, including waterway cross-sections, require field survey. Drones are transforming the way as a cheap and reliable method with the ability to create highly accurate three-dimensional models of ground surfaces using various sensor arrays.

^a Accuracy of flood frequency analysis depends on the availability and historical record lengths of data sets of rainfall and streamflow observations. Also relevant are the spatial density of observational networks, and the frequency and range of flows for which hydrographic measurements are made. Hydrographic measurements are essential for the conversion of observed stream levels to records of stream discharge. In developing countries, the data networks required are usually of poorer quality, and may be absent in certain areas. The accuracy of streamflow data may be low if programs of hydrographic measurements are poorly funded, and record lengths may be relatively short. While nothing can be done about the historical length of records, these requirements emphasize the utility and value of supporting government programs to improve data acquisition networks. These are investments that would be well repaid in the future.

Source: R. Osti. 2016. Framework, Approach and Process for Investment Road Mapping: A Tool to Bridge the Theory and Practices of Flood Risk Management. *Water Policy*. 18 (2). pp. 419–444.

Box 2: Flood Risk Mapping

Flood risk is a function of flood hazard (physical properties of flood), exposure, and vulnerability. It is usually represented by a composite index to signify the severity of risk. Flood risk mapping is an extension of flood hazard mapping. Facilitated by geographic information systems, it entails adding mapping information (or data layers) about land use, locations of buildings and other structures, access routes, etc., and can be supplemented with metadata such as building floor levels, surface elevations of roads, railways and levees, number of people in schools or hospitals, crop types and seasonal rotations, and any other details that may be useful during emergency response or for estimating potential or actual flood damages and risk. These information overlays allow evaluation of the exposure of assets and people to flood hazard during floods of varying probabilities of exceedance. Hazard and exposure are two of the three key elements of flood risk, the third being vulnerability. Vulnerability is less suited to spatial mapping, as it depends on human responses and actions before, during, and after floods with potential to reduce damage to property and assets, and minimize danger to human life. The details of risk mapping methodologies are available from different sources.

Source: R. Osti. 2016. Framework, Approach and Process for Investment Road Mapping: A Tool to Bridge the Theory and Practices of Flood Risk Management. *Water Policy*. 18 (2). pp. 419–444.

In order to make the flood footprint and accountability mechanism (FFAM) effective, the preparation of river basin management plans, including the preparation of flood risk management plans (FRMPs) at a river basin scale, with due consideration of spatial planning and flood footprint, is highly recommended. While the overall flood footprint in the basin also depends on other sector and subsector plans, the FRMP can serve as baseline to mitigate the existing flood risk at an acceptable level. River basins are the natural spatial units for integration of hydrological processes, including floods. The flood footprint extends throughout a river basin, and any change in flood footprint caused by project interventions is not restricted to the immediate site of a project. Hydrological change in flood levels and extents can occur longitudinally well downstream and for more limited distances upstream; or can occur laterally, affecting the opposite bank and floodplain of a river or stream. Other induced changes (economic, social, and ecological) can occur over a wider area. Generally, the main impacts of other induced changes in flood footprint occur within the project's river basin; although, there are exceptions. In any case, the river basin is the most logical spatial unit in which to conduct integrated flood risk management planning. The desired management framework extends beyond the scope of single projects to development of a risk management strategy at river basin scale. Many developing countries lack technical expertise to run the hydrological or GIS-based models; hence, they will need capacity building to establish a functional FFAM.

A structured approach is recommended for the preparation of FRMPs at river basin scale.¹⁵ The structured methodology (Figure 5 and Table 1) requires a sequence of steps, beginning with a definition of objectives, and delivers an agreed plan for flood risk management that integrates measures to manage flood risk in the river basin and secure the benefits derived for future generations. Of course, the preparation of FRMP at river basin scale is just a prerequisite, which provides a strategic vision for the river basin and the foundation for implementation of an associated, coordinated investment plan. It is a means to the end of a properly integrated and coordinated development.

¹⁵ Y. Kobayashi and J. W. Porter. 2012. *Flood Risk Management in the People's Republic of China: Learning to Live with Flood Risk*. Manila: ADB.

Figure 5: Structured Planning Methodology for Flood Risk Management

Source: Adapted from Y. Kobayashi and J. W. Porter. 2012. *Flood Risk Management in the People's Republic of China: Learning to Live with Flood Risk*. Manila: Asian Development Bank. p. 49.

Table 1: Structured Approach for the Development of Flood Risk Management Plans

Step	Description
1. Definition of objectives	<ul style="list-style-type: none"> Define management objectives clearly, specify intended outcomes, and maintain a clear vision of the management plan objectives throughout the planning process.
2. Understanding the planning context	<ul style="list-style-type: none"> Review existing planning framework within which the flood risk management plan must operate, particularly other spatial planning instruments used in government administration. The planning context is characterized in terms of (i) land use and activities in the river basin; (ii) population, its distribution, and characteristics; (iii) public infrastructure and assets; (iv) access and evacuation routes; (v) locations of essential services such as telecommunications and utilities (i.e., water supply, sewerage, gas, electricity); and (vi) other aspects that distinguish the community and its exposure and vulnerability to flood risk. This preliminary stage typically requires data gathering and review processes.
3. Identification and quantification of flood risk	<ul style="list-style-type: none"> Analyze the nature and spatial extent of flood hazard, the exposure of people and assets to the flood hazard, and characterize their vulnerability. Hazard and exposure can be analyzed by using technical tools—e.g., flood frequency analysis, hydraulic modeling of flood flows, geographic information systems for display and spatial analysis, and hydrological rainfall–runoff modeling of floods. Vulnerability may be characterized by identifying sectors of the population less capable of fending for themselves (e.g., children, the elderly, and infirm), and the locations of essential facilities for social and economic functions of the community (e.g., schools, hospitals, water treatment and wastewater treatment plants, electrical substations and power plants, telecommunications exchanges, and other utilities). It is also important to assess existing infrastructure (e.g., access routes, flood prevention works, etc.) and capacity (e.g., flood warning services, warning times available for emergency response, existing plans for flood emergency response and recovery, governance constraints, community awareness of flood risk, etc.).
4. Assessment of alternative risk management options	<ul style="list-style-type: none"> Alternative ways of managing the identified flood risk should be considered. Each option will likely be a combination or portfolio of management measures—structural and nonstructural. Several options should be assessed with respect to their social, environmental, and economic impacts; implications; and benefits. In addition to existing flood risk, options are assessed in relation to future risk and acceptability of residual risk. Future risk considers additional risk due to future growth of population and development, plus the likely effect of future climate change due to global warming. Residual risk is the risk remaining after proposed flood risk management measures have been implemented. The same technical tools used in the identification and quantification of existing flood risk are applied in the assessment of alternative risk management options.
5. Appraisal of impacts	<ul style="list-style-type: none"> For each risk management option identified, economic benefits are quantified, and social and environmental impacts are evaluated. Social and environmental benefits and costs can be difficult to quantify, especially intangible benefits such as improved public health, business confidence for future investments, and ecological sustainability.

continued on next page

Table 1 *continued*

Step	Description
	<ul style="list-style-type: none"> • Cost-benefit analysis and determination of other measures of economic returns are always an important part of the appraisals, but are not the sole indicators of project merit. • Adverse environmental consequences should be minimized, or compensating counter-measures included. • Flood mitigation measures that work with nature rather than against nature (called “green” risk management measures) are preferred—e.g., recovery of floodplain storage and retention of wetlands.^a
6. Recommendation of a preferred option	<ul style="list-style-type: none"> • The preferred option arising from the appraisal stage is reviewed in more detail and refined before documentation as the recommended flood risk management plan (FRMP). • Assumptions necessary during the appraisal stage should be examined, and implications for robustness and resilience of the proposed plan to uncertainties in assumptions and estimates should be carefully considered. • Additional research may be required. • Least-cost alternatives for implementing structural measures should be compared, with inclusion of both capital expenditure and recurrent expenditure (for monitoring, maintenance, and future post-flood repairs and restitution).
7. Participation by stakeholders	<ul style="list-style-type: none"> • Consultation with stakeholders is essential throughout the process of FRMP development. • Stakeholders are all those with an interest in the outcomes and those that may be affected by the FRMP implementation, and include private, government, and commercial interests. • The affected community should be kept informed and provided with adequate opportunity for engagement. • Government agencies with relevant planning roles or responsibilities should actively participate in the planning process, and other agencies whose operations or activities may be affected by the implementation of the FRMP should be informed at appropriate milestones during its development. • A program for consultation should be prepared at the outset of the planning process and used to guide formulation of the FRMP.

^a R. Osti. 2016. Framework, Approach and Process for Investment Road Mapping: A Tool to Bridge the Theory and Practices of Flood Risk Management. *Water Policy*. 18 (2). pp. 419–444.

Source: Y. Kobayashi and J. W. Porter. 2012. *Flood Risk Management in the People's Republic of China: Learning to Live with Flood Risk*. Manila: Asian Development Bank.

B. Enabling Environment to Assure Accountability

While the technical tools for determining flood footprint are currently available given adequate resources, the main challenge in the future is assuring accountability. This is an institutional and administrative challenge and requires effective regulation of development projects to account for any change in flood footprint.

As already noted, the best spatial scale to account for flood footprint is at river basin scale. One obstacle to a more effective linkage of flood footprint and accountability is that the administrative institutions

of government rarely function at river basin scale. Instead, they function at scales determined by jurisdictional boundaries, which may include only parts of river basins, or may contain multiple river basins. This problem of spatial overlap is not insurmountable but, in practice, it does make assuring accountability much more difficult. Multiple jurisdictions often have differing planning and development priorities, and securing the necessary accommodation or compromise to achieve a unified approach at river basin scale depends on a common will to cooperate, or failing that, the exercise of authority at a higher level to compel cooperation.

There is also a problem of administrative overlap. Within their areas of jurisdiction, governments divide administrative responsibilities between multiple institutions or organizations (line agencies) by providing quite specific mandates, which fragments responsibility, and too often reduces flexibility and produces a silo mentality that inhibits straying beyond specified limits of their mandate or partnering effectively with other agencies to better manage cross-sector issues.¹⁶ Because flood risk may be altered by the roles of multiple government sectors or by cross-sector developments, it is ineffective to view the flood risk management problem in isolation or simply as a part of water resources management.

Some of the challenges and solutions encountered in the course of putting the integrated water resources management (IWRM) concept into practice in many countries are relevant here. The most common and widely discussed challenge is the lack of appropriate institutions with appropriate mandates, especially at a river basin scale. Generalizing IWRM implementation guidelines may be difficult as every basin is unique and the most appropriate mechanisms to apply IWRM at a river basin scale may differ from one basin to another. However, other issues in the application of IWRM in river basins have arisen from difficulties in the integration of policies in multiple government sectors, or even differences in approach and policy between water subsectors, administrative units, levels of organization and management functions, and geographic divisions of responsibility.

Local governments are sometimes reluctant to cooperate with river basin authorities as the latter may not make decisions in the interests and according to the priorities of local governments. River basin authorities plan and implement water projects of larger scope, whereas local governments plan and implement more local projects within the basin. On many occasions, accountability is poor as there is no mechanism for monitoring and evaluation of overall impacts of these uncoordinated interventions on flood risk in the river basin, especially for cross-sector projects. Although it is difficult to consider small-scale interventions in a wider river basin management plan, these could be mainstreamed through local development planning and appropriate screening procedures.

In many countries, the regulation of development projects occurs through official development approval procedures. These procedures are often a role of local governments (e.g., as in Australia, Canada, and the United Kingdom); but, if given the mandate, this role may be assumed by higher tiers of government, including river basin authorities, for major projects or for projects that overlap local government boundaries (e.g., as in the Mississippi River basin, the PRC, etc.). Development approval procedures are not required everywhere to account for changes in flood footprint (or flood risk). Where this is required, mostly on an ad hoc basis, responsible government agencies will generally be able to refer to an existing FRMP or existing flood mapping (flood hazard mapping or flood risk mapping); or may refer the development application to a separate agency for specialized consideration (such as an agency responsible for water resources management or a river basin management organization that has a role in

¹⁶ Flood footprint is relevant to many sectors of government administration. These include water resources management, water quality and public health, environment, agriculture, land use management, transport, fisheries and forestry, regional development, etc.

flood risk management). The referral with respect to flood impact of a proposed development is greatly facilitated if an FRMP, or at least a flood mapping capacity in a river basin scale, is available.

In developing countries, lack of availability of these technical products and capacities is generally the main reason why development projects are poorly coordinated and the linkage between flood footprint and accountability is broken. If these technical capacities do not already exist, significant effort is required to develop them and, in the context of individual projects, that is a major deterrent to good management practice. Local flood hazard maps are sometimes available (e.g., when produced for past projects), but are then often unsuitable to determine the upstream or downstream effects of any proposed project at regional or river basin scales. Importantly, for purposes of flood footprint and accountability mechanism (FFAM), hazard mapping should be dynamic, allowing the insertion or removal of proposed interventions to determine their impacts on the flood footprint. Whenever proposals are implemented, such maps need to be updated.

In certain countries, the linkage between flood footprint and accountability fails even where appropriate technical products are already present (either an FRMP or flood mapping). It can fail because there is no requirement for that linkage to development approval processes—in other words, no accountability. This is a crucial policy failure. This deficiency should be recognized by governments, which should be encouraged to remedy it by changes to policy or amendment to legislation, if necessary.

In the FFAM, a bottom-to-top approach is preferable that facilitates stakeholder participation. The key issue is not whether the projects are implemented by a basin authority or by local governments, but more how the overall development plans are formulated and how these will be implemented in terms of their impacts on existing flood risk in the entire river basin. The accountability mechanism requires harmonizing and synergizing different development proposals at different levels to mitigate the flood risk not just at the locality or project site but at the wider river basin scale. If there is any plan that negatively impacts the flood risk, either at the project site or elsewhere in the river basin, then there should be a mechanism to identify that and amend the proposal. If amendment is not a possibility, then the planner should find compensating elements that neutralize the negative impacts, which can be in the form of social, infrastructure, or financial compensation. Social compensation could mean reallocating affected people and securing their livelihood. Infrastructure compensation refers to the counterpart infrastructure for mitigating the negative impacts. Financial compensation involves cash to compensate possible losses—this is similar to the eco-compensation mechanism being practiced for environment and ecosystem protection.¹⁷

FFAM, therefore, requires an institutional capacity to monitor the flood footprint in the basin and help harmonize and synergize the local and basin-wide development plans, facilitate coordination between upstream and downstream administrative jurisdictions, engage all affected stakeholders, and provide strategic and technical guidance as needed. In other words, there is a need for institutional oversight—that could be a mandated role for a river basin authority. The accountability would be

¹⁷ Eco-compensation covers a range of different financial mechanisms and policy instruments, including transfer payments, monetary subsidies, project support, and other public or private sector measures, that adjust the relative benefits and costs of ecological service provision among key stakeholders. It is used to compensate those who invest money or suffer from economic losses when protecting the environment or restoring the ecosystems. (Definition taken from Q. Zhang and M. Bennett. 2011. *Eco-compensation for Watershed Services in the People's Republic of China*. Manila: ADB; and ADB and China Eco-compensation Policy Research Center. 2017–2018. International Conference on Eco-Compensation and Payments for Ecosystem Services. Agenda Background to the 6th conference [Chongqing, PRC, 8–9 December 2017] and the 7th conference [Anhui, PRC, 3–4 December 2018].)

effective with enforcement of statutory provisions under appropriate legislation, such as a water law or an environmental law, that relate to measures and resources used for flood and environmental risk management including rights, powers, duties, and obligations of regulatory bodies, agencies, organizations, and officials who are tasked with the necessary roles and responsibilities. This could require amendment to current legislation. There are also questions regarding who should be given the responsibility (and the means) of preparing FRMPs and/or flood risk mapping; and of how other government agencies can be obliged to comply with coordination requirements.

However, these are less technical problems than a problem of policy and allocation of resources. Yet, policy alone is insufficient to ensure proper linkage of flood footprint and accountability. Even with appropriate policy in place, political will and commitment by managers within government civil service are necessary to realize the policy intentions. Political will is necessary because this objective will inevitably be just one of numerous competing priorities of government, and it will atrophy without the sustained political support within government. It may need support through legislative amendments. In addition to political will at government level, enactment of policy measures will rely on commitment by capable senior civil servants. Organizational structures may need to be modified, or new procedures may need to be introduced, and these adjustments will need adequate resources to be implemented.

A recommended approach is to establish FFAM in which an independent regulatory body is required to coordinate the planning process and effectively engage stakeholders. A river basin authority can perform this function as long as they are mandated to do so, and as long as there is no conflict of interest on development budget allocation (Figure 6). In the PRC, the river chief system has recently been introduced that can be adapted to embrace the FFAM. This is being piloted under an Asian Development Bank (ADB)-financed project in Chongqing Municipality in the PRC (section VI-B).

Figure 6: Flood Footprint and Accountability Mechanism Framework

DP = development plan, FFA= flood footprint audit.

Source: Asian Development Bank.

There are essentially three basic organizational models for the administrative means to introduce changes that are essential to link flood footprint and accountability, as outlined in Table 2.

Whichever model is adopted to link flood footprint and accountability, adequate powers to enforce compliance are essential. That is unlikely to happen unless consultation has taken place in advance with key stakeholders (in this case, other government bodies) for good understanding to emerge about joint obligations and how they will cooperate under the proposed model. As issues will inevitably arise when interests are not fully aligned, a right of appeal needs to be provided against disputed decisions, and conciliation procedures agreed to amicably resolve differences before resorting to arbitration by higher authority.

Table 2: Alternative Organizational Models for Flood Footprint and Accountability Mechanism

Model	Remarks
1. Assign new duties to staff within the existing organizational structure of an existing government department or agency	<ul style="list-style-type: none"> • Simplest model to implement, but has the greatest risk of failure. • New duties will be in addition to existing duties; hence, as a minimum, this model requires additional resources: <ul style="list-style-type: none"> (i) extra staff to cope with an increased workload, and (ii) extra funding to accommodate the new role within existing department and/or agency programs. • Without guaranteed adequate additional resources, this model has little chance of success. • Demands management commitment, with senior staff prepared to take ownership of the process and make the effort to see it through until it is self-sustaining.
2. Modify organizational structure within an existing government department or agency	<ul style="list-style-type: none"> • Creating a new section or group to undertake the new duties demonstrates firmer commitment to achieve effective outcomes. • Attention necessary to ensure activities of the new section or group are well integrated within the organizational structure, not just an add-on or appendage to the old framework. • Adding a role to any existing organization to oversee the development planning of all local governments could generate conflict of interest, especially regarding allocation of resources. • Where jurisdiction over a river basin is shared with other jurisdictions at the same tier of government, having a special unit dedicated to project accountability and approval is more likely to achieve effective coordination.
3. Establish a new institution at river basin scale	<ul style="list-style-type: none"> • A river basin organization (RBO) could not be justified for ensuring accountability for project effects on flood footprint alone, and would serve to administer project activities with respect to other management issues requiring coordination at river basin scale. • It would typically be concerned with integration of water resources management and/or natural resources management throughout a river basin to ensure uniform approach and compliance with other plans (such as environmental management plans, water resources management plans, land use plans, etc.).

continued on next page

Table 2 *continued*

Model	Remarks
	<ul style="list-style-type: none"> • Establishment of a new RBO demonstrates a major government commitment to integrated management. • A formal agreement between governments or government agencies is often a prerequisite to determine how funding and other resources will be shared. • This model is the most difficult to implement; but, provided sufficient powers are conferred to ensure compliance, it has the greatest chance of success. The joint commitment required to forge a formal agreement provides a sound basis for sustained cooperation and sharing of responsibilities. • Creating a new body introduces a new layer of administration with potential to complicate and delay approval processes, which could be an impediment to desirable development. • Clear definition and division of responsibilities are essential for effective cooperation.

Source: Asian Development Bank.

C. Implementing a Flood Footprint and Accountability Mechanism by the River Basin Organization

This paper does not advocate any single model for linking FFAM. The appropriate choice will depend upon specific circumstances, and the most appropriate may be any one of the generalized models noted above. However, because river basin organizations (RBOs) are a good model well suited to this purpose, information is included here about some leading RBOs that are currently functioning. An international organization called the International Network of Basin Organizations, based in Paris, facilitates exchange of information between and about RBOs, and it has identified that there are literally hundreds of functioning RBOs in the world.¹⁸ The roles and institutional arrangements of RBOs vary considerably, but none of these RBOs has a required mandate to justify the FFAM. However, the most important aspect in making use of any institution to serve the FFAM is whether such agency (i) has technical capacities to perform dynamic flood risk management and can model any development change in the river basin to evaluate the impact on flood risk management scenarios in the entire river basin; and (ii) has a mandate to coordinate the development plans (and ideally make decisions), including water and other sector development plans, in the entire river basin that may have implications on flood footprint and, therefore, has authority to enforce the accountability mechanism.

One of the earliest RBOs was the Mississippi River Commission, established by the US government in 1879. Initially, its main purpose was to look after the river to maintain navigation and promote commerce. But after a major flood in 1927, flood protection became a key role. The US Army Corps of Engineers represents the federal government on the river commission and was given the task of preparing and implementing a comprehensive flood protection plan and undertaking necessary works for flood protection and stabilization of the waterway. Towards the end of the 20th century, greater attention has been directed to integration of measures (including nonstructural as well as structural flood risk reduction measures) and to environmental conservation. The Mississippi River Commission has seven members appointed by the US President, four appointed from government (including three from the

¹⁸ International Network of Basin Organizations.

US Army Corps of Engineers), and three other civilians that should include two civil engineers. It is not strictly an RBO because traditionally its activities have not extended to the upper parts of the river basin and are focused on the main stem of the Mississippi River and its floodplains. Although the chair of the commission has ultimate responsibility for decisions, regular public consultations take place to engage a broad range of stakeholders. Because the commission is an instrument of the federal government, it generally has sufficient power and influence to oblige compliance with its directives.

In France, legislation in 1964 led to the establishment of six river basin committees (RBCs) that covered the entire territory of metropolitan France¹⁹ plus the island of Corsica.²⁰ The responsibility of RBCs is generally water resources management, with greatest emphasis initially on water supply, water quality, and the environment; but, flood management also falls clearly within the RBC's mandate. They are required to prepare and implement water resources master plans, which include flood risk management measures. At sub-basin level, there are local commissions to prepare and act on water resource plans that implement provisions of the basin master plan. The legislation allows the RBCs to levy bulk water charges on water consumers and polluters, which finance implementation of works consistent with the plans. Execution of required works is generally contracted to third parties, which may include municipalities, local water supply and sewerage boards, private contractors, etc. The administrative board of the RBC is a small group of appointed or elected administrators and specialists, which heads a water agency that employs adequate staff to undertake planning, management, and administration. The function of the RBC is made more inclusive by convening large meetings (or sometimes referred to as “water parliaments”) at regular intervals with delegates from local authorities (40%), the national government (20%), and community members (40%) representing consumers, farmers, industries, and nongovernment organizations. At the national level, supervision of RBC activities is designated to the National Water Committee under the environment ministry (i.e., the Ministry of Ecology, Sustainable Development and Energy).

The International Commission for the Protection of the Rhine (ICPR) was established in 1950 to secure unified action by key riparian countries to address serious degradation of water quality in the Rhine River.²¹ The original five participating countries were France, Germany, Luxembourg, the Netherlands, and Switzerland. Their joint action and regulation succeeded in greatly improving water quality in the following decades. After the major floods in 1993 and 1995, ICPR was given the responsibility to prepare a flood action plan; and, under the 1999 Convention on the Protection of the Rhine, flood risk management was enshrined as part of an expanded mandate for integrated water resources management (IWRM) in the river basin, with emphasis on sustainable development, alluvial areas (floodplains), water quality, and ecology. The number of participating countries was increased to nine with the inclusion of Austria, Belgium, Italy, and Liechtenstein. A standing coordinating committee directs the implementation of management plans, with an annual plenary session attended by delegates from member countries. As occasion demands, a Conference of Rhine Ministers may be convened to agree on important political matters. In addition to the coordinating committee and its support staff,

¹⁹ Government of the French Republic; Ministry of Ecology, Sustainable Development and Energy (MEDDE). 2015. *French River Basin Committees: Governance and Participatory Implementation of Water Policy*. Information Leaflet. Paris: Ministère de l'Écologie du Développement Durable et de l'Énergie; and J. F. Donzier. 2013. *Best Practices from European and French River Basin Management: High Points of French Water Cooperation in Asia*. Paper presented at the Asia–Europe Meeting (ASEM) Seminar on Water and River Basin Management: A Green Growth Approach. Van Phat Hotel, Can Tho City, Viet Nam. 20–22 March.

²⁰ Corsica now has its own RBC, and the model has been extended to five river basins in French overseas territories.

²¹ International Commission for the Protection of the Rhine (Internationale Kommission zum Schutz des Rheins).

special purpose working groups address key issues, including one for the management of flood and low water. All participating countries contribute to operational costs.

Arising from the Danube River Protection Convention agreed in 1994, the International Commission for the Protection of the Danube River was established in 1998, with a small permanent secretariat to develop and implement a river basin management plan for IWRM.²² There are 14 contributing countries, plus the European Union, making it the largest multinational RBO in the world. Another four countries in the river basin have observer status. Representatives from member countries meet twice a year to coordinate plans and review progress. Seven standing expert groups guide the development of planning measures, including one expert group for flood risk management. Expert groups meet two or three times per year, and may establish task groups to address more specific issues. A flood action plan, or Action Plan for Sustainable Flood Protection in the Danube River, was prepared in 2004; and, in 2016, the Danube Flood Risk Management Plan received ministerial endorsement by member countries. Sub-basin flood action plans are prepared to coordinate and implement flood risk management measures at sub-basin scale. In multinational sub-basins, such as the Tisza and Sava, action plans are developed and coordinated by working groups or forums of specialists drawn from the nations with territory within the sub-basin boundaries.

In Indonesia, river basin management units with hydrologically defined boundaries (river basin units) were established in the 1990s followed by a stronger IWRM-supportive Law on Water Resources (July 2004). The law mandated these river basin authorities to prepare framework or strategic plan (*Pola*) and master plan (*Rencana*) for the basin of their responsibility.²³ These strategies and plans substantially cover conservation, utilization, and water safety, as well as data management and public participation. The coordination role with other sectors is assigned to a higher level authority, mainly the Basin Water Resources Management Council, at national and provincial levels. The council does not have technical capacity, but it oversees and endorses the strategy and plans more from the resources allocations and priority perspectives, with little or no engagement with basin authorities. In fact, both strategy and plan documents comprise the long- and short-listed planned water projects in the basin—meaning, the list is prepared based on the needs and the demand of the water sector but not necessarily the other sectors, which might have impact on the basin’s water including flood footprint. River basin authorities are mainly the technical entity or project implementation body; hence, they play a minimal role in the overall coordination and management of water resources. They also have no authority to influence the development plan of other sectors in the same river basin. The institutional and governance structures in Indonesia are more favorable to implement FFAM. Although Indonesia’s 2004 water law favored the IWRM in the river basin, the Indonesia’s Constitutional Court, on 18 February 2015, revoked the 2004 Law on Water Resources. The court reinstated the previous 1974 water law as the controlling legislation until a new measure is adopted.

In Southeast Asia, the Mekong River Commission (MRC) was established in 1995 by four foundation member countries: Cambodia, Lao People’s Democratic Republic, Thailand, and Viet Nam.²⁴ It is an important body for consultation and joint planning of the shared water resources of the lower Mekong River, based on IWRM principles. A council consisting of national ministers responsible for water resources management meets annually. Their joint decisions are implemented through a joint committee consisting of senior civil servants (department heads) who meet twice per year. A large secretariat

²² International Commission for the Protection of the Danube River (Internationale Kommission zum Schutz der Donau).

²³ ADB. 2016. *River Basin Management Planning in Indonesia: Policy and Practice*. Manila.

²⁴ A Mekong River committee was set up under the United Nations auspices as early as 1957, but has since been superseded.

undertakes technical and administrative functions. Technical studies carried out by the secretariat have greatly advanced understanding of the hydrology and environment of the river basin and provided sound scientific underpinning of management and development planning. Upstream states, i.e., Myanmar and the PRC, have observer status (“dialogue partners” in MRC parlance). Development in Myanmar has had little effect on the downstream states; and, although substantial development has taken place with little consultation in the PRC, cooperation and exchange of data and information have improved over the years. Initially, funding of MRC activities depended heavily on external donor governments (“development partners” in MRC parlance). The council has agreed to phase out external funding and become self-sufficient by 2030. Accordingly, the Secretariat is downsizing and its future activities may become more restricted.

River basin commissions (or water resources commissions) also operate in seven major river basins in the PRC.²⁵ These commissions are part of the organizational structure of the Ministry of Water Resources (MWR). Their role is closely matched to that of MWR and its subsidiary agency, the Flood Control and Drought Relief Headquarters, which includes coordination of water storage and regulation, water allocation, and flood management—i.e., issues relating to quantitative water resources management. Management of water quality and environmental conservation are responsibilities of other ministries and, therefore, do not come within the ambit of the river basin commission’s role. The system of management is not conducive to stakeholder participation in planning. For example, even though provincial government agencies are consulted and are expected to comply with the directives of a river basin commission, they have no direct representation in the commission. Management jurisdiction of a river basin commission in the PRC is not truly basin wide and is largely confined to the main waterways and lakes, not extending beyond the strip between river dikes on major rivers. In the case of the Yangtze River, provincial governments have usually failed to comply with guidelines of the Changjiang (Yangtze River) Water Resources Commission; hence, its effectiveness in coordinating river management has consequently declined.

The Drainage Services Department and the Environmental Protection Department of Hong Kong, China have imposed mandatory drainage and sewerage impact assessments for all development activities under both private and public investments.²⁶ This is to acknowledge that the urban environment is sensitive to land use changes, particularly with respect to urban flooding and water quality. These impact assessments include the formulation of proposed system and improvement measures aimed at minimizing the impact on total drainage system and downstream sewerage system in the city area. They are usually conducted under the current and future scenarios, including in coordination with the existing drainage or sewerage master plans. The authority-issued technical circulars outline the objectives and study scope of the impact assessments together with the technical guidelines. Although the approach is technical and yet to be developed to incorporate the dynamic changes of urban environment into a single set of impact assessment model and maintain the consistency in utilizing the technical tools for impact assessment, it is effective in maintaining the development quality of highly urbanized cities like Hong Kong, China.

The aforementioned cases are the advanced practices that satisfy the IWRM principles. These cases have attempted to improve water resources management at river basin scales through institutional,

²⁵ These seven river basins are Hai, Huai, Pearl (or Zhujiang), Songliao, Taihu (or Tai Lake), Yangtze (or Changjiang), and Yellow (or Huang).

²⁶ Government of the Hong Kong Special Administrative Region of the People’s Republic of China, Drainage Services Department; and Government of the Hong Kong Special Administrative Region of the People’s Republic of China, Environmental Protection Department.

financial, and technical reforms. However, individual subsectors like flood management are still viewed unilaterally with little interaction with other subsectors or sector developments that might have serious implications on that particular subsector, such as flood footprint or vice versa, in the river basin. These practices can be modified and upscaled to achieve the goal of FFAM in a river basin.

VI. SMALL WATERSHED TRIAL STUDY: LONGXI RIVER, PEOPLE'S REPUBLIC OF CHINA

Improvements to environmental and water resources management are strongly advocated by the PRC government as espoused in the Thirteenth Five-Year Plan, 2016–2020 and as promoted by the river chief system decreed by PRC's Central Committee and State Council in 2016.²⁷ Consistent with these directives and the selection of the Longxi River as one of the 16 national priority pilot projects for river basin water environment and sustainable development, the Chongqing Municipal Government formulated an ecological and restoration master plan 2030 for the Longxi River, and enlisted the Asian Development Bank (ADB) to assist in meeting the challenges with its innovative management approach. ADB introduced the flood and environmental risk management (FERM) approach for the basin, and proposed flood footprint and accountability mechanism (FFAM) to be adopted under the ADB-financed Chongqing Longxi River Basin Integrated Flood and Environmental Risk Management Project for the effective implementation of FERM.²⁸

A. Flood Management in the People's Republic of China

Flood disasters are becoming more frequent and damaging globally due to increased hazard, exposure, and vulnerability associated with both natural and human-induced causes, including climate change. In the People's Republic of China (PRC), the economic damage due to flood disasters has increased significantly in recent years. In 2016, the PRC suffered CNY365 billion (\$51.5 billion) flood damage, 60% of which was reported in the Yangtze River basin alone.²⁹ Flood damages were reported at over CNY214 billion (\$30.2 billion) in 2017 and CNY161 billion (\$22.7 billion) in 2018.³⁰ As of 11 July 2019, the provinces of Fujian, Guangdong, Guizhou, Hunan, Jiangxi, Sichuan, and Zhejiang and the autonomous regions of Guangxi Zhuang and Xinjiang Uygur have suffered the most disastrous floods of the year, which has already resulted in CNY54 billion (\$7.6 billion) direct economic damage (footnote 30).

The PRC government has long been relying on traditional approach to control flood through structural measures (e.g., dams, dykes, flood detention areas, flood diversion channels, etc.), which is no longer practical and economically feasible. Realizing that structural measures alone are not sufficient to reduce the impact of flood, the PRC government has now adopted an integrated flood risk management principles into its flood management practices. The worsening flood impact is associated with rapidly changing social, hydrometeorological, and environmental conditions along the nation's major waterways; therefore, it is important to invest in flood early warning system, flood plain management, soil and water conservation, ecosystem services maintenance, etc.

²⁷ Y. Xu. 2017. China's River Chiefs: Who Are They? *China Water Risk*. 17 October.

²⁸ ADB. People's Republic of China: Chongqing Longxi River Basin Integrated Flood and Environmental Risk Management Project.

²⁹ China Institute of Water Resources and Hydropower Research. 2016. *Flood and Drought Disaster in China*. Annual Bulletin. Beijing: IWHR.

³⁰ China Institute of Water Resources and Hydropower Research. Various years (2017, 2018, and 2019). *Flood and Drought Disaster in China*. Annual Bulletin. Beijing: IWHR.

Policy and legal framework. The government passed the Flood Control Law in 1997. After the massive economic loss sustained from the 1998 flood in the Yangtze River basin, the government issued the 32-word policy statement on flood management.³¹ Since then, the government has placed significant investments in land use management and soil and water conservation in the upper watersheds, with afforestation programs and programs to raise public awareness and to modify behavior in agriculture communities. In 2002, the National People's Congress revised the 1988 China Water Law and adopted the 2002 China Water Law covering integrated water resources management (IWRM), water conservation, water resources planning, ecological and environmental protection and restoration, and integrated flood risk management. Along with these changes, the PRC government has shifted flood management practices from dependence on structural measures to a balanced approach using both structural and nonstructural measures. While the government is changing its course of flood management practice, water governance in the PRC is not meeting the rapidly changing sector, institutional, and policy environments. Hence, it is increasingly facing a challenge with more complicated problems and more ambitious goals, resulting in poor applications of flood risk management principles into practices.

Institutional arrangements. In the PRC, major institutional reform took place in 2018, which is not so much related to water resources, in general, but rather to water and environmental quality. The newly formed Ministry of Ecology and Environment has clear mandate to curb pollution and help prevent systemic destruction of the ecosystem, in which water plays a significant role. However, the new Ministry of Ecology and Environment needs to collaborate with other ministries to meet its mandates as the water pollution becomes a complex and multidisciplinary task. In the absence of proper coordination, institutional weakness in flood risk management in the PRC will remain as the mandate is distributed over several ministries including the MWR, Ministry of Ecology and Environment, Ministry of Natural Resources, Ministry of Agriculture and Rural Affairs, Ministry of Emergency Management, and others. The mandate of river basin commissions, which serve as coordination body in the river basin's water sector, needs to be reinforced to (i) enhance the coordination mechanism among administrative boundaries and line agencies under the new institutional setup, and (ii) avoid any potential fragmentation with individual sub-basins within the basin. While the institutional mandates and policy may affect the progress of flood risk management, the coordination, communication, and consensus-building among key stakeholders, including central and local governments, would be vital to support the application of flood risk management processes in the PRC. The coordination problem between overlapping institutions, the ongoing advocacy by public officials for gray infrastructure (i.e., structural measures), and the lack of ability to hold local officials accountable for implementing national policies will pose further challenges in the realization of flood risk management. In 2016, the China State Council released a document that set out an ambitious national plan for the river chief policy, aiming for full implementation by 2018. The river chief system may help promote coordination and integrated approach of flood risk management, but the system itself is yet to be fully developed and functional.

³¹ This policy statement, which consists of 32 Chinese characters, was issued in quick response to the 1998 floods. It covers eight directives: (i) protect the mountains to plant trees, (ii) return arable land to forests, (iii) demolish polders to release floods, (iv) transform farmland into lakes, (v) contribute to labor supply, (vi) relocate people in new townships, (vii) reinforce levees of main stem rivers, and (viii) dredge river channels and lakes. (H. Wan. 2003. *Policies and Measures on Flood Mitigation in China since 1998*. Paper prepared for the International Conference on Total Disaster Risk Management. Kobe, Hyogo, Japan. 2–4 December.)

B. The River Chief System

This new system promotes green development in the PRC and introduces more specific accountability for control over water pollution, environmental protection, and management of water resources. It is the central government's response to the country's declining environmental conditions and water quality. Its origins lie in the notable water quality incident in Lake Tai in 2007, which threatened water supply for the city of Wuxi in Jiangsu Province. The city administration was able to improve lake water quality by assigning responsibility to local officials and party members to take immediate action.³² In December 2016, the notion of a river chief system was made into an official national policy with the issuance of the *Opinion on Fully Promoting the River Chief Mechanism* by the state council.

The appointed river chiefs are generally individuals in leadership positions, such as provincial governors or heads of local governments. These individuals are given explicit responsibility for arresting the environmental and water quality decline and are accountable to the national government for resolving such issues in their jurisdictions. They are expected to take appropriate action to improve coordination and achieve the desired outcomes, and may be penalized if they fail to meet set targets. Although the official focus of the river chief mechanism is clearly water quality and environmental protection of water resources, it introduces a concept of accountability that could potentially be extended in scope to embrace FFAM.

In Chongqing Municipality, river chiefs have been appointed, comprising the mayor of the municipality for the overall municipal mandates and the individual governors or mayors of the local counties or cities under the municipal government within the Longxi River basin. At present, water resources bureaus at each level are acting like a river chief secretariat. Staff from relevant municipal government departments, such as water resources and environmental protection, is supporting river chiefs in complying with the requirements. To strengthen the application of the river chief system, particularly the application of FFAM in the Longxi River basin, the ADB-financed project (footnote 28) will enhance the capacity of the existing water resources bureau, or establish a specialized workforce directly under the river chief office, to coordinate and enforce FFAM in the Longxi River basin. Although it is initially focused on the Longxi River because of its status as a pilot river basin, the mandates of the newly established unit can be expanded to other similar watersheds within the municipality. Within the Longxi River basin, river chiefs at local government level are heads of county or district governments (Liangping District in upstream, Dianjiang County in middle, and Changshou District in downstream); township and village leaders are also appointed river chiefs. In the Longxi River basin, development plans are prepared by individual administrative units. The approach for river basin development, with consideration of spatial planning and supported by coordination mechanism among local governments, is yet to be introduced to apply FFAM in the river basin. During the project appraisal, it was found that the downstream areas could suffer the most due to upstream interventions. The issue could have been more complex, if local governments shared the same reach (such as left and right banks, where the dike built on one side can result in flooding in other side), unlike the existing three local governments in the Longxi River basin, which form a cascade. In addition to planning coordination among the three local governments within the Longxi River basin, a real-time river monitoring system will also be established to assist the river chief take action in any event of flood and environmental concerns arising in any section of the Longxi River.

Water quality indicators dominate the assessment used to evaluate the performance of river chiefs. There are also some concerns on the river chief system per se, such as how the system works under current water laws, how to treat transnational or transprovincial rivers, responsibility sharing on right and

³² Hou Liqiang. 2018. Government Implements River Chief System across the Country. *China Daily*. 17 July.

left banks of a river, the role of the relevant river basin authority and other agencies, linkages with IWRM, monitoring and evaluation criteria for the river chief system, etc.³³ Despite these reservations, the system can evolve into a more effective mode of management that improves accountability and has potential to be extended for FFAM purposes.

C. Case Study Area

The Longxi River basin in Chongqing Municipality of the PRC has been selected as a trial project to consider the potential of the concept of FFAM and its challenges for practical application. A first-order tributary sub-basin of the much larger Yangtze River basin, the Longxi River was the subject of an ADB-supported transaction technical assistance (TRTA) project that was completed in 2018 in advance of a proposed loan project. FERM was the explicit subject of the TRTA, and among its stated objectives were development of an FFAM and mainstreaming of FERM in sector project planning and design.³⁴

On the northeastern side of Chongqing Municipality—one of four special municipalities in the PRC administered by the central government—the Longxi River flows generally north to south, joining the upper Yangtze River downstream of the city of Chongqing. The area of the sub-basin of the Longxi River is just under 3,000 square kilometers, is entirely within Chongqing Municipality, and has recently experienced rapid urbanization and industrial expansion.

The river traverses three local government jurisdictions: Liangping District, Dianjiang County, and Changshou District of the Chongqing Municipality. Division of responsibilities between these jurisdictions has been one of the challenges in establishing an integrated planning and management system. Environmental conditions—water quality, river health, and ecology—have been seriously degraded by the rapid development. Because of inadequate urban planning and regulation, flood risk along the Longxi River has been aggravated. The problem tree in Figure 7 illustrates the overall problems with FERM in the Longxi River basin.

Although the eco-compensation mechanism has already been established in the Longxi River basin, it has not been functional yet. A more in-depth study of upstream–downstream links under the spatial planning approach will help promote eco-compensation and establish FFAM. In that respect, the institutional capacity of local governments on FERM should be strengthened. An integrated FERM plan, sector coordination, and implementation of critical measures are urgently required to promote sustainable development in the watershed, including infrastructure development, physical connectivity, and economic competitiveness.

³³ The intention to create mechanisms for more effective management of water quality and river health is highly laudable and demonstrates how serious the national government is about environmental conservation. The slogan “one river, one policy” encapsulates the aspiration for a unified management at river basin (or at least sub-basin) level—this is consistent with what this paper is advocating and is of relevance to the introduction of FFAM. However, the appointment of multiple river chiefs within river basins or sub-basins, while maintaining current geographic jurisdictional limits for different tiers of government administration, could prove an obstacle to proper coordination. River chiefs are accountable for water quality in their particular river reach, which appears to run counter to an ideal of integrated management at river basin scale and, particularly, in river basins that span more than one province or administrative jurisdiction. The concept is to improve partnership between agencies responsible for water resources management and environmental protection, and the river chief mechanism provides a platform for department coordination and communication. At the national level, this has been effective; but, success at other levels of government has so far been variable. Within agencies, duties associated with river chief activities are an extra burden, and it remains to be seen whether barriers due to divisions of institutional responsibilities can be successfully bridged.

³⁴ ADB. 2018. *Preparing Yangtze River Economic Belt Projects: Chongqing Longxi River Basin Integrated Flood and Environmental Risk Management Project, People's Republic of China*. Revised draft report (March). Manila (TA 9311-PRC).

D. Project Interventions

The limited scope of this single project does not enable all the management issues in the Longxi River basin to be addressed. Rather, it is intended to demonstrate how a more integrated approach to flood and environmental risk management (FERM) can be implemented and to propose a future program based on that model that is compatible with the current planning and institutional framework, and which also supports the introduction of the mandated river chief system.

The project targets four desired outcomes:

- (i) **Capacity building for FERM**—establishment of a network for monitoring river health; development of a watershed simulation model (water quantity and quality); preparation of a comprehensive FERM plan and investment road map for the river basin; training programs for local governments and community members on solid waste management, early warning systems for flood and water quality, and better use of pesticides and fertilizers, etc.; updating or development of emergency response plans for floods and water quality events; recommendations for land use management; updating reservoir operation guidelines; and support for the institutional adaptation to the new river chief system.
- (ii) **Ecological conservation measures**—restoration and expansion of existing wetlands and lakes, restoration and greening of river corridors and lake shores, and river bank protection and erosion control works.
- (iii) **Implementation of flood risk management infrastructure**—discontinuous flood protection embankments; temporary detention of floodwaters; removal of waterway obstructions including reconstruction of bridges, crossings, and weirs; a flood diversion channel; and construction of emergency shelters and evacuation routes.
- (iv) **Wastewater management and pollution control infrastructure**—sewer networks, wastewater treatment facilities, vegetation buffer zones (bioshields) along rural river banks, and provision of collection bins for solid waste to deter disposal in waterways.

E. Flood Footprint Evaluation

The proposed interventions include nonstructural and structural measures with a portfolio of nature-based measures and gray infrastructure, as well as an early warning system from upstream (Liangping District) all the way downstream to Changshou Lake (Changshou District) that discharges into the main course of the Yangtze River (Figure 8). All urgent water-based infrastructure proposed under the project were tested for their flood footprint through rigorous river basin modelling. The dynamic flood hazard map of the river basin developed during project appraisal will be used to evaluate the FERM plan (to be drafted under the project) as well as to screen other sector development plans (e.g., the upcoming five-year development plans of each administrative unit in the river basin).

The flood footprint analysis compared the change in flood hazard area due to each proposed intervention in each location (1-kilometer grid) in the entire river basin covering all three administrative units. The combined effect of all proposed measures in the river basin in terms of hazard area with and without project interventions is illustrated in Tables 3 and 4. The total inundation area in all return periods and in all administrative units can be reduced, although the measures were targeted for 20 years return period of flood under the project. The reduction in inundation depth and area is largely compensated by the wetlands and temporary inundation areas, mostly the seasonal farmlands.

Figure 8: Project Interventions in the Longxi River Basin, Chongqing Municipality

Note: The diagram is not drawn to scale or shape, but is sketched merely for demonstration purposes.

Source: Asian Development Bank.

Table 3: Inundation Area for Each Flood Return Period
(in square kilometer)

District/County	10-Year	20-Year	50-Year	100-Year
Without measures				
Liangping	69.06	75.47	83.13	90.25
Changshou	96.37	101.24	105.73	108.77
Dianjiang	236.88	244.83	254.20	260.48
Total	402.31	421.54	443.06	459.50
With measures				
Liangping	64.20	70.82	79.47	86.84
Changshou	93.01	97.18	101.52	104.39
Dianjiang	196.94	205.74	215.54	222.63
Total	354.15	373.74	396.53	413.86

Source: Asian Development Bank.

Table 4: Decrease in Inundation Area Due to Project Interventions
(in square kilometer)

District/County	5-Year	10-Year	20-Year	50-Year	100-Year
Liangping	4.99	4.85	4.65	3.66	3.42
Changshou	2.53	3.36	4.06	4.21	4.38
Dianjiang	39.58	39.94	39.10	38.66	37.85
Total	47.10	48.15	47.81	46.53	45.65

Source: Asian Development Bank.

Likewise, the changes in peak flow discharge along the river were compared with different scenarios of project intervention, prior to the finalization of the proposed plan. One set of different scenarios used to optimize the dike size at different location is presented below.

The proposed test cases are as follows:

- Case 0: Entire river dike along the Longxi River from Liangping District to Changshou District;
- Case 1: Discontinuous dike (intermittent dike) with no flood retention by wetland;
- Case 2: Discontinuous dike considering detention in Shuanggui wetland in Liangping; and
- Case 3: Discontinuous dike considering both Shuanggui wetland and Sanhe wetland.

The locations of water level (E) observation points used in the test cases are labelled as follows, where L, D, and C represent Liangping District, Dianjiang County, and Changshou District, respectively.

- L-1: Longxi River, Helin town;
- L-2: Guixi River, Liangping central district;
- L-3: Longxi River upstream section, Renxian town;

- L-4: Longxi River after the confluence of Qijian River, Yunlong town;
- D-1: Longxi River, Gao'an town;
- D-2: Longxi River after the confluence of Wolong River, Yantai town;
- D-3: Guixi River, Xinmin town;
- D-4: Huilong River, Yong'an town;
- C-1: Longxi River upstream of Changshou Lake;
- C-2: Longxi River in Dandu town;
- C-3: Longhe town; Dayu River, Yuntai town; and
- C-4: Longxi River downstream of Changshou Lake.

Table 5 presents the results of flood level computations for a flood return period of 20 years or annual exceedance probability (AEP) of 5%.³⁵ E_0 , E_1 , E_2 , and E_3 represent flood levels corresponding to the four different test cases. As seen in the table, all flood level reductions range from 0.3 meters to 2.0 meters, except for point D-4 with a reduction of 3.68 meters. Point D-4 is a narrow gorge located near the junction of Longxi main river channel and the tributaries of Guixi River and Huilong River. This makes flows at this location more prone to overtop. Since observation point D-4 is on the tributary Huilong River in Dianjiang County and point C-3 is on the tributary Dayuxi River in Changshou District, these two observation points are not affected by the wetland regulation; thus, no flood level change occurs for either wetland retention case.

Table 5: Water Level for Different Test Cases
(in meter, AEP=5%)

District/County	Observation Point	Test Case Water Level				Difference		
		E_0	E_1	E_2	E_3	$E_0 - E_1$	$E_1 - E_2$	$E_1 - E_3$
Liangping	L-3	439.17	438.32	438.06	438.06	0.86	0.25	0.25
	L-1	432.16	431.79	431.57	431.57	0.37	0.22	0.22
	L-2	430.97	430.67	430.48	430.48	0.30	0.19	0.19
	L-4	413.97	413.36	413.15	413.15	0.61	0.21	0.21
Dianjiang	D-3	390.78	389.48	389.34	389.23	1.30	0.14	0.26
	D-4	379.57	375.89	375.89	375.89	3.68	0.00	0.00
	D-1	376.45	375.79	375.35	375.27	0.66	0.44	0.52
	D-2	375.48	374.77	374.41	374.34	0.71	0.36	0.43
Changshou	C-3	367.05	366.37	366.37	366.37	0.67	0.00	0.00
	C-1	336.61	335.61	335.30	335.25	1.00	0.31	0.36
	C-4	267.24	265.17	264.88	264.73	2.07	0.29	0.44
	C-2	228.53	227.03	226.75	226.61	1.50	0.28	0.42

AEP = annual exceedance probability.

Source: Asian Development Bank.

³⁵ As per the PRC's regulation, flood management infrastructure in urban setting should be designed for a minimum of 20 years return period of flood.

The discharge reduction at each observation point for a 20-year flood event is presented in Table 6. The results show the same trend as flood level reductions. In the table, Q_1 , Q_2 , and Q_3 represent water discharge corresponding to case 1, case 2, and case 3, respectively.

Table 6: Discharge Reduction from Different Test Cases
(m^3/s , AEP=5%)

District/County	Observation Point	Test Case Water Level			Difference	
		Q_1	Q_2	Q_3	$Q_1 - Q_2$	$Q_1 - Q_3$
Liangping	L-3	505.97	441.79	439.76	64.18	66.21
	L-1	118.63	114.99	114.98	3.64	3.65
	L-2	454.31	425.40	427.68	28.91	26.64
	L-4	437.28	414.66	414.21	22.62	23.06
Dianjiang	D-3	98.22	92.47	63.64	5.75	34.58
	D-4	388.80	373.95	375.70	14.85	13.10
	D-1	1,481.65	1,447.18	1,442.26	34.47	39.40
	D-2	1,831.45	1,811.72	1,806.02	19.72	25.42
Changshou	C-3	436.62	397.12	376.97	39.50	59.65
	C-1	2,530.21	2,506.90	2,497.61	23.31	32.61

AEP = annual exceedance probability, m^3/s = cubic meter per second.

Source: Asian Development Bank.

Although detailed damage assessment could not be carried out for the entire river basin during project appraisal, the reductions in the cost of the earthen dikes in the downstream reaches were calculated to demonstrate the effect of integrated measures. Table 7 shows the calculated results of dike construction cost reduction by upstream flood retention. The total cost is reduced by about CNY6.12 million (\$0.86 million) for case 2 and CNY7.43 million (\$1.05 million) for case 3.

Table 7: Cost Reduction Results for Case 2 and Case 3

Item	Case 2			Case 3		
	Liangping	Dianjiang	Changshou	Liangping	Dianjiang	Changshou
L (km)	63.61	29.50	68.86	63.61	29.50	68.86
H (m)	0.22	0.24	0.22	0.22	0.30	0.31
UP (CNY/ m^2)	120.00	120.00	120.00	120.00	120.00	120.00
V (CNY '000)	2,355.46	1,182.56	2,582.20	2,355.46	1,511.68	3,560.75
Total (CNY '000)	6,120.23			7,427.89		

CNY = Chinese yuan, km = kilometer, m = meter, m^2 = square meter.

Notes:

H = mean value of the reduced water level, which can be determined based on Table 5;

L = total length of the embankment (162 kilometers);

UP = construction cost of the embankment per square meter, and UP value can be determined by considering the economic report (CNY120 per square meter is used); and

V = total reduction in dike construction cost.

Source: Asian Development Bank.

During the selection of the project components by individual local governments, several similar sets of comparative evaluations were carried out, ensuring no intervention will impair flood risk either downstream or upstream of the proposed area. If any intervention was found essential to mitigate local flood risk but would cause some level of harm to areas upstream or downstream, all three local governments closely coordinate and resolve the issues with some compensation measures, such as increased flood retention area or enlarged wetland areas. The complete set of proposed project interventions deliberated ways to promote a flood footprinting and accountability system in the river basin, showing that project activities will not just protect local areas but will also reduce the 20-year flood peak discharges by 15%, 12%, and 2.5% from Liangping to Dianjiang, Changshou, and ultimately the Yangtze main river, respectively. During project implementation, similar activities will be performed for finalizing the FERM plan, and for the upcoming 5-year development plans of the local governments, including Chongqing, to be undertaken by the newly proposed unit to be established under the river chief secretariat in the municipal government.

F. Flood Footprint and Accountability Mechanism

The flood footprint is altered by works such as flood protection embankments, temporary floodwater detention, modifications to lakes and wetlands, flood diversion, and updated reservoir operations—although reservoir operations only affect the lowest reaches of the Longxi River downstream of the Changshou Reservoir in Changshou District.

Determination of the change in flood footprint was aided by standard analytical tools. These included hydrological flood frequency analysis to determine floods of different probabilities of exceedance, application of two-dimensional hydrodynamic modeling to estimate extents of inundation with and without works, and flood risk mapping using GIS. Four test cases were modeled to demonstrate the approach: (i) a base case with continuous flood protection dikes flanking main waterways; (ii) discontinuous dikes that would allow selected floodplain inundation for temporary flood storage; (iii) discontinuous dikes as in case (ii), plus floodwater detention in the Shanggui Wetland located in the upstream Liangping District; and (iv) discontinuous dikes plus floodwater detention in Shanggui Wetland as in case (iii), plus floodwater detention in Sanhe Wetland in the central Dianjiang County.

The modeling demonstrated reduced flood peak levels downstream due to the test interventions. In certain locations, discontinuous dikes alone (case 2) could produce significantly lower peak water levels for a 20-year flood (with 5% annual probability of exceedance)—up to 3.68 meters lower at Yong'an Town near the confluence of the Huilong tributary and the Longxi River in Dianjiang County. Additional reductions of up to 0.52 meters in peak flood levels could be achieved by modifications to facilitate floodwater retention in the two wetlands. At the downstream end of the Longxi River near its confluence with the Yangtze River, a reduction of 1.92 meters in peak flood level could be achieved in a 20-year flood. The total area inundated throughout the Longxi River basin could significantly be reduced. Not only do the test cases reduce flood levels and areas of inundation in the river basin, but compared to the base case with continuous river dikes, the test measures with discontinuous dikes also achieve cost reductions. According to the aforementioned project outcomes, the project will produce numerous aids to accountability (Table 8).

Accountability, however, also has institutional and human dimensions. Project support for the river chief system, which is an initiative of the PRC government, includes establishment of a special development coordination unit in the Chongqing Municipal Department of Water Resources. The unit will be staffed mainly by trained flood risk management specialists who will have authority to screen all development

Table 8: Summary of Aids to Accountability Mechanism by the Longxi River Basin Flood and Environmental Risk Management Project

Description	Comment
Enhancement of flood early warning networks and update of emergency response plans	Enables precautionary measures in advance of floods and more effective flood emergency response
Development of network for monitoring river health and response plan for critical water quality events	Enables remedial measures during episodes of degraded water quality, and provides data for more effective planning and/or management
Flood risk mapping	Provides important guide for future development regulation and vital information for emergency planning and response
Development of river basin model simulating water quantity and quality	Provides a useful tool for planning and management
Preparation of flood and environmental risk management plan and investment road map	Provides direction for future planning and management, and blueprint for future action
Training of local officials and community members	Empowers people with greater knowledge and raises skill levels for more appropriate action and response
Recommendations for land use management	Provides means for regulating exposure to flood hazard
Recommendations for river chief implementation	Supports institutional adaptation to new river chief system

Source: Asian Development Bank.

plans of the three local governments in the Longxi River basin. This relies on model 2 (i.e., *modifying organizational structure within an existing government department or agency*), as described in Table 2, section V-B. There is a risk that, unless there are influential staff within the existing institutions who are very committed to the introduction of FERM and the concept of flood footprint and accountability mechanism (FFAM), the outcomes sought by the project may not be sustained and the initiatives for improved planning and management may flounder. One of the purposes of training programs within the project is to stimulate engagement with project objectives and generate the commitment essential for sustained success.

In the Longxi River basin, the study was able to demonstrate the change in flood footprint downstream brought about by works upstream. This proved very instructive. The downstream local government (Changshou District) now has a clearer understanding of the benefits it derives from upstream interventions, and discussions are proceeding to share funding for proposed works such that contributions are made by the downstream local government to partly compensate for cost of works proposed upstream that would transfer benefits downstream. This would represent a significant shift towards future management at river basin scale.

Without motivated support within the institutions of government, any structural changes to the organization of management agencies would almost certainly meet resistance, and this is true in any country. Because of institutional inertia, attempts to apply model 2 or model 3 (*establishing a new institution at river basin scale*) understandably face escalating degrees of difficulty. There is typically a dilemma presented in the trade-off between an ideal model for sustainability of outcomes and a practical model likely to achieve more limited incremental change.

It may be an instructive reality check to consider the example of the Tarim River basin in Xinjiang Uygur Autonomous Region of far western PRC, which was the subject of a World Bank project for improved integrated water resources management (IWRM) during the 1990s. That project supported provincial and national authorities to create a new river basin organization—a bold new initiative.³⁶ The Tarim River Basin Water Resources Commission (TRBWRC) was established with a joint standing committee and a technical and administrative bureau in 1997. The standing committee had representatives from provincial agencies for water, agriculture, environmental protection, pastures, and forestry. With the consensus of all participating agencies, the TRBWRC produced a management plan for IWRM that provided an excellent framework to address considerable challenges of equitable water allocation in a region of water scarcity. A later water resources review of the region found that, even though the TRBWRC was still functioning, it had failed to prevent overuse of water in irrigated areas upstream and severe water shortages for downstream water users and key environmental assets.³⁷ According to the review, the commission had insufficient powers to enforce compliance with the provisions of the agreed management plan, and irrigation diversions upstream had continued to increase to the detriment of other users and the environment downstream.³⁸ The experience in the Tarim River basin shows that pitfalls may arise regardless of which model for water resources reforms is followed. On the other hand, successful outcomes from examples of RBOs in Europe noted in section V-C should be kept in mind.

VII. ISSUES AND RECOMMENDATION IN THE ADAPTATION OF FLOOD FOOTPRINT AND ACCOUNTABILITY MECHANISM

Flood risk management has been practiced in various ways or at different stages by many developing countries. Adaptation of the flood footprint and accountability mechanism (FFAM) could be a challenging task for some; whereas, for other countries, it is relatively easy as long as they have supportive policies and clear institutional mandates. Adopting a new mechanism in development planning certainly requires some changes.

Due to complexities in resource allocation and conflict of mandates, sector departments are usually reluctant to align their sector development with other sectors. There is often a lack of organization that can lead the FFAM and, even if such organization exists, it may not have the technical capacity or mandate to influence the planning process. Also, lack of supportive policies and laws may hamper the application of FFAM. Many countries still rely on conventional infrastructure, and modifying or adjusting these infrastructure planning and design in a river basin context may be considered as a complex task or reform. Similarly, the coordination among administrative units may not be realized as each will compete for their own development. Moreover, politically, this process can be influenced. As FFAM considers a spatial planning approach rather than a localized one, there could be some level of compromise in resource utilization, which consequently can trigger conflict of interests among beneficiaries.

³⁶ P. Millington, D. Olson, and S. McMillan. 2006. Case Study 3: Tarim River Basin and the Tarim Basin Water Resources Commission, People's Republic of China. *Integrated River Basin Management: From Concepts to Good Practice*. Washington, DC: World Bank.

³⁷ N. Thevs. 2011. Water Scarcity and Allocation in the Tarim Basin: Decision Structures and Adaptations on the Local Level. *Journal of Current Chinese Affairs*. 40 (3). pp. 113–137.

³⁸ The situation in the Tarim River basin has since improved. After amendments to the Environmental Protection Law in 2014, more rigorous control of water allocations has been implemented with better enforcement and greater accountability for meeting targets (F. Hu. 2017. 5 Facts about the Tarim River. *China Water Risk*. 17 October). Although the TRBWRC has been instrumental in implementing these reforms, the improvements were more because of the revised national policy and not because of the model of the TRBWRC.

In general, however, FFAM is a holistic approach and it can bring about win-win scenarios among users and uses in the long run. Appropriate government policies and laws and their strong enforcement will be critical for the effective application of FFAM. Many developing countries, which have basic institutional and policy foundation, can apply the concept—such as in the People’s Republic of China (PRC), where the river chief system is already rolled out and where coordination is key for success. As discussed in the following subsection, the river chief system has several gaps that can be filled by applying the FFAM approach.

A. River Chief System Application

As of June 2018, the PRC had put in place the river chief system nationwide. In July 2018, the Ministry of Water Resources (MWR) announced an urgent need to establish a long-term mechanism for coordination among river chiefs in transprovincial river basins, which is required to attain the goal of effective flood risk management and pollution control at the river basin level. The main tasks proposed are (i) improving the basin coordination mechanism to leverage the role of basin management authorities in comprehensive coordination, supervision, and monitoring; (ii) exploring the establishment of upstream–downstream and mainstream–tributary ecological compensation mechanisms; and (iii) establishing regulations, technical standards, and indicators for river and lake management and protection.

As part of its institutional reform, the Yangtze Water Resources Commission of the MWR set up the Bureau of River and Lake Management in 2019, with the following main tasks: (i) undertaking responsibilities such as coordination, guidance, supervision, and monitoring of the application of the river chief system; (ii) establishing communication and consultation mechanisms with provinces and municipalities within the basin; and (iii) carrying out a study on major issues of the river chief system, including the “one river, one policy” approach for transprovincial rivers and lakes, emphasizing a tailored plan for each river, coordinated prevention and control efforts across regions, and joint law enforcement.

Just as the river chief system may be useful in the PRC to facilitate the application of the FFAM, the FFAM is a technical tool that can help facilitate the application of the river chief system. The river chief system is practical under the unique system of governance in the PRC, but may or may not be effective in many other countries.

B. Promoting Flood Footprint and Accountability Mechanism in the People’s Republic of China

The PRC appears as a leader in water security in the Asia and Pacific region. But when compared with other national plans, there is a mismatch between the country’s institutions and management of its water resources and its leading policies. Roles and responsibilities for water management should be clarified and coordinated between government organizations, political jurisdictions, and national policies. With water-related mandates being delegated to about 10 government agencies (comprising national ministries and commissions, and local-level administration and council offices with overlapping functions), better water governance can help solve the water security problems in the PRC. The institutional reform undertaken by the government in early 2018 to strengthen and modernize the country’s governance system and capacity has consolidated some of these overlapping water management functions. The newly established Ministry of Ecology and Environment is now in charge of river basin management, water function planning, and water pollution control; the MWR has taken over the management of state-focused mega water projects; and the new Ministry of Natural Resources has absorbed the MWR’s functions of water resources research and water ownership and rights registration.

The PRC government is now formulating its Fourteenth Five-Year Plan, 2021–2025. As with the previous plan, the PRC will continue to make integrated water resources management (IWRM) as one of its priorities, particularly in terms of strengthening the institutional capacity in resources planning, design, implementation, and operations. To help the PRC government achieve improved water security, possible assistance in the areas of IWRM and sustainable land management would include (i) strengthening water security, water governance, and water pollution control; (ii) improving forestry management and water-related disaster risk management; and (iii) promoting innovative eco-compensation mechanisms, water environmental regulation and compliance, and other market-based instruments to support environmental protection and pollution control.

In 2016, the river chief system was endorsed by the PRC State Council, stipulating that the river chief mechanism must be fully established by 2018. Several donors, including ADB, have been supporting the application of the river chief system in the Yangtze River basin. The proposed FFAM is part of such support and is being promoted in new water projects in the PRC. Despite any sector focus in the PRC, FFAM could play a significant role in development planning and project design, in general, by facilitating a coordinated approach, precluding duplication, and improving sustainability of investments.

C. Application of the Flood Footprint and Accountability Mechanism in the Yellow River Basin of the People's Republic of China

The PRC's Yellow River flows, from west to east, through nine provinces and autonomous regions—Qinghai, Sichuan, Gansu, Ningxia Hui Autonomous Region, Inner Mongolia Autonomous Region, Shaanxi, Shanxi, Henan, and Shandong—before draining into the Bohai (Yellow) Sea. The 5,500-kilometer long Yellow River feeds about 12% of the PRC's population, irrigates about 15% of arable land, supports 14% of national gross domestic product, and supplies water to more than 60 cities including Beijing and Qingdao municipalities located outside the river basin. This is the second largest river basin in the PRC, after the Yangtze River basin, and the world's most sediment-concentrated river flow. Due to the river sedimentation, the riverbed in the lower reaches has continuously been raised and, in many locations, has even exceeded the ground levels, resulting in frequent floods and river course changes in recent years (Figure 9). The flood in 1987 in the Yellow River basin was the largest, which killed over 900,000 people. Large flood events have been recorded almost every year in different parts of the Yellow River basin, causing significant damages.³⁹ The Yellow River Conservancy Commission has been playing a key role in managing water resources in the basin, but it lacks the mandate to coordinate the overall development in the river basin.

In September 2019, the PRC's president called for an integrated approach to promote ecological protection and high-quality development in the Yellow River basin. The president highlighted the country's struggles against floods and droughts in the Yellow River since ancient times. The message emphasized the importance of spatial planning and that the national planning of the population, urban, and industrial development should be realistic based on available water resources. The government is now preparing a master plan for the Yellow River basin and also prioritizing the water security study for this river basin. The FFAM will play a crucial role in supporting spatial planning and achieving quality development in the Yellow River basin. Assistance can be extended to the PRC government, such as in (i) drafting the river basin master plan, with priority on spatial planning encompassing FFAM principles; (ii) drafting the water legislation and policy recommendations based on international know-how; (iii) financing innovative infrastructure aiming at FFAM, and maintaining quality in water resources

³⁹ Since 2000, flooding in the Yellow River basin has been recorded, remarkably during 7–10 July 2000, 30 August 2003, 29 July 2007, 20 March 2008, 17 January 2009, 26 July 2010, 13–14 August 2011, 20 July 2012, 16–21 July 2013, 2016, and 2017.

development; (iv) piloting FFAM in small and medium-sized river sub-basins, which have suffered the most from flood disasters; and (v) disseminating the knowledge and experience.

D. Integrated Flood Risk Management at River Basin Scale

The FFAM is mainly a communication and decision-making mechanism to be used by the relevant coordination authority. As noted in section V-A, technical tools are readily available that enable change in flood footprint to be assessed and thus provide a sound foundation for accountability in integrated flood risk management (IFRM). The most crucial are flood risk mapping and the development of flood risk management plans (FRMPs) at river basin scale.

Systematic programs for producing flood risk mapping, as in the PRC, provide the best foundation. However, many developing countries feel they cannot undertake such a commitment given the limited resources at their disposal, while numerous other needs and priorities compete for these resources. Even considering the limitations, it is recommended that developing nations do initiate national flood risk mapping programs, allocating to them whatever limited funding they can afford and beginning their programs with highest-risk river floodplains. Human skills and resources are also essential, so attention may be needed to focus on educational curricula that provide basic skills and on more advanced skills training for specialist(s) either locally or internationally. In addition to these capacity-building measures, all development projects that may be affected by flood should, at every opportunity, include flood risk mapping as a necessary undertaking during feasibility or design studies. In this way, a national library of flood risk mapping can gradually be assembled.

FRMPs at any scale are important planning tools that support accountability in flood risk management, but these should be prepared at river basin scale. For very large river basins, a master plan can first be prepared for the scale of the entire river basin, and more detailed FRMPs can then be prepared at sub-basin scale consistent with the master plan, as done in France. It is more difficult to achieve the best spatial integration if FRMPs are prepared at smaller scales first.

Preparing FRMPs at river basin scale is difficult if, as is often the case, the territory within the river basin boundaries falls under multiple administrative jurisdictions. In some cases, this problem can be overcome by assigning responsibility to a higher tier of government, provided that the entire river basin then falls within its jurisdiction. That also depends on the system of government. In the US, for example, the federal government assumed primary responsibility for flood management along the Mississippi River (discussed in section V-C). In Australia, however, where the federal government provides some funding but eschews responsibility for flood management, flood management in the large Murray–Darling Basin is coordinated between the relevant states, with the river basin organization (RBO)—i.e., the Murray–Darling Basin Authority—only offering strategic advice and providing support by means of a shared database, operating main stream reservoirs, acting as a secondary referral agency for proposed developments, etc. In both cases, RBOs were established to address the problem of multiple jurisdictions and, as noted in section V-C, many other RBOs operate around the globe.

In general, RBOs are the best model for IFRM in large, multijurisdictional river basins. But to succeed:

- they need to be compatible with pre-existing institutional frameworks for government administration,
- they need consensual support from the multiple jurisdictions in which they operate, and
- adequate powers must be conferred so their decisions are not easily overturned (although some right and means of appeal is desirable).

Development approval procedures provide an appropriate administrative mechanism to enable accountability for changing flood footprint. Development approvals should be mandatory for any development project that entails engineering works, not just for projects that aim to modify flood risk. The approval process must consider the nexus between water quantity, water quality, and ecology—in other words, not just the effect on flood risk, but also on the physical environment, water quality, and the ecosystems.

Whatever model is used to effectively coordinate regulation, as part of their project preparation procedures, multilateral lending institutions like ADB should support the establishment of effective governance mechanisms so that ongoing regulation of development will be effective; hence, the benefits derived from financed projects will not be eroded by subsequent development within river basins. This paper advocates the assessment of changes in flood footprint as a routine step in the preparation of projects of any sector that involve physical interventions, i.e., engineering works. Assessment of the flood footprint change should be one item on the project preparation checklist. In some cases, the assessment of flood footprint change will be very simple and fast. In the case of a facility to be constructed on the upper slopes or crest of a hill, for example, it may obviously be unlikely that project implementation would change any flood footprint. In such case, the check-box should be ticked that indicates no further assessment of flood footprint change is necessary. For many proposed projects, however, it will not be immediately obvious that no change in flood footprint would occur if the project is implemented. In all such cases, some investigation and technical analysis should be mandatory. This is similar to the process in environmental impact assessments. Institutional measures will also be appropriate for inclusion in project scopes to support introduction of comprehensive development approval procedures by governments in member countries where these are deemed insufficient.

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Institutional and Governance Dimensions of Flood Risk Management

A Flood Footprint and Accountability Mechanism

This working paper proposes a concept of flood footprint and accountability as a mechanism to guide institutional arrangements and administrative procedures. It is useful in coordinating project activities within flood risk zones and in adjoining areas through appropriate spatial planning at river basin scale. Flood footprint is defined as the potential impacts of floods on different sectors and vice versa. The paper also discusses a trial study in the Longxi River basin that demonstrates how technical tools could be used to assess the probable change in flood footprint from different risk management scenarios.

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