ADB

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India: Operational Research to Support Mainstreaming of Integrated Flood Management under Climate Change

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Operational Research to Support Mainstreaming of Integrated Flood Management under Climate Change

FINAL REPORT Phase 1

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Ministry of Water Resources

Central Water Commission

Asian Development Bank

ADB

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ABBREVIATIONS

ACCCRN	Asian Cities Climate Change Resilience Network
ADB	Asian Development Bank
ADPC	Asia Disaster Preparedness Centre
AIFERM	Assam Integrated Flood and Riverbank Erosion Risk Management Project
ALTM	Air-borne Laser Terrain Mapping
APFM	Associated Programme on Flood Management
BAPES	Bihar Aapada Punarwas Evam Punarnirman Society
BB	Brahmaputra Board
BKFRP	Bihar Kosi Flood Recovery Project
CAP	Contingency Action Plan
CBFRML	Community-based Flood Risk Management and Livelihood
CDP	City development plan
CFMP	Catchment flood management plan
CMG	Crisis Management Group
CRC	Central Relief Commissioner
CWC	Central Water Commission
CWPRS	Central Water and Power Research Station
DDMA	District Disaster Management Authorities
DFID	Department for International Development
DPC	District Planning Committee
DPR	Detailed project report
DRM	Disaster risk management
DRR	Disaster Risk Reduction
EA	Environment Agency for England and Wales
EC	European Commission
EU	European Union
FEMA	Federal Emergency Management Agency
FFG	Flash Flood Guidance
FM	Flood management
FMIS	Flood Management Information System
FRMRC	Flood Risk Management Research Consortium
GCM	Global climate model
GFCC	Ganga Flood Control Commission
GFDRR	Global Fund for Disaster Reduction and Recovery
GoB	Government of Bihar
GoI	Government of India
GoMP	Government of Madhya Pradesh
GWP	Global Water Partnership
HPC	High-Powered Committee
ICPDR	International Commission for the Protection of the Danube River
IFM	Integrated flood management
IFMP	Integrated flood management plan
IFRM	Integrated flood risk management
IIT	Indian Institute of Technology
IMD	India Meteorological Department
INCCA	Indian Network for Climate Change Assessment
INCCC	Indian National Committee on Climate Change
IWRM	Integrated Water Resources Management
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
KII	Key Informant interviews
KUSP	Kolkata Urban Services for the Poor
LiDAR	Light detection and ranging
MoEF	Ministry of Environment and Forestry
MoUD	Ministry of Urban Development
MoWR	Ministry of Water Resources
MPUSP	Madhya Pradesh Urban Services for the Poor
NCMC	National Crisis Management Committee

ABBREVIATIONS CONT'D…

NDC	National Development Council
NDMA	National Disaster Management Authority
NEPA	National Environmental Policy Act
NERUDP	North Eastern Region Urban Development Programme
NFIP	National Flood Insurance Program
NFMI	National Flood Management Institute
NGO	Non-government organisation
NIH	National Institute of Hydrology
NRSC	National Remote Sensing Centre
NUIS	National Urban Information System
NWA	National Water Academy
OR	Operational Research
PATA	Policy and Advisory Technical Assistance
PRA	Participatory Rural Appraisal
PRI	Panchayati Raj Institution
RBO	River basin organisation
RCM	Regional climate model
SDMA	State Disaster Management Authority
SDRF	State Disaster Response Force
SEEDS	Sustainable Environment & Ecological Development Society
SEPA	Scottish Environmental Protection Agency
SWAT	Soil and Water Assessment Tool
TA	Technical Assistance
TERI	The Energy and Resources Institute
TVA	Tennessee Valley Authority
UIDSSMT	Urban Infrastructure Development Scheme for Small & Medium Towns
ULB	Urban Local Bodies
UN/ECE	United Nations Economic Commission for Europe
UNCED	UN Conference on Environment and Development
UNDP	United Nations Development Programme
USACE	US Army Corps of Engineers
WHO/EURO	World Health Organisation's Regional Office for Europe
WMO	World Meteorological Organisation
WRD	Water Resources Department
ZP	Zilla Panchayat

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I. INTRODUCTION

A. Purpose of this Report

1. This report summarizes the outcome of the first phase (Phase 1) of the Policy and Advisory Technical Assistance (PATA) 8089, Operational Research into Mainstreaming Integrated Flood Management under Climate Change. Phase 1 concentrated on scoping the successive Phase 2 work largely following the structure and concept outlined in the TA paper[1] (Annex A).

B. Background[2]

2. Strengthening the resilience of flood-prone areas against flooding is an important component of the climate change strategy of the Government of India. The National Water Mission of the National Action Plan on Climate Change (NWM, 2011) has identified a need to develop flood management strategies for the country and for these to include plans for community-based adaptation. The 2012 draft National Water Policy advocates structural and non-structural measures to avert floods and droughts that include preparedness and coping mechanisms. Through the 12th 5-Year Plan (GoI, 2012) and otherwise, the government is promoting sector reforms at the state level to achieve balanced and integrated approaches to flood management.

3. Flood management is an important facet of climate change adaptation in India because rainfall and the risk of extreme rainfall events are expected to increase in large parts of the country, notwithstanding the uncertainty associated with such projections (Annex D). In September 2011, the Asian Development Bank (ADB) completed technical assistance (TA)[3] that supported the National Water Mission in establishing the requirements for effective, coordinated planning processes for climate change adaptation. The TA identified the key institutional and reform needs for integrated water resources management. Globally, greater efforts are now being made to achieve a more integrated approach to flood management since infrastructure alone cannot deliver the desired results. The steering committee for India's 12th five-year plan has recommended the application of holistic integrated basin development and flood management in the country. In response, state governments have emphasized the difficulties they face in implementing holistic approaches to flood management. The present TA seeks to address these gaps and place practical and feasible options for IFM planning at the sub basin level.

4. The TA Operational Research for Mainstreaming Integrated Flood Management under Climate Change is included in ADB's country operations business plan, 2012–2014 under the 2012 pipeline. In December 2011, the Ministry of Water Resources (MOWR) asked ADB to support operational research initiatives to help better integrate non-structural and community-led measures into flood planning and management. ADB fact-finding was conducted on 15 February and 9 March 2012, to consult the government on the preliminary design of the TA, including expected impact, outcome and outputs; the financing modality; cost estimates and implementation schedule and arrangements.

5. The TA is being implemented in two phases, starting with Phase 1 from March to August 2013, which has comprised scoping and planning studies. These studies involved (i) a review of the lessons learned from the integration of structural and non-structural components of flood management in India and globally; (ii) identification of the scope and location of the research activities; and (iii) preliminary data collection, and support for the phase 2 start-up. Phase 2 is scheduled for 18 months and will immediately follow Phase 1. It will comprise operational research to support the mainstreaming of integrated flood management (IFM) in a way that takes into account projected future conditions and climate change uncertainties.

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[1] ADB Technical Assistance Paper, Project Number 45017 Policy and Advisory Technical Assistance (PATA), May 2012: India: Operational Research to Support Mainstreaming of Integrated Flood Management under Climate Change; para 1 to 3 and 10 and 11.
[2]. Adapted from the TA Paper.
[3] TA 7417-IND Support for the National Action Plan on Climate Change Support to the National Water Mission, Final Report, September 2011.

The research envisaged under Phase 2 will develop proposals for IFM strategies for India. The studies will focus on two pre-identified sub-basins that are highly vulnerable to flooding and encompassing both rural and urban areas. Through these sub-basin studies it will be possible to examine a broad mix of flood and flood management issues typical for common flood issues in India and relevant for replication in other sub-basins. The research will incorporate flood risk assessments for key sectors in the selected sub-basins and will include a review of international experience of IFM. There will be comparison and evaluation of these results with lessons learned in the selected sub-basins to ensure that approaches tested in India are based on real evidence of effectiveness.

6. The concept of IFM was first outlined in 2003 in a concept paper produced by the World Meteorological Organization (WMO): "Integrated Flood Management Concept Paper". A revised concept paper was produced by the Technical Support Unit of the Associated Programme on Flood Management (APFM) in 2009 (WMO, 2009). The revised paper outlines how IFM sits within the concept of Integrated Water Resources Management (IWRM), and summarizes very clearly the fundamentals:

7. "A holistic approach to emergency planning and management is preferable to a hazard-specific approach, and IFM should be part of a wider risk management system. This approach fosters structured information exchange and the formation of effective organizational relationships. In integrated flood management planning, achieving the common goal of sustainable development requires that the decision-making processes of any number of separate development authorities be coordinated. Every decision that influences the hydrological response of the basin must take into account every other similar decision."

8. Integrated flood management should be considered as being part of environment and natural resource management that should be devolved to the lowest appropriate level. Climate change is generally expected to increase flood hazards in most places, and flood management is considered to be a priority under the United Nations Framework Convention on Climate Change. The degree of vulnerability to flooding increases with socio-economic development, and as more facilities are located on floodplain land. It is also the case that with increasing population pressures, the poor often occupy the most flood prone areas. The project is designed to address both of these aspects in an integrated manner.

9. Focussing on practical work packages, the National Water Mission of the National Action Plan on Climate Change (NWM, 2011) formulates goals and strategies in five thematic groups. The third provides “focussed attention on vulnerable areas including over-exploited areas” and states as one of the eight goals and strategies: “Systematic approach for coping with floods – mapping of areas likely to experience floods, establishing hydraulic and hydrological models and developing comprehensive schemes for flood management and reservoir sedimentation”

C. The TA Organization and Schedule

10. Phase 1 of the TA was primarily a project preparation phase. As part of the activities under this Phase, a review of current Indian and international best practice in IFM has been carried out. It is acknowledged that at present there is not a universally applicable IFM formulation, and that there must be adaptation to the nature of floods and the problems they create, including a thorough understanding of socio-economic conditions, and the level of risk that societies are prepared to accept and adapt to.

11. Phase 1 studies have identified, through a strong consultative process with Central and State authorities, two sub-basins in which appropriate IFM approaches can be piloted and tested. Primary data have been collected for these sub-basins and a broader data collection process has been initiated through communication between CWC and relevant Central and State organisations. Testing and evaluation of IFM approaches will be carried out in Phase 2 studies.

12. A team of six consultants, two international and four national worked from March to July 2013 in several distinct block inputs to prepare the scope for Phase 2. The work of the team is documented in three reports. A draft Inception Report was prepared during the first weeks of March 2013 and later included the results of the round-table discussion between Central and State organizations held on 3 April 2013. The final Inception Report was issued on 23 May, after the first Project Review Committee

meeting on 14 May 2013. The draft Interim Report, which aims to summarize current Indian and international practice to manage floods in an integrated manner, was submitted to MOWR and CWC on 1 July 2013. This draft Final Report was submitted on 16 July 2013 to Central Government counterparts and subsequently State Organizations in Bihar and Odisha. This revised draft Final Report was prepared based on ADB comments on 19 August 2013 and issued in October 2013. The Final Report was prepared after the Project Steering Panel meeting at the end of January 2014 and launched in February 2014..

D. This Report

13. This Phase 1 report explains the consultative process applied to identify two sub-basins for detailed integrated flood management planning during Phase 2, and provides background information relating to the two sub-basins. This information is presented in five sections. Following this Introduction, Section 2, Flood Practices summarizes international best practice and flood management practices in India, from the interim report. Section 3, Consultation Process and Selection of Focal Sub-basins, explains how the intra-state Burhi Gandak basin in Bihar and the inter-state Brahmani/Baitarani basin in Odisha and Jharkhand were selected. Section 4, Initial Field Investigations, describes the findings from intensive field level visits and consultation with multiple stakeholders, which leads into Section 5, Outline Phase 2 Activities. Section 6, Outlook, focuses on the Phase-2 data collection process and timeline. Section 7, References, concludes this report.

14. Eleven annexes provide background and elaborate on different aspects based on background investigations most conducted during the field visits. Annex A contains the TA Paper for this policy and advisory technical assistance. Annex B summarizes international best practice. Annex C focusses on flood management practices in India. Annex D describes climate change impacts including a brief summary of the scientific literature on current methods for issuing long-range forecasts of Indian summer monsoon rainfall, projections of changes in mean and extremes of monsoon rainfall under climate change, and some salient future research needs. Annex E lists the people met and consulted during the field visits in June 2013. Annex F describes the institutional frame work. Annex G describes economic aspects. Annex H describes data requirements including the initial process of data acquisition guided by Advisor (Technical), CWC. Annex I provides updated terms of reference (TOR) for Phase 2 of this TA. Annex J describes community perspectives on flood issues and management practices. Finally, Annex K summarizes the discussion during the Project Steering Panel meeting on 26 January 2014.

II. FLOOD PRACTICES

A. International Practices

15. The concept of Integrated Flood Management as outlined and promoted by the Associated Program on Flood Management is being adopted in many countries. Implementation of the approach is well established in Europe where the European Union Floods Directive gives a very clear description of what is expected of member states.

16. Central to the development of integrated flood management plans is the creation of river basin organisations (RBOs). Different models exist for RBOs. In England and Wales, the Environment Agency is an executive non-departmental public body that develops and implements IFMPs. This is a very neat organisational model and the agency has the role of a RBO. In other countries different models exist where responsibilities for flood management are dispersed between different organisations and states in a river basin. In these cases the role of a RBO is as a central co-ordinating body. The International Commission for the Protection of the Danube River (ICPDR) is an example of a model that could map to the river basins of India. On a much smaller scale, the role of the Scottish Environmental Protection Agency in Scotland as a co-ordinating body is another example of where RBO functions can be performed without divesting responsibilities from organisations that have a current role. The keys to successful IFM are transparency, cooperation, co-ordination, inclusion and solidarity.

17. The fundamental building blocks for creation of an Integrated Flood Management Plan (IFMP) for any particular basin are as follows:

- digital terrain model for catchment delineation;
- digital terrain model of floodplains (ideally based on LiDAR);
- catchment land-use and soils data (derived from satellite imagery);
- hydrological rainfall-runoff modelling to produce flood hydrographs at a range of return periods;
- river cross sections for the length of river that creates significant flood, and survey of bridge / culvert openings and other features that may restrict flow;
- computational hydraulic modelling to produce flood inundation or flood hazard maps at a range of return periods;
- detailed floodplain land-use mapping using satellite imagery (roads, embankments, commercial and industrial properties, public utilities (e.g. water treatment, electricity sub-stations, etc.), residential properties and property classifications);
- survey of levels of roads and typical floor levels of properties in the floodplain;
- flood risk mapping (combination of flood hazard maps with land-use).

18. Once flood risk maps are prepared it is possible to begin creation of the IFMP. It is necessary to establish planned developments: urban expansion & urban infrastructure, roads, railways, water supply, waste disposal, power, agriculture and irrigation, forestry etc. Then follows identifying and evaluating potential flood mitigation measures - structural and non-structural.

19. It is clear that non-structural measures have to play an increasing role in flood management. With increasing flood hazards and risks, residual risk is increasing. For existing flood defences, it is likely in many places that the standard of protection is declining with increasing flood frequency and magnitude under climate change.

20. Annex B contains detailed background.

B. Flood Management Practice in India

1. Technical and Planning Aspects

21. The review of current flood management practices in India has led to a number of conclusions with regard to issues that should be addressed as a part of Phase II of this ADB TA:

- In view of the fact that various recommendations made by committees considering flood issues in the past have not been implemented, it is of paramount importance to undertake a detailed examination to identify the practical difficulties and possible reasons that have prevented implementation of various recommendations that were considered most appropriate at the time of finalization of the committee reports. This would require examination of not only the technical and institutional aspects but also the social and financial aspects. It is clear from many past reports that the requirements of IFRM are well understood, but the modality for its implementation has yet to be found.
- In preparing all future reports, emphasis should not only be on 'ideal' or 'most appropriate' solutions. The solutions must be practical and implementable.
- The activities related to flood management (particularly flood forecasting) require highly specialized technical units with experts from the field meteorology, hydrology, communication etc. Government policy of moving staff is not conducive to the sustainability of specialized units, and the opportunities that exist for specialised staff in the private sector need to be recognised when reviewing pay and promotion prospects.
- A number of hydrological models have been developed for selected flood forecasting sites with the objective of improving the accuracy of flood forecasts and also to increase the warning time. However, these models are not being widely used and earlier models based on statistical relationships are still in use. The reason for the slow uptake of improved modelling approaches needs to be assessed.
- Despite several recommendations and some pilot studies into flood inundation modelling, the flood forecasts are still in the form of water level forecast. Forecast of

the likely inundated areas due to incoming floods are still not made. There must be an assessment of how inundation forecasts can be more widely introduced.

- Design criteria for flood embankments, and particularly freeboard allowances should be reviewed in the light of the longer hydrological records that now exist, and with adoption of integrated flood risk planning which would include structural as well as non-structural measures.
- Community participation has been advocated by almost all of the committees and experts that have addressed flood issues, and several pilot projects have been implemented. However, a working model eludes. Investigations need to identify the most appropriate models for community participation during the course of (a) planning and design, (b) implementation, and (c) operation and maintenance etc.?
- Benefit cost analysis is a pre-requisite for appraisal and acceptance of flood control projects. However, existing procedures and guidelines for assessment of benefits continue to be questioned, particularly with regard to the indirect benefits which are large and not properly accounted for.

2. Institutional Aspects

22. From the institutional perspective, FRM responsibilities can be grouped into two broad roles i.e. i) flood forecast and warning system and ii) food mitigation measures. While flood forecast is the mandate of Central Water Commission, dissemination of flood warning and implementation of flood mitigation measures fall in the domain of the state revenue department and technical arms of the state governments. Based on the current understanding, improvements to the existing arrangements are suggested below. This will be updated and fine-tuned after the detailed focal sub-basin scoping study.

23. Flood loss estimates: There are divergent flood damage estimates within and between states, and the Central Water Commission depends on state inputs for national estimates. Flood damages are currently estimated based on simplified assumptions, because the existing data is insufficient for an accurate assessment. These assessments need to be improved, and assessments of indirect damages included also. There is a requirement to develop standardised approaches to flood damage estimation that can be used at the state level.

24. Flood Management Programs**:** Flood Management Program Guidelines follow a scheme based approach focusing primarily on resource allocation between the centre and the states for flood mitigation. The resource provision for prevention and preparedness activities is minimal. Provision for flood insurance does not exist as a preventive measure.

25. Community Participation**:** There is very little community participation or input to the planning or design process in flood risk management.

26. Public Awareness**:** There is a lack of awareness of flood hazards, and preparedness for flood disasters. The national disaster management system promotes the governments to undertake large-scale preparedness measures such as awareness generation. Some state governments have initiated mass awareness generation activities on disasters and its management through different programs. For example, under the UNDP sponsored Disaster Risk Management Program, sensitization meetings were held in the state of Odisha to generate awareness about flood and cyclone management.

27. Disaster Management**:** The shift from a relief approach to the promotion of a prevention and preparedness culture is the major strength of the current national disaster management system. Re-designating the centre and state relief departments as disaster management units and departments is a first step towards this move. Following the new nomenclature the tasks of the departments at various government levels are being redefined with emphasis on preparedness, development of databases and preparing them to manage disaster/emergency situation more efficiently. The national disaster management guidelines have made a good beginning in this area. This needs to be promoted across agencies at all levels.

28. The District Planning Committee plays a central role in the district planning process by consolidating rural and urban plans of the district, leading to a draft development plan for the district. The DPC provides the link between rural and urban plans as well as sector plans and crucial to the local planning process which is the mandate of local governments. The planning process being carried

out in the district is largely sector-specific and the DPCs play an instrumental role in integrating sector plans for a unified district plan. Although flood management is implicit in the disaster management component of DPCs, the capacities of the local governments to plan and execute flood responses are extremely weak. So is the fund flow to local governments. Therefore, it is necessary to build flood preparedness, response and relief as an implicit component of DPCs, especially in the most flood prone states. There also has to be vertical integration of district level plans into the river basin context and an IFRM approach.

29. IFRM requires a river basin approach. Several committees and previous reports have identified the need for river basin organisations to be formed for the creation of IFRM plans. Such organisations need to be capable of performing an inter-state role. A key aspect of Phase II studies has to be in developing institutional models for river basin organisations with responsibilities for developing or co-ordinating the development of integrated flood risk management plans at the basin scale.

30. The budget allocation practices in the planning system are based on two major types of expenditure i) Plan Expenditure and ii) Non-plan Expenditure. Routine repairs and schemes of flood embankments and other structural measures are covered under non-plan funds. Once the funded projects have been completed maintenance is financed through non-plan expenditure, the budget allocations to such schemes generally are just about adequate to meet establishment costs.

31. Technical skills, coordination during relief and community participation during rehabilitation are key factors for successful post-disaster management. Similar is the case with non-technical skills, especially at the cutting-edge level of governance i.e. local governments and field staff of technical departments. Development of knowledge base needs to be strengthened to understand and analyse historical river processes, flooding patterns and erosion threats. It is necessary to promote co-operation and exchange of ideas and information between agencies through workshops, training and community meetings. National Disaster Management Authority has demonstrated this successfully by including of all national and state level research institutes, to promote a long term sustainable knowledge development. Disaster management needs to be integrated at the planning process at district, block, GP and city levels through leadership from the states. The Zilla Panchayats and Block Panchayats in rural areas and the Urban Development Departments in towns have an important role to play.

32. Communities are normally flood resilient. They adapt quickly to emergencies. This coping mechanism comes in repeated annual cycles carrying heavy coping costs. There is a need to generate higher level of flood awareness, in order to proactively respond to flood emergencies as well as prepare themselves to respond proactively. Therefore, the need for community education on flood management becomes an important concern of FRM.

3. Community Participation

33. While literature is available on implementation of IFRM projects that involve communities, literature is also available on flood management programmes that have adversely affected communities. An example is an account of flooding and flood management in the Kosi river basin. The lessons derived out of several programmes aimed at flood management in the Kosi river basin are illustrated in the book published by Peoples Science Institute, Uttarakhand and SANDARP, Delhi-'Trapped between the Devil and Deep Waters'.[4] The book provides a historical account of past efforts made to tame the Kosi river. The book explains how the flooding problem has shifted from one place to another, from one population to another, affecting livelihoods from agriculture, livestock, fisheries, fuel, sanitation in flooded areas, status of education, child labour, health services, migration, criminalisation etc.

34. An evaluation of the UNDP disaster risk management programme illustrates factors influencing community participation in the UNDP DRR:

- Non- occurrence of major disaster leading to complacent attitudes;

[4] Trapped! Between the Devil and Deep Waters, Dinesh Kumar Sinha, August 2008.

- Competing livelihood needs , law and order hindered interest and involvement of community in programme activities;
- Training was provided on disaster risk mitigation but the community was not provided with equipment to support their activities;
- Involvement of PRI /local government was not uniform and thus affected the programme and communities participation;
- There was a lack of documentation of traditional coping mechanisms;
- More inclusive approach desired to involve the vulnerable groups within the communities;
- People were shy to adapt participatory approach resulting in partial exclusion of NGOs;
- Lack of trust filled partnership between the local government and NGOs.

35. It is clear from recent approaches and is also reflected in policies and programme guidelines that community involvement is an important element of effective IFRM and that their participation should be ensured at all stages of the implementation cycle. Flood risks can hence be better addressed through a more robust community involvement in both structural and non-structural measures at planning and implementation phases. This can be much beyond community education on residual risks.

36. Along with the capacity building of the local government and local communities there needs to be integration of existing programmes implemented by various line departments. Leadership is crucial among the factors that influence the programme performance and hence there is a need to address factors influencing effective leadership and programme involvement. This translates into the need for training of government officials and authorities.

37. Evaluation of available studies illustrates that there is still a great scope for engaging communities, especially women, with more emphasis on the quality of participation rather than the numbers involved. While addressing community participation, it is also critical to address the well-being and concerns of the vulnerable groups within the communities including women, children, disabled, indigenous groups, and minority groups to formulate an inclusive and participatory flood management strategy and design future programming needs to address inclusion and gender equity.

38. The programmes should also address the varying nature of vulnerabilities of these groups and the capacity of communities and other stakeholders. The community needs and risks should be assessed so that the programmes are realistic and not too ambitious also with respect to availability of resources. The gaps in capacity and expertise, which can be potential barriers in community participation need to addressed by entering into effective partnerships with NGOs, SHGs, NYKS, teachers, Anaganwadi workers, health care service providers, government functionaries and local public representatives.

39. Specific concerns are in urban settings where the communities are more heterogeneous and conventional ways of eliciting community participation are not effective.

40. Annex C provides more background.

III. CLIMATE CHANGE

A. Existing Knowledge and Approach

41. There is now a great deal of literature on the potential impacts of climate change on water resources, and by extension on the potential impacts of climate change on floods. Quantifying the potential impacts of climate change relies on scenario testing. While most global climate models (GCMs) broadly agree on the direction of change of future temperature for most parts of the world under most emissions scenarios, there is less agreement on the magnitude and direction of possible precipitation changes. The outputs of GCMs and nested regional climate models (RCMs) are now often used in water resources assessments. Typically in water resources, different GCMs would be used with one or more RCMs for a number of emissions scenarios to produce a range of scenarios of future climate that can be used as input to hydrological and water resources simulation models to assess potential impacts on water resources. It is generally accepted that there can be no robust

prediction of future climate evolution, and planning must be undertaken within uncertainty bounds, but a physics based modelling approach often lies behind this.

42. With regard to the potential impacts of climate change on future flood magnitudes and frequency, quantification is very much more difficult and elusive, even in scenario terms. Floods are primarily in response to discrete high intensity and relatively short duration rainfall events, in contrast with the long term drought conditions that might be the primary driver in water resources assessments. Precipitation remains one of the least well represented process in global and regional climate models, and this is compounded by scale effects. GCMs are typically operating on a grid scale of about 200 km, and precipitation rates are averaged over very large areas. RCMs might operate on a grid scale of 25 km, but have boundary conditions derived from GCMs, and again high intensity localised rainfall may not be well represented. While the present models may not give robust quantitative estimates of potential future changes in flood producing rainfall events, they will give an indication of likely trends. The literature thus tends to be qualitative rather than qualitative.

B. The Indian Summer Monsoon

43. The summer monsoon rains represent India's great source of life and great threat to life. These rains that fall between June and September supply about 78% of India's annual rainfall (and above 90% in many of India's regions) – the basis of sustenance of its population and economy. Drier years bring large losses to agriculture and industry, most strongly affecting the poor; though less tragically than in the historical past when such years brought terrible famine and loss of life. In recent years, it has been the monsoon's most extreme downpours of cloudbursts and cyclones (phenomena which are more likely to occur in overall wetter summers) that have caused catastrophic loss of life and material damages – exposing an urgent need for adaptive actions. Long-range forecasting of the monsoon's total rainfall each summer has great value for agriculture, for advance planning to meet food shortages, and for early flood warning.

44. While statistical methods have been used for forecasting summer monsoon rainfall for over a century with periodic improvements, the predictive skill of current methods remains limited, albeit surpassing the skill of dynamical models. But recent research developments that combine dynamical and statistical approaches offer promise for improved skill. The long-range forecasting of extreme rainfall and flooding risk is a yet bigger challenge requiring future research. The other big challenge is the ability to project the response to future climate change. What changes can we foresee for the summer monsoon's mean rainfall totals, and for its flood-generating extremes? The available scientific means for exploring these question are the coupled ocean-atmosphere global climate models (OAGCMs, or simply GCMs), but their application to simulating historical and future characteristics of the Indian summer monsoon has important limitations. One GCM, that has tested as best for the Indian monsoon region, indicates a likely moderate increase in mean summer rainfall and increase in the frequency of extreme rainfall events and flood risk – with the significant caveat that atmospheric black carbon, an important climate forcing possibly capable of counteracting those effects in this region, is currently not accounted for in GCMs.

C. Climate Change Impacts in India

45. A number of studies try to identify potential climate change impacts. A few are highlighted here, while a more detailed review is provided in Annex D:

- The United Nations Development Programme (UNDP) "Human Development Report 2007/2008" (UNDP, 2007) broadly highlights the development issues associated with climate change. The effect on climate change on water is likely to affect humanity most. The UNDP report (UNDP, 2007) identifies that it is the poor who are bearing the brunt of climate change and that in the future it will be humanity as a whole that faces the risks that come with global warming.
- The United Nations World Water Development Report 2 "Water a Shared Responsibility " (UNESCO, 2006) states that "…in many countries there is a huge deficit of water storage and flood protection infrastructure at all levels and scales, which will be aggravated, especially in the light of increased climate variability and volatility".

- The World Bank report titled "India's Water Economy Bracing for a Turbulent Future " (World Bank, 2005) identifies number of critical issues, ranging from an increase in flooded areas, to more widespread water scarcity implying the need for large investments in water storage, and the need for improved management of water resources including floods.
- The Ministry of Environment & Forests in "India's Initial National Communication to the United Nations Framework Convention on Climate Change " (Ministry of Environment and Forests, Government of India, 2004) clearly states that "India has reasons to be concerned about the impacts of climate change".

D. Government Initiatives – An Overview

46. The Government of India has taken a broad number of initiatives to progress climate science in India, and to improve understanding of potential climate change impacts. Some key initiatives are (again Annex D provides more detailed background):

- Constitution of Standing Committee for assessment of impact of climate change on water resources.
- Research Project: Assessment of Water Resources under Climate Change Scenario at River Basin Scale.
- Short and Long-term Action Plans for Studies and Research.
- Establishment of Professional Chairs at different universities.
- A large number of specific studies, completed or on-going conducted by prominent universities and organizations.
- Constitution of the Indian National Committee on Climate Change for promoting research and studies in the area of impact of climate change on water resources.

IV. CONSULTATION PROCESS AND SELECTION OF FOCAL SUB-BASINS

47. Confirmation of the scope of work for Phase 2 and the selection process for the sub-basins took place in several stages between March and May 2013. Numerous stakeholders from central government, flood affected states, and knowledge institutions were involved as detailed in the following sections.

A. Initial Consultative Process

48. The PATA started with consultation meetings with central government organizations in March 2013, involving the main stakeholders responsible for implementing both structural and non-structural measures for flood management. While structural measures are oriented towards prevention and preparedness, non-structural measures, which historically concentrated on response, relief, and recovery, are increasingly geared towards preparedness. Table 1 classifies the key central government organizations and the main focus of their work.

Table 1: Central organizations and flood relevant focus

	Structural measures	Non-structural measures
Organization	Ministry of Water Resources Central Water Commission Ganga Flood Control Commission Water Resources Departments Dam Safety Organizations	National Disaster Management Authority Central Water Commission
Focus	Proactive: Prevention (embankments, anti-erosion works) Preparedness (flood shelters)	Proactive: Preparedness (flood forecasting and warning, awareness building and education (training), insurance) Reactive: Response, relief, and recovery

49. Key points raised by Central organizations, and further detailed in the inception report are:

- Flooding is a key obstacle to development. The most common causes are natural river and coastal floods, and sometimes flow releases from dam operations.
- Government prefers to consider floods from a drainage basin perspective.
- Government prefers prevention and preparation over relief and rehabilitation. In this respect, flood plain zoning plays a fundamental role.
- Government desires a holistic, coordinated approach balancing structural and non-structural measures following international best practice.
- There is a need to better understand potential climate change impacts on IFM.
- PATA 8089 should develop models that are replicable for other sub-basins. In this respect flood hazard and risk mapping and techniques to increase the capacity of local populations to cope with floods are very important. The six most flood-prone states - Andhra Pradesh, Assam, Bihar, Odisha, Uttar Pradesh, and West Bengal - provide a good starting point. The PATA provides a good opportunity to update existing Flood Management or Master Plans.

50. More detailed documentation on the initial consultation meetings is provided in the Inception Report of May 2013.

B. Round Table Discussion

51. Nine States[5] , five national organizations[6] and six research organizations[7] exchanged views on integrated flood management and developments on 3 April 2013 at a round table meeting held at the invitation of CWC and ADB. The meeting generally agreed that:

- Most flooding results from river floods, mostly with sufficient lead time for response, with some events due to man-made dam-release floods. Coastal and local flash floods are other fairly common problems.

[5] Five of the six most flood prone states, namely Andhra Pradesh, Bihar, Odisha, Uttar Pradesh, West Bengal, and in addition Gujarat, Maharashtra, and Uttarakhand.
[6] Ministry of Water Resources – National Water Mission, Nation Disaster Management Authority, Central Ground Water Board, Central Water Commission, Ganga Flood Control Commission.
[7] IMD, NIH, NIT Srinagar, NRSC, Survey of India, IIT Roorkee.

- A need to better understand flood hazards is widely perceived, despite recent developments in flood mapping based on observed flooding patterns.
- The current high degree of dependence on embankments does not alone solve the problem, as on the whole they do not have a good track record. Dams can mitigate floods, but their operation for flood control can cause complications.
- Non-structural measures present a mixed picture:

    - While flood forecasting and warning works well for large rivers, it is not reliable for flash floods.
    - Adequate flood response by local populations is often well developed, as demonstrated by comparatively small numbers of casualties even during high floods.
    - State governments are piloting a number of preventive measures, with room for further development especially in terms of outreach to communities.

52. The participants generally considered that PATA 8089 should focus on:

- Natural river floods, with consideration of dam release problems.
- The development of flood management planning measures for two basins plus a continued process of regular information sharing and discussion, rather than focusing on one basin with only rudimentary work in two others.
- Community issues and measures to increase community resilience.
- New technologies to assist land-use zoning, starting with flood hazard and risk mapping.

53. Contributions from the participants are documented in the Inception Report of May 2013.

C. Guidance from Project Review Committee

54. During the first project review committee meeting held on 14 May 2013 the Ministry of Water Resources provided the following guidance:

- With emphasis being placed on River Basin Organizations, consider coordination issues between the different government agencies involved and how to move towards integrated management.
- Consider improvements in the development of flood master plans, specifically with respect to digital elevation models and flood simulation modelling.
- Consider means by which GoI and State Departments may increase community resilience against floods.
- The need for replicability calls for a focus on large floodplains, specifically the Ganga and some coastal plains, with typical problems found more in the eastern part of the country.
- Consider developing flood management planning measures for two basins, instead of addressing one fully and two others in a rudimentary fashion only. One basin should be within one state (intra-state) and the other should cover two states (inter-state).

55. Details of the meeting are provided in the Interim Report (See Appendix C, pages 123 - 128).

D. State Level Consultation

56. Subsequent to the project review committee meeting the states of Bihar and Odisha were visited for detailed state consultations.

1. Bihar

57. The consultation meeting in Patna on 15 May 2013 involved central and state-level organizations[8] . A number of potential interstate and intra-state basins were discussed. It quickly became apparent that the typical flooding problems experienced in Bihar were associated with the northern Ganga tributaries. Given that most rivers flow from Nepal, timely data availability for basin modelling will be an issue. The most representative basin would be the Burhi Gandak, which only marginally includes Nepali territory and is not covered by any on-going program of the State Government. The participating organizations named nodal points for future coordination of PATA activities. The discussions are documented in detail in the Interim Report (Appendix C. page 129 - 134).

2. Odisha

58. The consultation meeting held in Bhubaneshwar on 16 May 2013, involved relevant state and state-level organizations[9] . The discussion quickly prioritized issues relating to the deltaic plains, which account for the dominant flood problems. Of the three basins contributing to the delta, the Mahanadi, covering five states, is the largest, while the Brahmani covers two states and the Baitarani lies entirely within Odisha. The participants informed that there are several on-going and planned programs for the Mahanadi, but the combined Brahmani/Baitarani basin is not yet covered. The Brahmani has one dam, operated by the WRD. The participating organizations named nodal points for future coordination of PATA activities. Details of the discussion are documented in the Interim Report (Appendix C. page 135 - 138).

E. Confirmation of Basin Selection

59. The suggested basins involve a number of relevant issues and meet the selection criteria voiced during the consultative process in the following ways:

- they cover the most flood-prone states of Bihar and Odisha;
- they allow for replicability of representative natural river and coastal flood issues;
- climate change is relevant to expected future impacts of rainfall, river floods and sea level rise;
- there are no on-going similar initiatives in the basins;
- they have developed SDMAs for community outreach towards increased preparedness and resilience;
- the states express interest and willingness to participate in the TA and nominated nodal points for different organizations.

60. Key information for each basin is summarized in Table 2.

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[8] GFCC, CWC, NIH, WRD, BSDMA.
[9] WRD Ministry, CWC, WRD, OSDMA, Odisha Water Planning Organization.

Table 2: Basin relevance to core selection criteria

	Burhi Gandak	Brahmani/Baitarani
States	Bihar	Jharkhand (upstream), Odisha (downstream)
Flood Issue	River flood – Ganga plain	River flood – deltaic plain Sea level influence High local rainfall (cyclone)
Dam	none	Rengali Dam
Climate change issue	Increased river flooding Changes in rainfall duration and intensity	Increased river flooding Sea level rise Changes in rainfall duration and intensity (cyclones)
Data availability	IMD rainfall gauge stations CWC gauge stations	IMD rainfall gauging CWC river and rainfall gauge stations WRD gauge stations

V. INITIAL FIELD INVESTIGATIONS

A. Bihar – Burhi Gandak Basin

1. Basin Description

61. The Burhi Gandak flows between Gandak and Bagmati rivers in south easterly direction from the Himalayas until it meets the Ganga at Khagaria, some 100km east of the state capital Patna (Figure 1). The around 20,000km² large catchment lies between 83.6oE 28.0oN and 86.7oE 25.3oN. More than 200 km of the downstream river course is embanked often at both banks.

Figure 1: Burhi Gandak with gauge stations from different organizations (FMISC, WRD, Bihar)

62. The river course exhibits mostly single meandering channel with a well-defined low-water channel (Figure 2). The floodplains especially behind the embankments are used for agriculture.

Figure 2: Photos of the Burhi Gandak in Muzzafarpur (top) and Samastipur (below) district

63. Bihar is the most flood affected state in India, having around 17% of the flood prone area of the country with 30 out of its 37 districts being flood-prone (NRSC, 2013). Four of the six districts through which the Burhi Gandak flows are among the top five worst flood affected districts in Bihar (Figure 3), according to the flood hazard index[10] .These four districts are Khagari, Samastipur, Muzaffurpur, and East Champaran, and their flood hazard characteristics are given in Table 3. Figure 4 displays the flood hazard[11] for Muzaffarpur and Samastipur as identified from satellite analysis (NRSC, 2013).

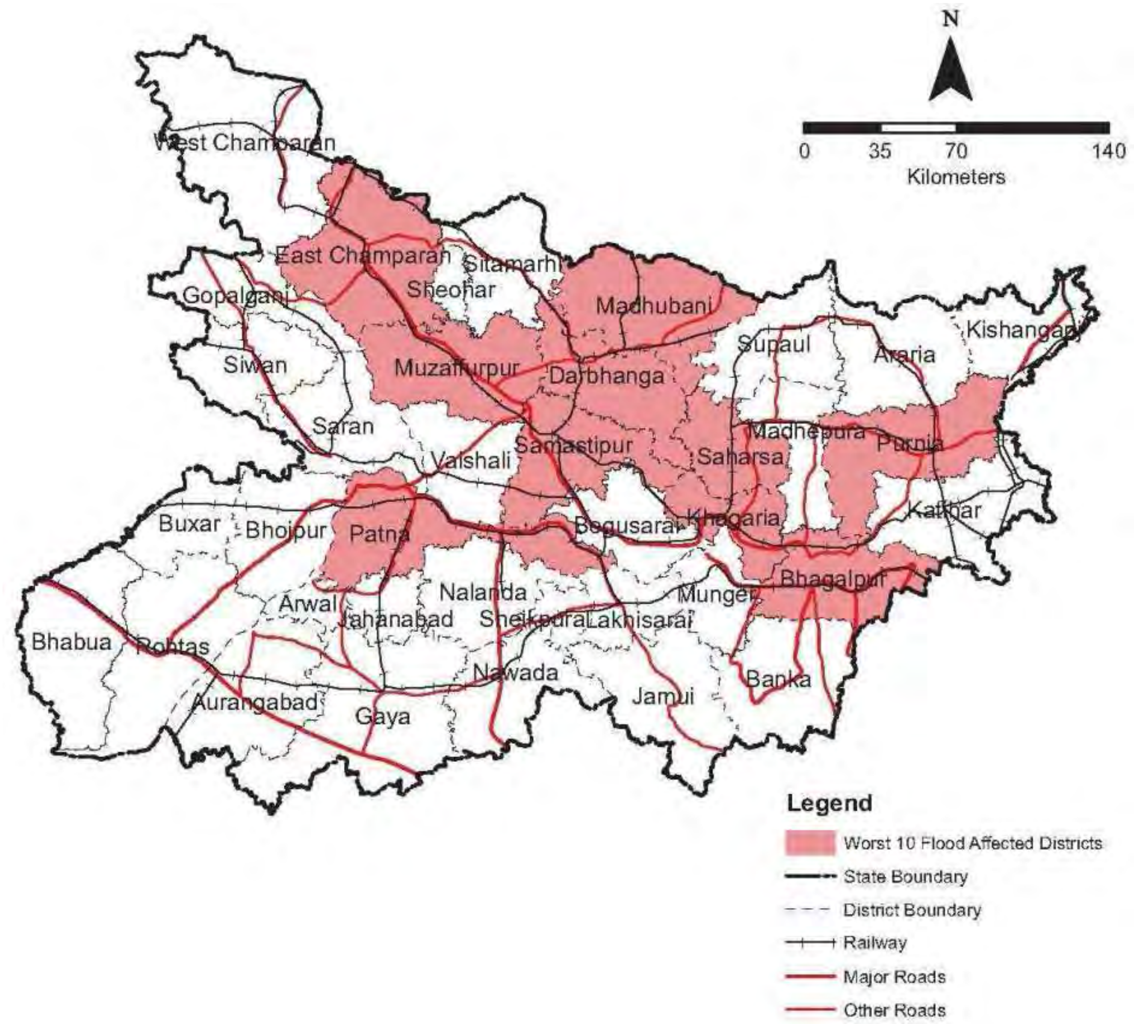


Figure 3: Worst flood affected districts in Bihar (NRSC, 2013)

10 For the methodology of calculating the flood hazard index refer to Figure 21 in the Bihar Flood Atlas, 2013. The Flood Hazard Index FHI = ∑(Hw*Aw)*∑(IAVw)), where Hw = hazard category, Aw = hazard area, IAW = intra annual variations.

11 The flood hazard was derived from satellite imagery of annual flooding during the 13 year period from 1998 to 2010. The flood hazard was determined based on the number of years an area was flooded. The five categories distinguish: very low: 1-2 times, low: 3-4 times, moderate: 5-7 times, high 8-10 times, and very high 11-13 times. There is no flood frequency associated with this definition of flood hazard.

Table 3: Characteristics of worst flood affected districts (NRSC, 2013)

District	District Area (Hectares)	Total Flood Hazard Area (Hectares)	% Flood Hazard Area	Flood Hazard Index
Khagaria	148,600	96,578	64.99	150
Samastipur	290,400	124,649	42.92	108
Muzaffurpur	317,200	136,324	42.97	102
East Champaran	396,800	168,380	42.43	95

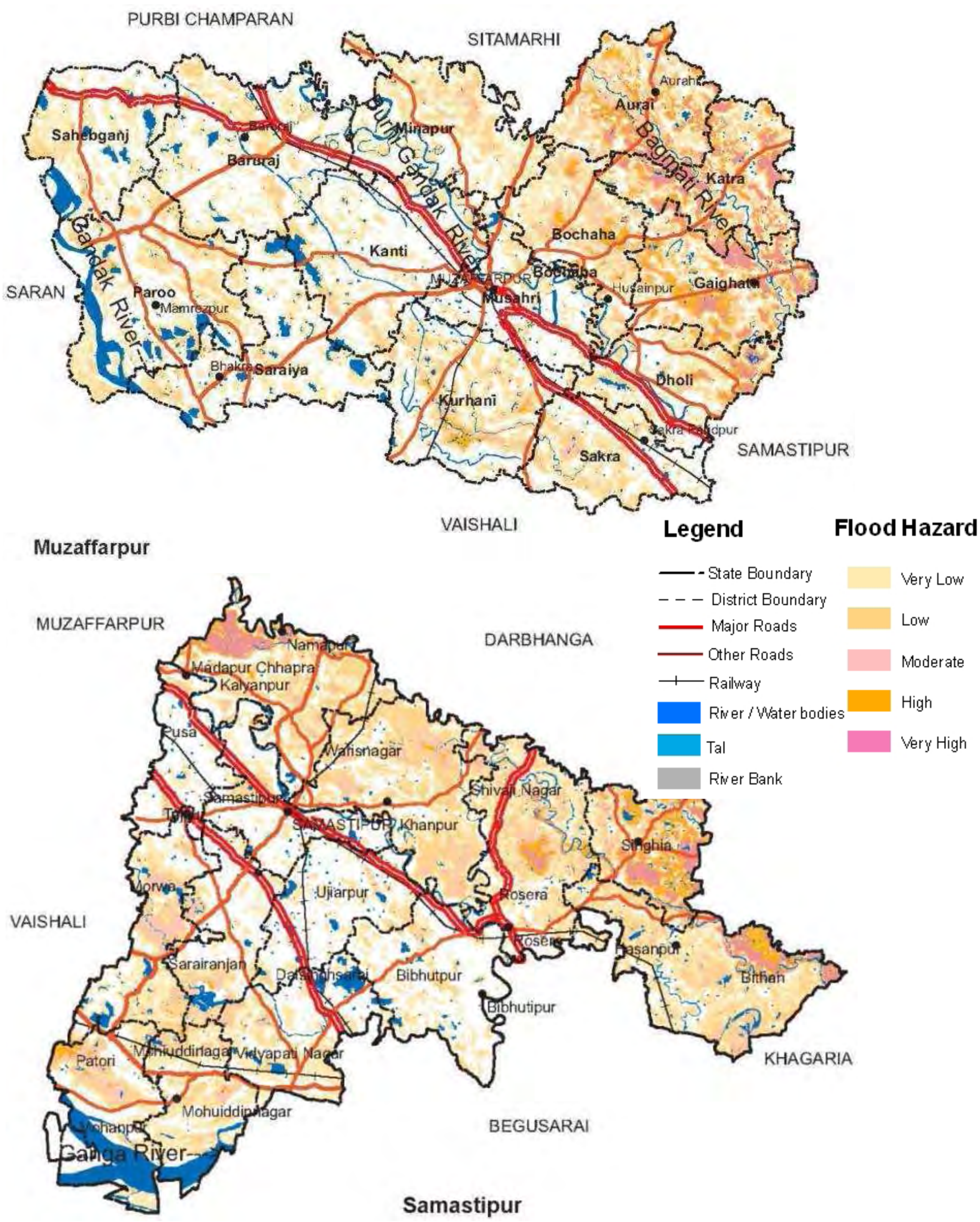


Figure 4: Satellite based flood hazard maps for Muzaffarpur (top) and Samastipur (bottom) (NRSC, 2013)

64. As a "short term" protective measure, 320 km of flood embankments have been built along critical river reaches of the Burhi Gandak. State-wide 3,430 km of embankments have been constructed since 1954, protecting around 2.9 million ha from regular flooding. In the Burhi Gandak basin only about 12% of the 0.21 million hectares of "water logged" area has been protected.

2. Socio-economic Environment

65. Bihar has a primarily agrarian economy characterized by an extremely high population density and poverty – the highest in India –, especially in the districts north of the Ganga. The per capita income is INR 26,800 (USD 500, 2012/13) with a GDP of INR 144,278 (USD 2500, 2012/13), corresponding to about 40% of India's national average, and over 50% of the population lives below the poverty line. Additionally, the Poverty Head Count has not improved since the mid-1980s, standing at 53.5% for 2009/10, while the all-India figure is 29.8%. While Bihar leads the poverty rate in urban areas with 29.4% in 2009/10, it ranks second in rural areas with 55.3%. Bihar has the second lowest urban population at 11.3% of the total population and the thirds highest population density at 1,106 persons/km².

66. North of the Ganga, high population density coincides with the highest percentage of flood hazard areas and below average GDP (Table 4). Development of irrigation has been given top priority, with substantial investments for creating irrigation potential. The ultimate irrigation potential in Bihar is put at 9.8 million ha. Approximately 2.8 million ha have been provided with irrigation using 15 major and 78 medium schemes, with some others under development.

Table 4: Key socioeconomic data (Source: NRSC, 2013 and Finance Department, 2013) (continues)

District	Total area [km²]	%age covered by Burhi Gandak	Total Flood Hazard Area [km²]	% Flood Hazard Area	Cropped Area [km²]	High and very high hazard cropped area [km²]
West Champaran	5,228	69	568	11	344	17
East Champaran	3,968	53	1,684	42	1,005	75
Muzaffarpur	3,172	60	1,363	43	943	115
Vaishali	2,036	69	492	24	317	0
Samastipur	2,904	17	1,246	43	702	65
Begusarai	1,918	26	566	30	178	0
Khagaria	1,486	10	966	65	586	217
Munger	1,419	4	158	11	92	1
Bihar	94,163				15,855	1,135

District	Total Population	Population Density [persons/ km²]	Per capita GDP 2009/10 (in 2004/5 prices)	Literacy [%]	Length of national and state highways 2012, [km]
West Champaran	3,922,780	750	9,910	58.1	213
East Champaran	5,082,868	1,281	7,640	58.3	238
Muzaffarpur	4,778,610	1,506	12,246	65.7	300
Vaishali	3,495,249	1,717	10,063	68.6	279
Samastipur	4,254,782	1,465	8,970	63.8	287
Begusarai	2,954,367	1,540	14,322	66.2	138
Khagaria	1,657,599	1,115	7,968	60.9	107
Munger	1,359,054	958	18,669	73.3	108
Bihar	103,804,637	1,102	11,944	63.8	8,591

67. The predominantly agrarian economy is characterised by extreme low labour productivity and highly vulnerable to annual flooding. On average around 15% of the area is flooded annually (Figure 5), affecting a population that has doubled since the early 1980s. Over the last ten years the relief expenditure has sharply increased, both overall and per person (Figure 6). 2007/8 and 2008/9 do not correlate with the area flooded when compared to earlier years.

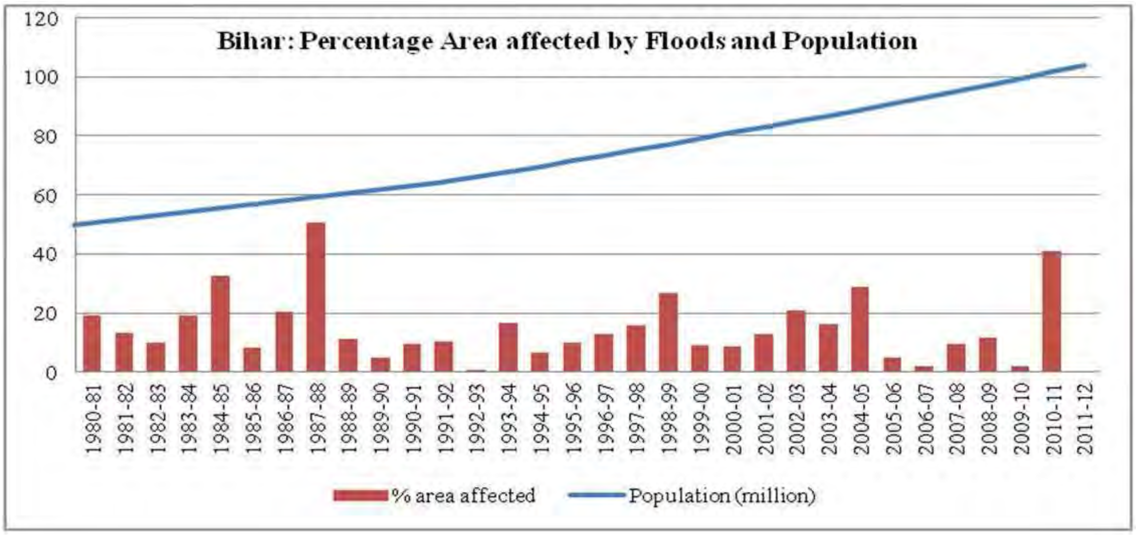


Figure 5: Flooded area and population development in Bihar

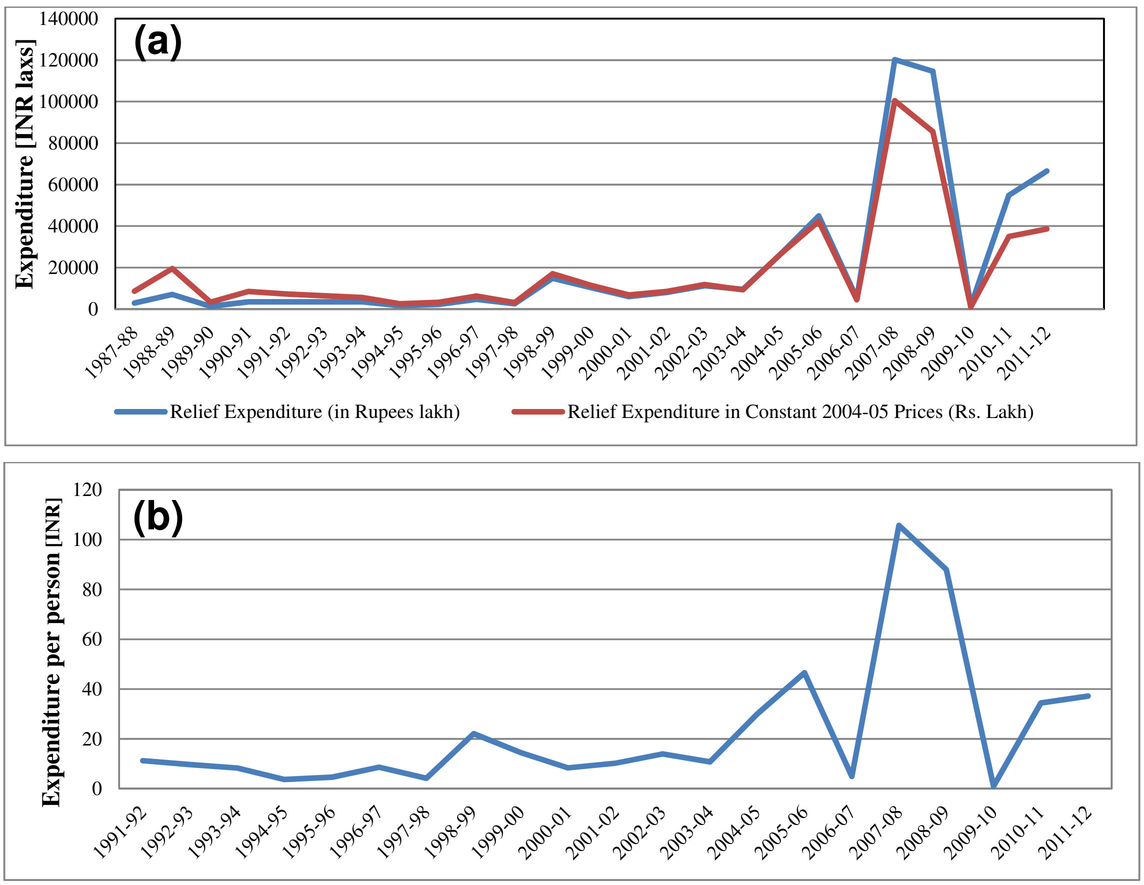


Figure 6: Relief expenditure overall (a) and per person (b) in 2004-05 current prices.

68. Expenditure for relief and recovery are supplemented by expenditure for preventive measures, largely the construction, raising and strengthening of embankments through the Water Resources

Department (WRD). The overall WRD budget also shows a sharp increase over the last ten years (Figure 7). About 40% of the WRD's annual budget is spent on flood management[12] . When compared with the expenditure for relief and recovery, the budget for preventive measures (WRD) and reactive response are roughly equal.

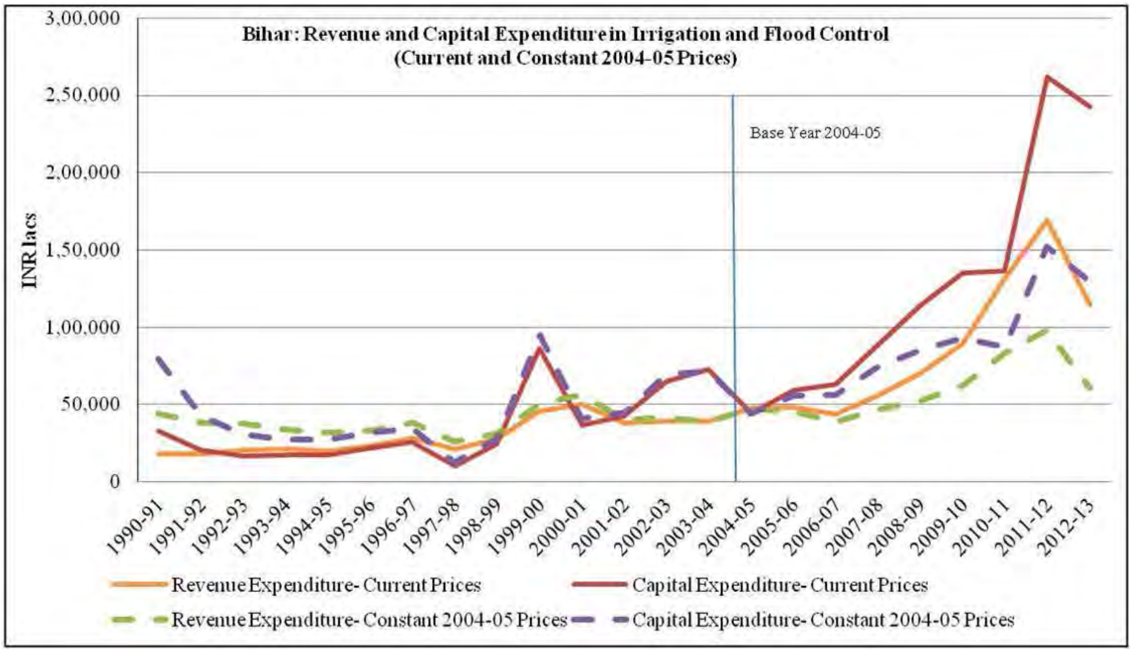


Figure 7: Development of WRD expenditure

69. When compared with the extent of flood damages in the state, the amount spent by the WRD on flood mitigation continues to remain very small. Over the last decade (2000 to 2010), the cumulative expenditure on flood management was only 3% of the cumulative flood damages in the state (valued at constant 2004-05 prices). The State's relief budget is commonly a small percentage of the estimated flood damages (Figure 8). Even during the exceptional year of 2007/8 flood relief expenditure of INR 100,439 lacs stand against damages of INR 6,542,508 lacs, or 15% of the occurred damages.

70. More details are provided in Annex G.

3. Institutional Environment

71. The water policy of Bihar (GoB, 2010) prioritizes water use, with flood and drought management included under Priority 6: environmental etc. (Figure 9). Section 6.2. of the policy makes a reference to flood and drought management aspects, however, without operational guidelines for flood management activities. There is a clear intention of prioritizing drought affected areas. The specific prescription on flood management is narrow and specifies only reactive, post-flood management tasks of developing suitable water and sanitation systems. Consequently, IFM is not specifically addressed by the policy.

[12] SE Flood Management, WRD, 6 June 2013.

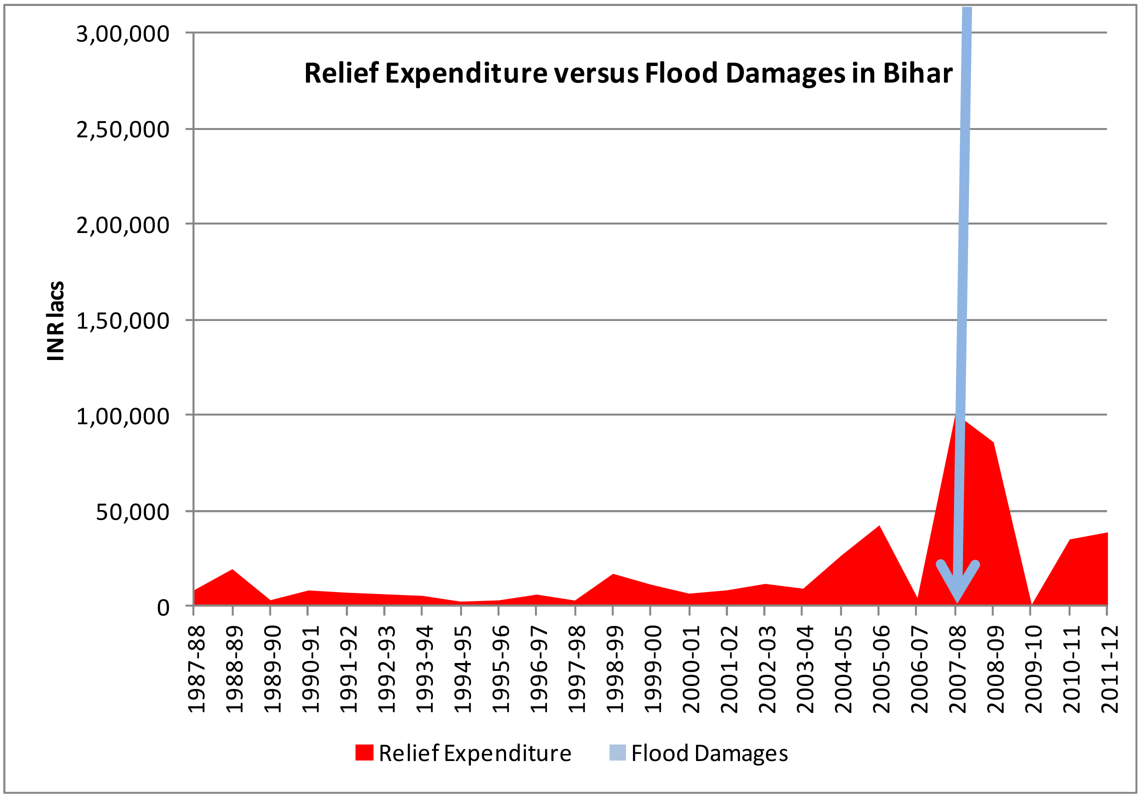


Figure 8: State relief expenditure compared with flood damages (the 2007/8 figure is shown as arrow)

72. The central government organization, Ganga Flood Control Commission, first prepared comprehensive flood management plans for the Burhi Gandak in 1986. This plan has been updated several times. Much information for preparing the plans is obtained from the Water Resources Department and hence depends on availability and quality of the provided information.

73. A number of government organizations play different roles at different levels in relation to floods. Three tiers of state government are distinguished: state, district, and community levels (Table 5). Institutions can also be classified according to whether they deal with structural or non-structural measures (Table 1). Three disaster functions are important - prevention, preparedness, and response - and can be distributed to all three levels as shown in Figure 10. A number of research institutions are active at each level, such as the Water and Land Management Institute (WALMI) and the Indian Institutes of Technology (IITs).

74. The WRD is organized geographically and the implication is that the Engineer in Chief North or South is responsible for both irrigation and structural flood management, under his territory. During the flood season from mid-June to late October, the Water Resources Department operates flood control rooms that receive and disseminate water levels as well as trends and sometimes flood forecasts. Warnings are issued when water levels reach 1 m below danger level, commonly defined as the bankful level of the rivers when they start spilling over to the floodplains.

Priority 1: Drinking water for human beings

Prioirity 2: Drinking water for livestocks

Priority 3: Other domestic, commercial and muncipal uses

Priority 4: Agriculture

Priority 5: Power generation

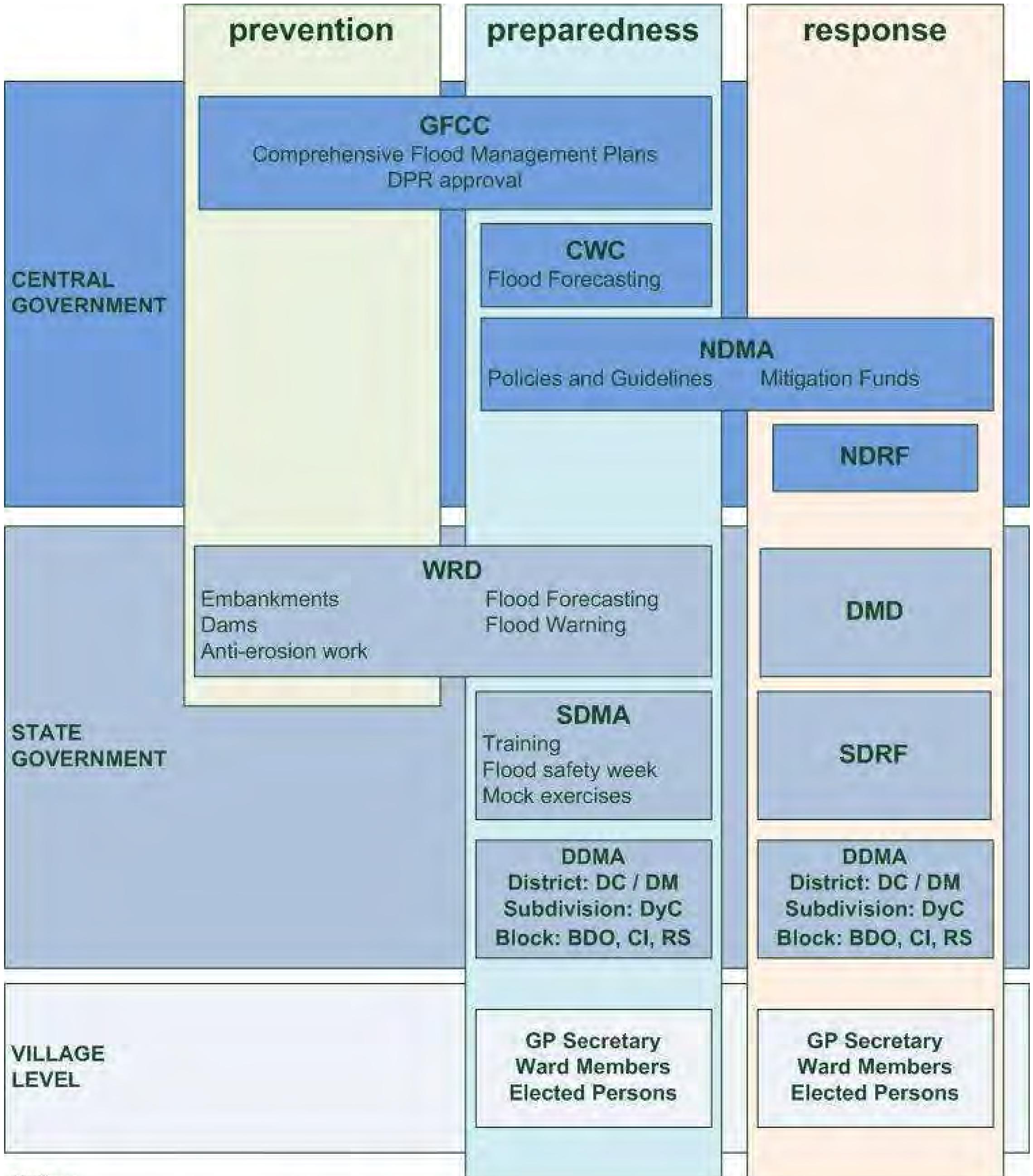
Priority 6: Environmental, ecological, industrial and non-consumptive uses

Prirority 7: Others

Figure 9 Prioritization of water issues in the Bihar State Water Policy

Table 5: Institutions and core functions

	Key Institutions	Core Functions
Tier 1	(i) Water Resources Department (including Irrigation Department),	State level water policy, implementing irrigation schemes and programs, flood control programs, flood losses, coordination with CWC, GFCC and other central agencies, piloting flood forecast, issuing flood alerts etc.
Tier 1	Department of Agriculture,	State level agriculture policy, implementing agriculture schemes, administering subsidies, crop loss estimates etc.
Tier 1	Department of Local Self Government	Coordinating with line departments, administering departmental schemes and programs, certifying beneficiary lists for receiving benefits under flood compensation, organizing relief measures during floods etc.
Tier 1	State Disaster Management Department State Disaster Management Authority, State Disaster Response Force	Post-flood rehabilitation, construction of flood shelters, flood education, community engagement
Tier 2	District Administration, Revenue Department, Divisional Offices of Irrigation Department, District Offices of Agriculture Department, Animal Husbandry Department	Flood monitoring, structural protection measures, flood loss estimation, flood compensation, cattle loss estimate, post-flood fodder distribution
Tier 3	Block Development Office, Gram Panchayats and Urban Local Bodies	Flood mitigation implementation, certification of post-flood beneficiary list, monitoring of schemes, ensuring compliance, managing flood shelters



Notes:

GFCC	Ganga Flood Control Commission
CWC	Central Water Commission
NDMA	National Disaster Management Authority
NDRF	National Disaster Response Force
WRD	Water Resources Department
SDMA	State Disaster Management Authority
DMD	Disaster Management Department (Bihar)
R&DM	Revenue and Disaster Management Department (Odisha)
SDRF	State Disaster Response Force
DDMA	District Disaster Management Authority
DC/DM	District Collector (Odisha) / District Magistrate (Bihar)
DyC/ CI	Deputy Collector / Circle Inspector
GP	Gram Panchayat

Figure 10: Institutional responsibilities with respect to flood management in Bihar.

75. The relatively recently established State Disaster Management Authorities (SDMAs), while very active and bringing new ideas into the IFM process, are currently being integrated into the state level operations. The existing Disaster Management Department has not been absorbed by the Bihar SDMA (BSDMA), but rather co-exists together with the newly formed State Disaster Response Force (SDRF) in continuing the disaster response function.

76. The BSDMA in following the National Disaster Management Act follows a holistic approach[13] which is reflected in its work culture. BSDMA collaborates with related departments primarily at the state level and utilizes expertise available in the NGO sector for disaster management activities. In association with NGOs and CSO partners, it has prepared and released a number of awareness raising and public education materials. Creating an inventory of volunteers and training them in disaster response is a noteworthy achievement of BSDMA.

77. BSDMA has proved to be a 'centre of excellence' for state-wide disaster preparedness activities. Its key strengths are excellent leadership, strong networking at all levels (national, state and lower levels), and encouraging/generating strong political support, consistent training, and preparing and releasing clear guidelines on disaster management. Because of its operational autonomy, BSDMA has been able to retain its staff on a long term basis and maintains a stable institutional setup.

78. More details are provided in Annex D.

4. Community Perspective

79. Three locations, selected after discussion with BSDMA, were visited in the Burhi Gandak basin, covering rural and more urbanized environments (Table 6). The consultation process included individual and group interviews and interactions as depicted in Figure 11 and Figure 12. Participatory Rural Appraisal (PRA) techniques administered in these locations included transect walks, focused group discussions, hazard mapping, priority rankings, semi-structured interviews, etc. Key Informant interviews (KIIs) recorded the perspective of Panchayati Raj Institutions (PRI), village level frontline workers such as school teachers, Kisan Mitra (agriculture extension personnel), ASHA- paramedical staff, Vikas Mitra, block level and district level officials. The tools used for data collection included semi structured questionnaires and interview guides.

80. The Participatory consultations held in the selected villages included local residents in groups of at least 15-25 at a time. All the community consultations ensured presence and participation of at least 30 to 50 per cent women.

[13] Covering the whole spectrum of disaster management: prevention, mitigation, preparedness, response, rehabilitation, and reconstruction.


Figure 11: Consultation process in Bihar (selected photographs)

Figure 12: Local residents showing flood levels during high floods.

Table 6: Key characteristics of the visited focus villages in Bihar

Study Site, Block	District	Characteristic	Population (2001)	Floods
Chak Mahsi, Kalyanpur	Samastipur	Rural	5,705	1987, 2002, 2004, 2007 (highest)
Rosera, Kalyanpur	Samastipur	Urban	27,492	2004, 2007
Rajkhand Uttari, Aurai	Muzzafarpur	Rural	15,691	Annually, 2004 (highest)

a. Flood Behaviour:

81. River floods are a common phenomenon, however with temporal and special variability of extremes. Communities in Chak Mahsi faced the last floods in 2007, whereas Rajkhand Uttari gets flooded every year and experienced a major flood in 2004. The flood risk in Rosera is derived from the two rivers, Buri Gandhak and Kareh, which experienced their last flooding in 2007.

b. Flood Impacts:

82. Communities are aware of both positive and negative flood impacts. There are quite a number of positive impacts:

- Rich soil is deposited onto the fields;
- Floods reduce the population numbers of rats and other animals that otherwise destroy crops and grains;
- Communities receive cash compensations for damages from the Government;
- In Chak Mahsi, livestock is perceived to be safer from theft during the flood season.

83. These positive impacts stand against a larger number of negative impacts, the details of which are reported in Annex E:

- Economic impacts:
  - Loss of assets, mainly houses
  - Loss of livestock or increased diseases
  - Health hazards, such as typhoid, eye infections, gastroenteritis
  - Indebtedness to money lenders
  - Income loss due to lack of paid employment, mostly in agriculture
  - Crop losses
- Social impacts:
  - Need for outmigration, mostly of men, increasing the vulnerability and workload of women with children and elderly
  - Reduced or no education
  - Fatalities, often drowning of children
  - Increased stress levels
  - Disrupted transport and communication
  - Lack of food
- Environmental and health impacts:
  - Stagnant water
  - Snake bites
  - Loss of culture fish
  - Contaminated drinking water
  - Lack of sanitation facilities
  - Lack of safety

c. Flood Preparedness:

84. The communities have multiple ways of preparing themselves for floods. Before the flood season, people stockpile food and fodder, and identify shelters, mostly on embankments or at government owned buildings such as school, Panchayat Bhawans etc. During the flood, rather than depending on direct government warnings, they tend to follow radio or television warnings and apply indigenous knowledge and techniques to predict water levels, such as observing the mango yield on the trees, observing the direction of water current in the river etc. In addition, communities closely watch the performance of the existing embankments and try to provide emergency measures if required. Communities are aware of the fact that flooding in their region depends on the rainfall in Nepal and hence they keep themselves updated on the rainfall in Nepal.

d. Coping Strategies:

85. In the case of disastrous floods there is a large and growing dependency on government help, even though this is considered insufficient or unfairly distributed. Self-help within the communities plays some role. Communities co-operate and assist their neighbours and relatives to deal with the

situation. Direct measures are to move to higher ground, eat and drink less, or accept drinking of unsafe water. Besides emergency sale of belongings to cover the cost of essentials, loans are often taken.

86. The most difficult aspect of recovery is coping with the loss of family members. The community in Rajkhand Uttari reported 2 deaths during the 2004 floods. The loss of life was considered as non-recoverable by the people, while it generally takes from 2 to 15 years to recover from the economic losses. The communities were able to articulate short and medium term recovery strategies addressing the loss of shelter and livelihood. There is a high demand for government support to restore livelihoods and agricultural activities. Communities also asked for interest-free or low-interest credit, compensation and assistance to rebuild houses, and reconstruction of access roads and other damaged infrastructure.

e. Urban Flooding:

87. Separate discussion with the DFID-assisted Support Programme for Urban Reform (SPUR, also known as Samvardhan) on urban flooding at Muzaffarpur revealed that urban drainage is a significant issue, as an open sewer system discharges directly into the Burhi Gandak and has been badly affected by unplanned town development. Some parts of the city, like the northern parts and the Bela Industrial area, face flooding every year. The City Development Plan (CDP) for Muzzafarpur mentions the need for a comprehensive drainage strategy, and the goals of immediate extension and augmentation of the existing drainage network – especially in the areas near to Industrial Area and Zero Mile.[14] The CDP recommends the preparation and implementation of a Drainage Master Plan as a first step to address flooding in Muzzafarpur.

88. More details are provided in Annex J, Part A.

B. Brahmani/Baitarani

1. Physical Environment

89. The Brahmani and Baitarani rivers flow between the Subarnrekha and Mahanadi in a south-easterly direction from Jharkhand into the Bay of Bengal, some 100 km east of the Odisha state capital Bhubaneswar (Figure 1). The around 32,000 km² catchment lies between 83.5oE 23.8oN and 87.0oE 20.5oN with 67% of the basin in Odisha, 30% in Jharkhand and 3% in Chhattisgarh. The delta consists of an intricate set of channels often shared by several rivers (Figure 14).

90. The downstream river exhibits mostly fairly straight channels with sand bars in places and with a well-defined low-water channel (Figure 15 and Figure 16). The floodplains are used for agriculture.

91. The deltaic area of the Brahmani and Baitarani is covered by a number of old irrigation projects, some built as early as the 1870s (Figure 17) and fed from "high level canals" starting at upstream river diversion points.

[14] City development Plan Muzzafarpur (2010-30).

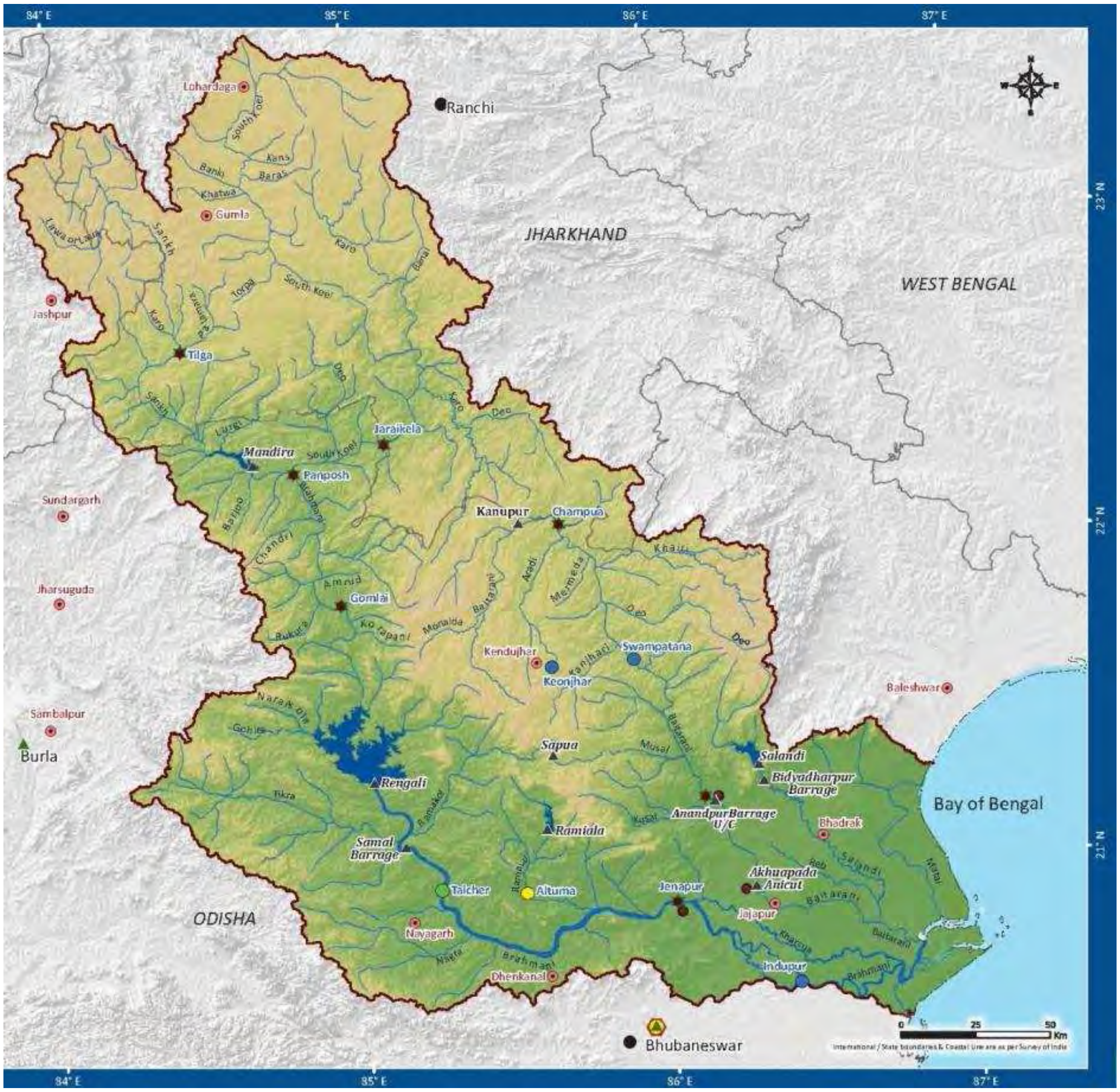


Figure 13: River basins in Odisha (source: MoWR, 2012)

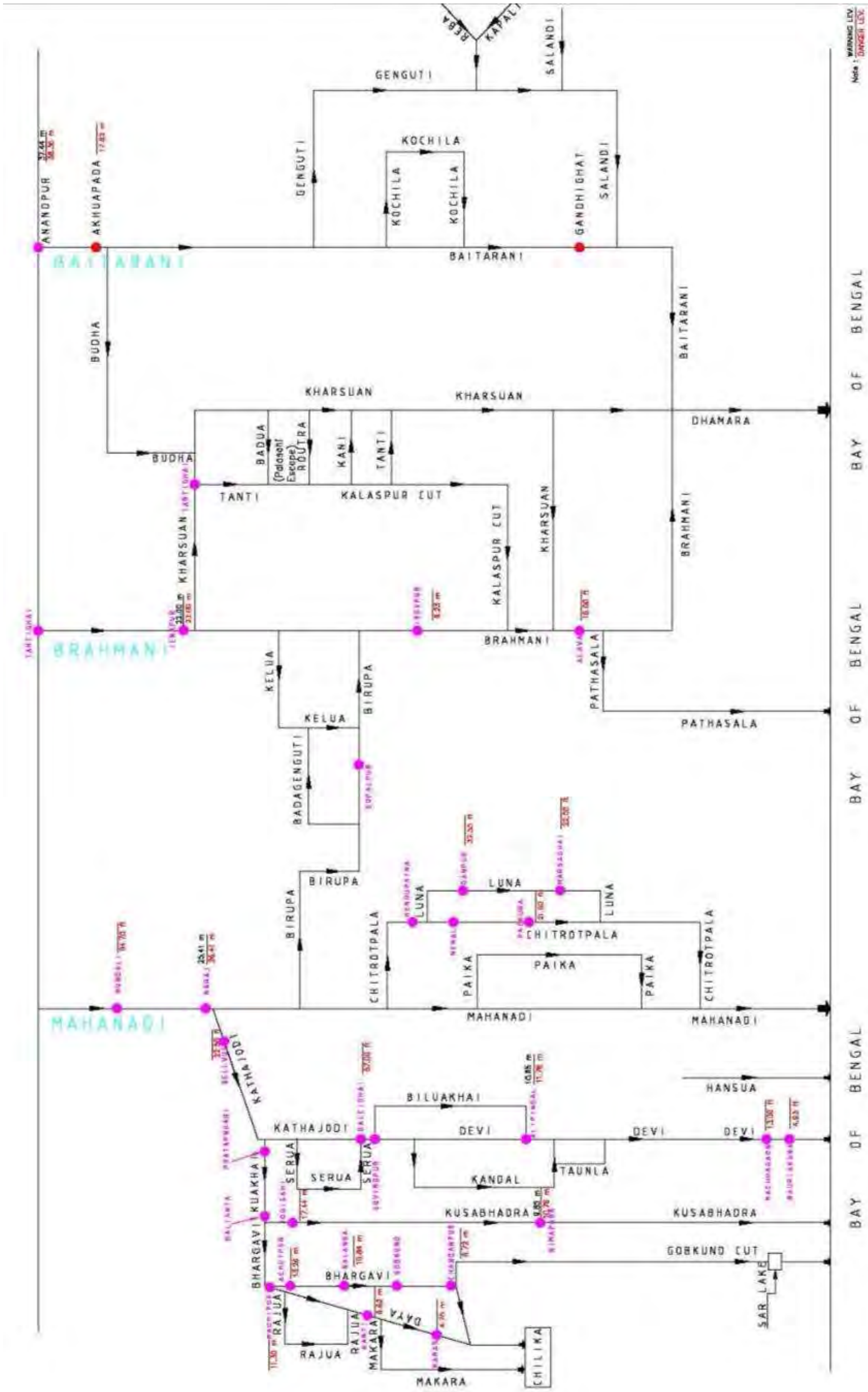


Figure 14: Schematized deltaic channel network (source WRD, Odisha)

Figure 15: Floodplain and Kharasrota river from NH 5 Bridge.

Figure 16: Birupa upstream of the confluence with Brahmani and Indupur Gheri.

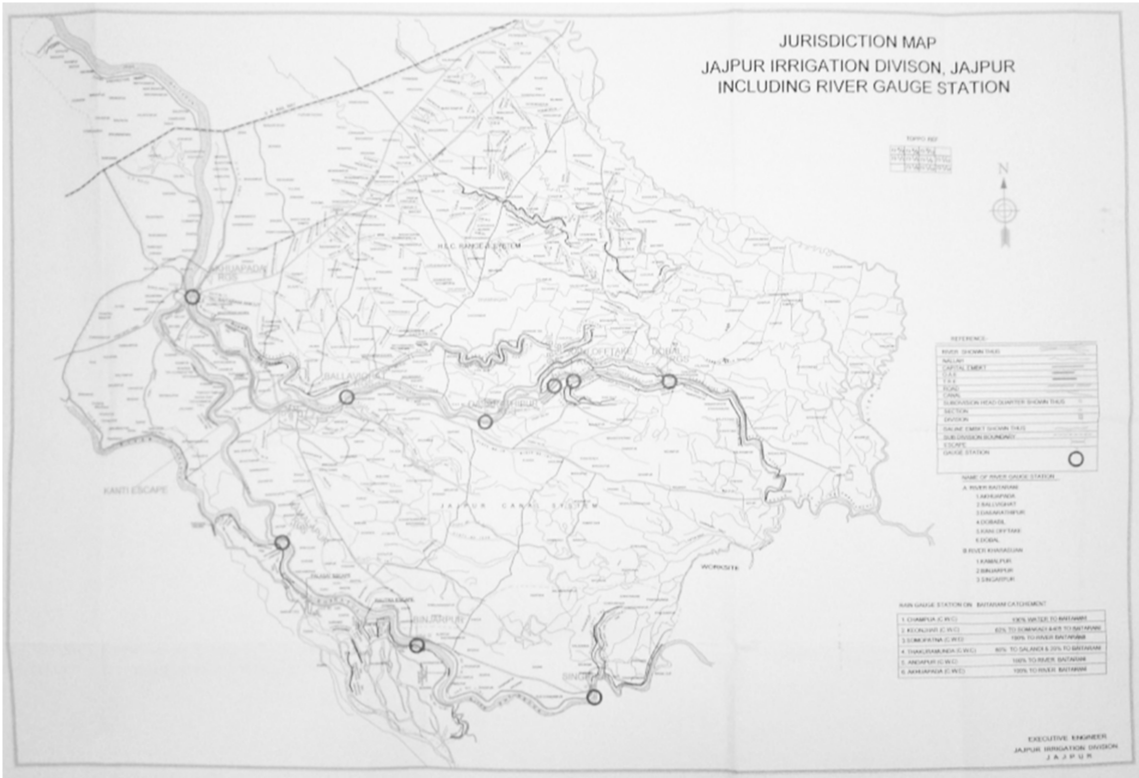


Figure 17: Irrigation maps for the area between Baitarani and Brahmani (source WRD)

92. The irrigation schemes are operated annually from 15 July to 15 October and for minor supplementary irrigation from 15 January to 15 February (WRD Bhubaneswar). The later irrigation season is restricted by the availability of water in the rivers and the need for conducting simultaneous maintenance work. The canal system fulfils the dual functions of providing irrigation water and flood embankment protection.

93. Embankments in Odisha are of three different standards as shown in Table 7. Temporary relief embankments (TRE) were overtopped during the 2011 flood when 49 breaches occurred. Other embankments, not overtopped, did not breach at that time. Recognizing this risk associated with TREs, the WRD has a continuous program to raise and strengthen embankments. In some places immediate strengthening takes place through “dowel bunds”, the raising of the embankment by building a smaller embankment on the river side of the actual crest, which leaves the road connection open (Figure 18). In many places irrigation canals, having supply levels well above floodplain level, also serve as flood embankments. Many of these canals/embankments are a century old and until today provide reliable flood mitigation.

Table 7: Embankment standards in Odisha

	Capital Embankment	Other Agricultural Embankment (OAE)	Temporary Relief Embankment (TRE)
Freeboard	HFL + 1.2 m	HFL + 1.2 m	HFL +0.9 m
Crest width	3.66 m	2.4 m	2.4 m
Total length in Odisha	1,591 km	2,444 km	1,535 km

Figure 18: Embankment at Indupur Gherry raised on the river side through a dowel bund.

94. The Rengali dam on the Brahmani River provides partial storage of flood waters, with an area of up to 37,840 hectares at full level. Five turbines of 50MW capacity generate hydropower. 35km downstream of the dam, a barrage stores flood releases for irrigation purposes. Operation has to balance between hydropower storage and flood cushioning, which is difficult especially towards the end of the flood season when the dam should be filled to the maximum for hydropower production during the dry season. Late rainfall during this period can result in sudden emergency releases and flooding of downstream areas (Discussion with CWC in March 2013).

95. Flooding in the deltaic plains involves a complex combination of different flood types. River flows that transport water from north-west to south-east are at times obstructed by high sea levels. High sea levels correspond with depressions over the Bay of Bengal and cyclones, adding intense rainfall, moving from east to west in upstream direction, as third flood component. The impacts of the 2011 super-cyclone, leading to extreme river levels in October, are still well remembered in the State.

2. Socio-economic Environment

96. The per capita NDP in Odisha is INR 22,864 (USD 450, 2012/13). The agricultural sector contributes 15% to the GPB but employs 60% of the workforce directly or indirectly. The 11 districts of the Baitarani and Brahmani basin, cover 39% of the State area but contribute 46% to the GDP, with most of the districts having above average population density (Table 8).

Table 8: Key socioeconomic data (Source: Odisha Economic Survey 2012-13)

District	Total area [km²]	Area in Baitarani Basin [km²]	Area in Brahmani Basin [km²]	Area liable to floods [km²]	Cropped Area ['000 ha]	Share in GDP [%]
Balasore	3,806	42			234	4.38
Bhadrak	2,505	2,198			169	2.39
Jajpur	2,899	1,006	1,825		142	4.08
Kendrapada	2,644	274	1,107		138	2.10
Angul	6,375	31	4,226		193	7.06
Keonjhar	8,303	6,824	1,723		281	6.26
Mayurbhanj	10,418	2,926			380	4.16
Sundargarh	9,712	181	5,794		300	8.72
Sambalpur	6,657		1,371		177	3.26
Dhenkanal	4,452		3,957		165	2.56
Deogarh	2,940		2,512		65	0.58
total	60,711	13,482	22,515		2,244	46
Odisha	155,707	13,482	22,516	41,000	5,654	100

District	Total Population (2011)	Population Density [persons/ km²]	Per capita NDP 2009/10 (in 2004/5 prices)	Literacy [%]	Access to toilets within premises [%]	% of Villages Electrified
Balasore	2,317,419	609	17,726	81	28	99
Bhadrak	1,506,522	981	16,827	83	20	100
Jajpur	1,826,275	630	20,658	80	23	97
Kendrapada	1,439,891	545	15,774	86	18	90
Angul	1,271,703	199	40,299	79	24	95
Keonjhar	1,802,777	217	30,462	69	15	93
Mayurbhanj	2,513,895	241	17,565	64	19	92
Sundargarh	2,080,664	214	30,100	74	28	74
Sambalpur	1,044,410	158	29,402	77	23	92
Dhenkanal	1,192,948	268	22,023	79	18	97
Deogarh	312,164	106	20,350	73	9	91
total	17,308,668	285				
Odisha	41,947,358	269	22,846	73	22	79

97. Development of irrigation has been given very high priority by the State Government during the 12th Five Year Plan (Government of Odisha, Economic Survey 2012-13). The state has 6.2 Mha of cultivated land with a net irrigation potential of 2.4 Mha (March 2011) created through major, medium and minor irrigation projects of the WRD. An additional, 0.6 Mha of net irrigation potential have been created through other sources such as dugwell, water harvesting structures, small check dams. Irrigation intensity in the State stands at around 30% in comparison to the all-India average of nearly 45%. The government plans to provide irrigation facilities to at least to 35% of the cultivable land in each block. To realize the above target, major investments in irrigation schemes are in place such as the ADB-supported Odisha Irrigation Improvement Project, approved in 2008. In 2009/10 the state government launched two innovative irrigation programs focussing on check dams and sustainable ground water harvesting.

98. Floods impact on an increasing population and as such flood damages (Figure 18) and relief costs are on the rise. The flooded area correlates with flood damages and population affected. Over the last ten years the relief expenditure has sharply increased, overall and per person (Figure 20).

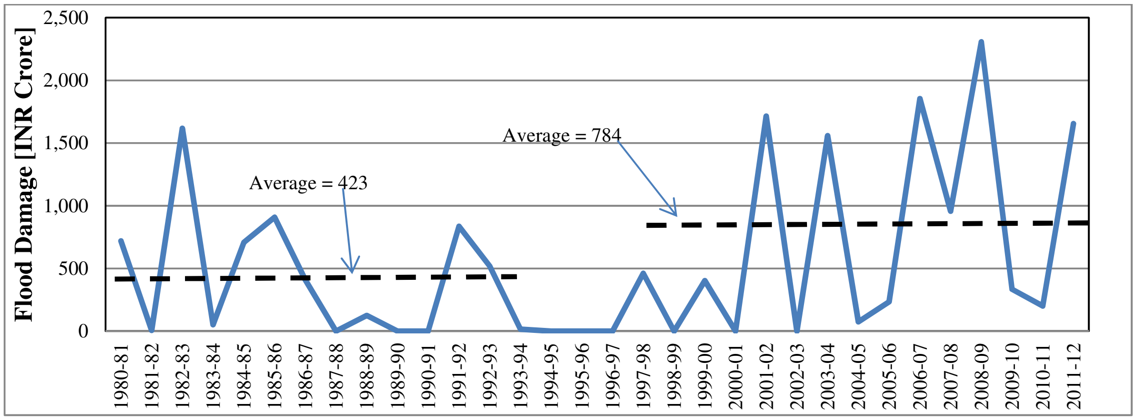


Figure 19: Flood damages in Odisha in 2004/5 prices

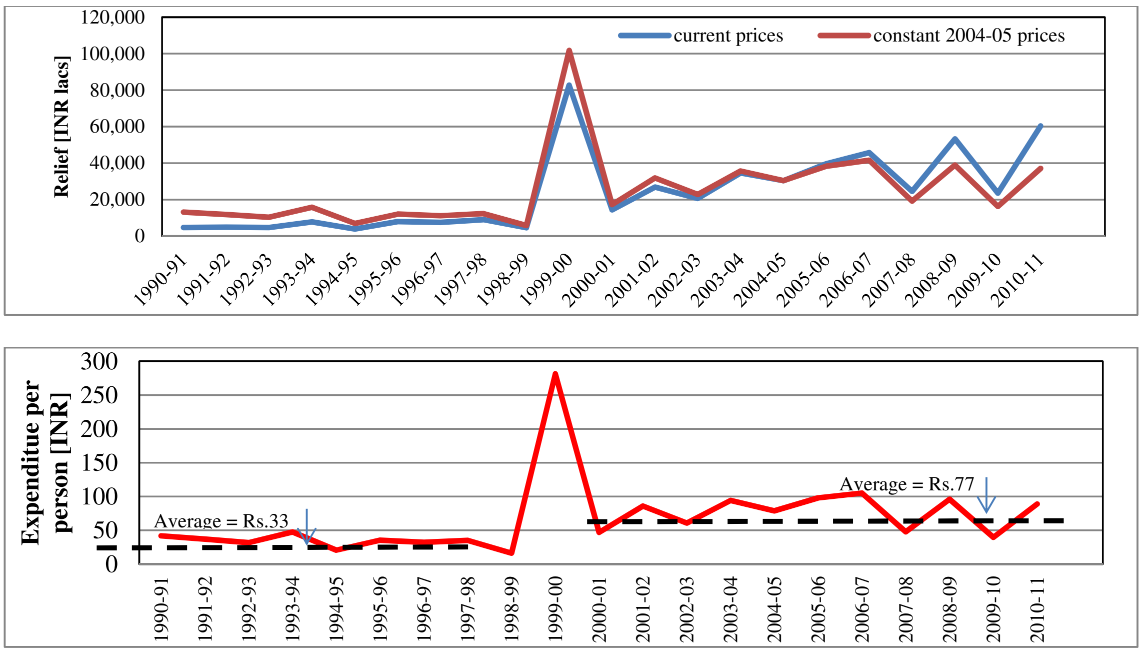


Figure 20: Relief expenditure overall (top) and per person (bottom) in 2004-05 current prices

99. Expenditure for relief and recover are complemented by expenditure for preventive measures, largely the construction and raising and strengthening (R/S) of embankments through the WRD. The overall WRD budget also shows a sharp increase over the last ten years (Figure 21). Substantial funds are allocated to flood management infrastructure (Figure 22).

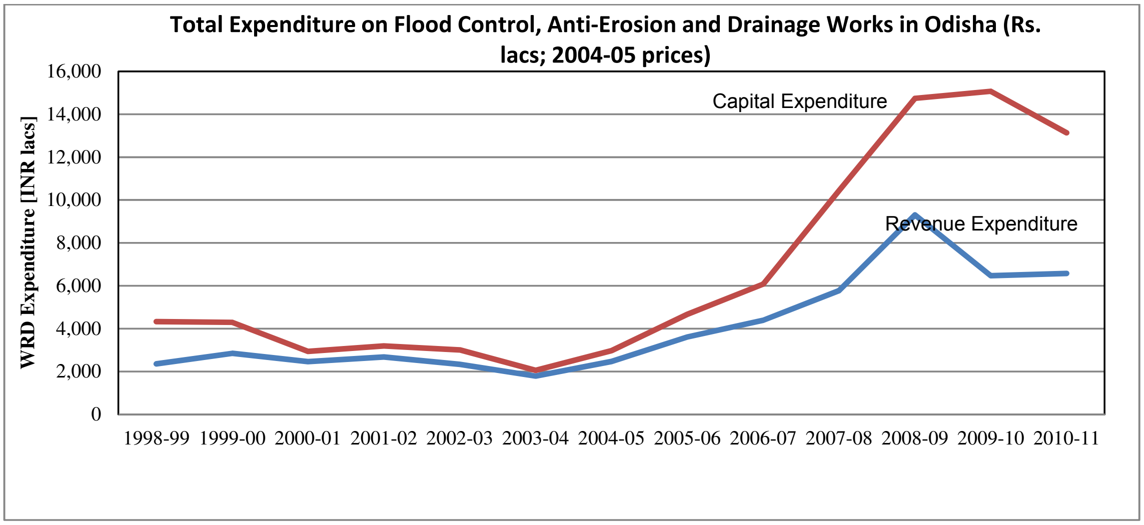


Figure 21: Development of WRD expenditure

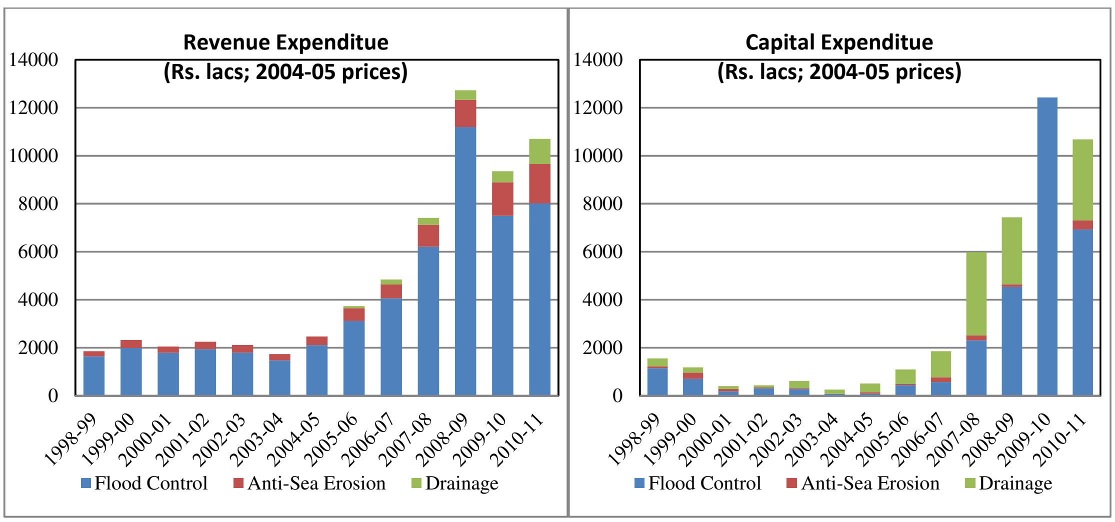


Figure 22: WRD expenditure on flood control, drainage, and coastal protection works

100. More details are provided in Annex G.

3. Institutional Environment

101. The water policy of Odisha[15] was approved in 2007 prior to the revised National Water Policy 2012. The state water policy prioritizes the water uses as indicated in Figure 23. The State water policy has 16 sections with section 10 for flood control and management: (1) State water plan, (2) Institutional mechanism, (3)Drinking water, (4) Development of water resources for irrigation and drainage, (5) Hydro-power, (6) Industrial water supply, (7) Ecology and water quality, (8) Resettlement and rehabilitation, (9) Groundwater development, (10) Flood control and management, (11) Management of saline ingress, (12) Participatory irrigation management, (13) Financial sustainability, (14) Catchment treatment, (15) Safety of dams, and (16) Role of NGOs.

[15] State Water Policy 2007, Government of Odisha, Water Resources Department.

Priority 1: Drinking water and domestic use (human and animal consumption)

Prioirity 2: Ecology

Priority 3: Irrigation, agriculture and fisheries

Priority 4: Hydropower

Priority 5: Industries including agro-industries

Priority 6:Navigation and other uses

Figure 23 Prioritization of water issues in the Odisha State Water Policy

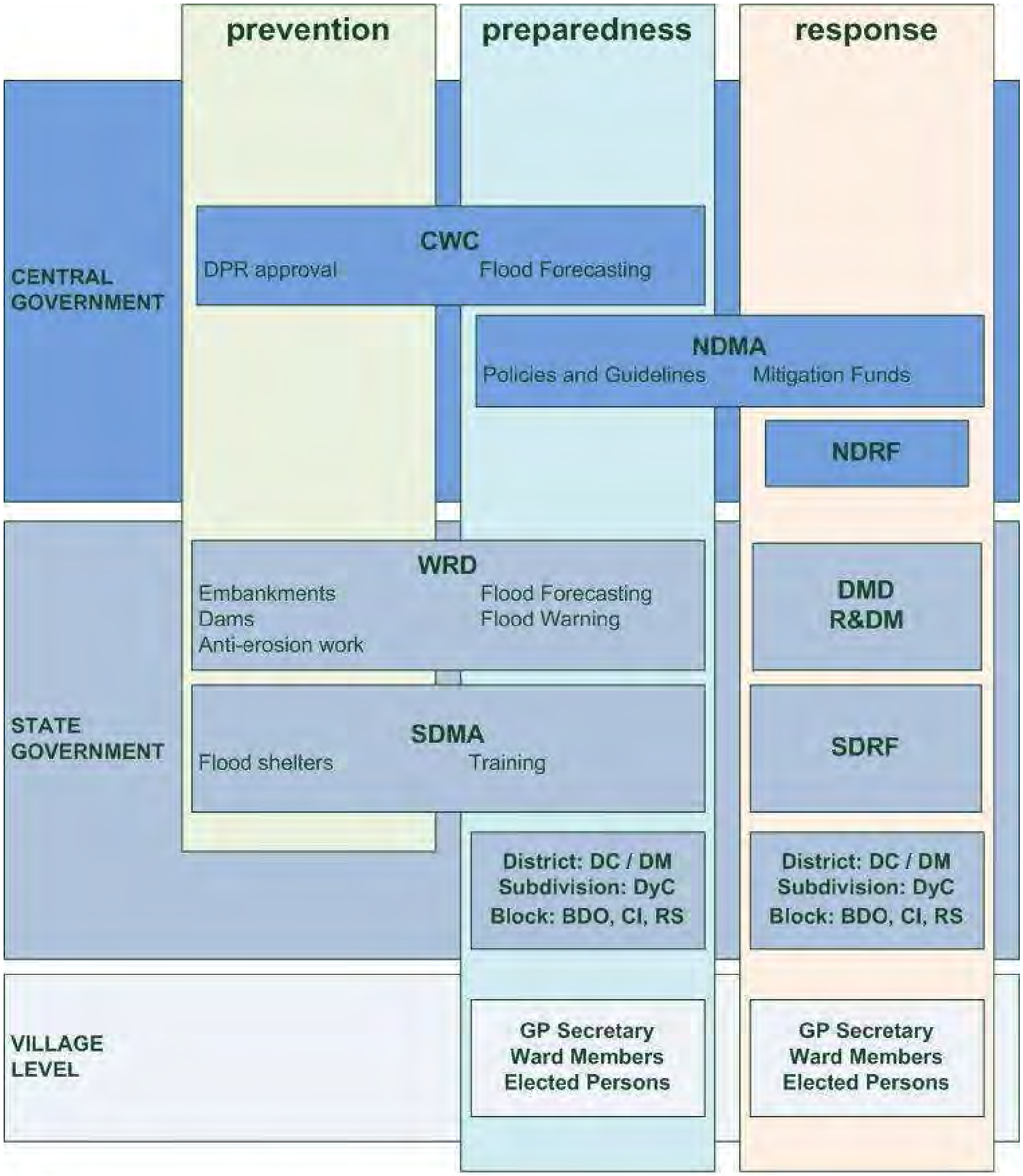
102. The organizational arrangement of WRD in Odisha is hierarchical, headed by the Principal Secretary supported by five Additional Secretaries, each with specific functions. Flood Control and Drainage is under one Additional Secretary, who also handles several other functions. An Engineer-in-Chief is the technical head of the WRD supported by 23 Chief Engineers. The CEs have a combination of geographical and functional responsibilities and some are named Basin Managers, when responsible for irrigation schemes[16] . One major constraint faced by the WRD is shortage of staff, especially in flood management and research.

103. Odisha has eleven major basins, including the Brahmani and the Baitrani. The Odisha Water Planning Organization within the Water Resources Department is mandated to develop basin plans, following basin studies to be conducted in four phases, of which three phases have already been completed. An IWRM plan for Baitarani basin has been completed by the department. A River Basin Organization for Baitarani basin has been constituted but is currently dormant. Figure 24 summarizes institutions and functions at different levels. At each level a number of research institutions are active, such as the Water and Land Management Institute (WALMI) or Indian Institutes of Technology (IITs).

104. Similar to Bihar the WRD operates flood control rooms during the flood season, commonly from 15 June to end of October. The flood cells receive and disseminate water levels as well as trends and in places flood forecasts. Warnings are issued when water levels reach 1 m below danger level, commonly defined as the bankful level of the rivers, when they start spilling over and flooding the plains.

105. The OSDMA is largely active at the state level. A core activity is preventive measures, specifically the construction of flood shelters. The OSDMA has no lower level organizations, but imparts trainings to communities. The flood shelter construction in places reflects on the reliability of the flood protection embankments. As mentioned earlier TRE can get overtopped and consequently OSDMA has started building flood shelters behind embankments (Error! Reference source not found.).

[16] Basin management in the department has a narrow definition that restricts itself to irrigation management.



Notes:

CWC	Central Water Commission
NDMA	National Disaster Management Authority
NDRF	National Disaster Response Force
WRD	Water Resources Department
SDMA	State Disaster Management Authority
DMD	Disaster Management Department (Bihar)
R&DM	Revenue and Disaster Management Department (Odisha)
SDRF	State Disaster Response Force
DC/DM	District Collector (Odisha) / District Magistrate (Bihar)
DyC/ CI	Deputy Collector / Circle Inspector
GP	Gram Panchayat

Figure 24: Institutional responsibilities with respect to flood management in Odessa

Figure 25: Flood shelter behind temporary relief embankment in Kendrapara division

106. Some key similarities and differences between BSDMA and OSDMA are tabulated below.

Table 9: Comparison of BSDMA and OSDMA

BSDMA	OSDMA
The Bihar State Disaster Management Authority was established in 2007, eight years later than Odisha. Registered under the Societies Act.	The Odisha State Disaster Mitigation Authority (OSDMA) was set up as an autonomous organization, immediately after super cyclone in 1999
BSDMA was the first state level agency to have a full time Vice-Chairperson, with extensive experience in disaster management	The institution was renamed as State Disaster Management Authority in 2008 to reflect the true nature of its work. The Department of Revenue and Disaster Management Department is the administrative department.
BSDMA works closely with all state level departments and field level organizations, including Panchayati Raj organizations	OSDMA has implemented a program on Disaster Risk Reduction (DRR) using UNDP assistance. resulting in improved project coordination mechanisms and inter-departmental convergence
No specific focus on Climate Change. Extensive work has been carried out to set and publish guidelines and carrying out community awareness activities.	Climate Change and disaster reduction component is being addressed through state level, sub-regional level and city level workshops. The lessons learned through DRR are of immense help to the proposed phase 2 TA, although flood management is not the core activity of DRR.

107. More details are provided in Annex F.

4. Community Perspective

108. Two locations, selected in consultation with OSDMA, were visited in the Brahmani/Baitarani and Mahnadi delta (Table 10). The two villages have recently built flood shelters (Figure 26), which allows the assessment of the impact of preventive measures.

Table 10: Key characteristics of the visited focus villages

Study Site, Block	District	Characteristic	Population	Water hazards
Goudashahi Govindpur, Similia Panchayat Jajpur	Jajpur	Rural with flood shelter	1,100	Flood and drought
Parakula, Marshaghai	Kendrapara	Rural with flood shelter	1,738	Regularly annually floods, 2011 highest flood

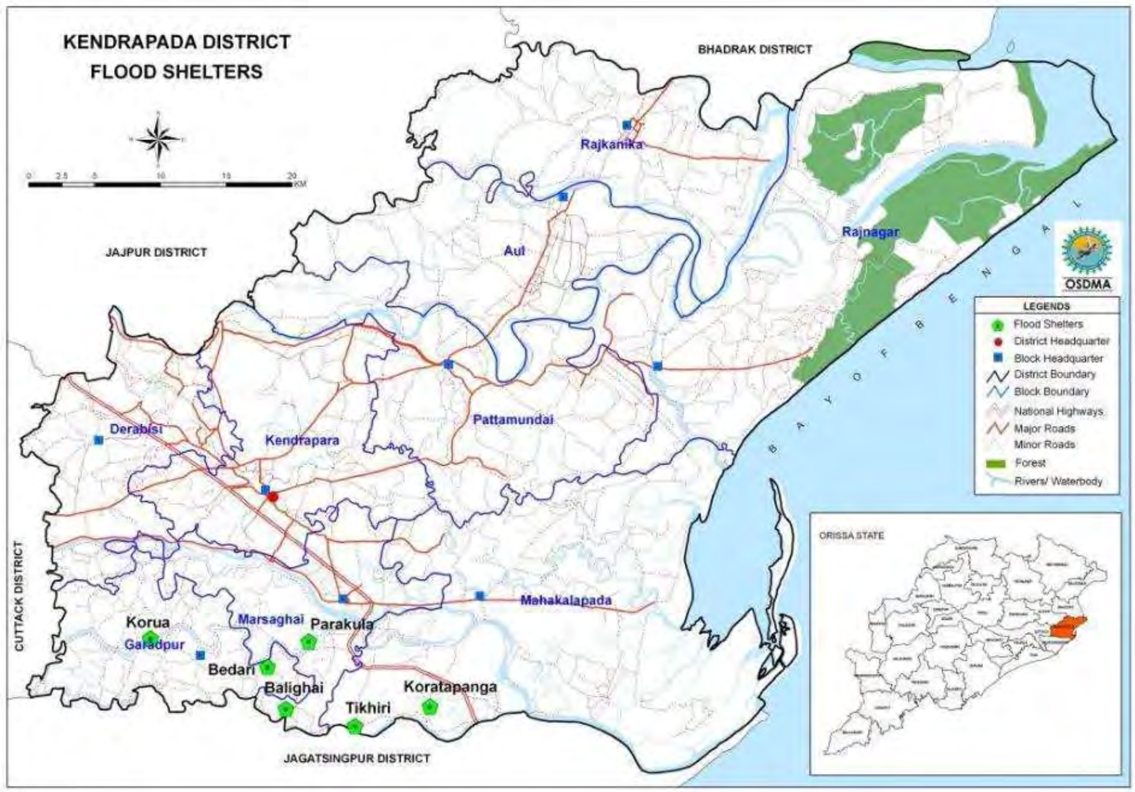


Figure 26: Location of flood shelters in the deltaic region of Odisha (source OSDMA)

109. The consultation process followed the same semi-structured format used in Bihar and covered individual and group interviews and interactions as depicted in Figure 26. Focus Group Discussions (FGD) were held with PRI members, self-help groups, village functionaries such as school teacher, and members of the shelter management committees. The number of women involved during the consultation process ensured gender balanced participation.


Figure 27: Consultation process at Gaurgovindpur (left), and Parakula (right)

a. Flood Behaviour:

110. The communities report that the period from 1st of June to 1st of October is considered as flood period. The State of Odisha faced two successive severe floods in the months of September 2011 in the river Mahanadi, Brahmani/Baitarani and their tributaries. Parakula gets flooded every year.

b. Impact of floods:

111. Communities in Bihar and Odisha reported quite similar responses to floods. Communities in Kendrapada district also reported the positive flood impacts of deposition of fertile soil and cash compensation for damages as opposed to the long list of negative impacts, namely:.

- Economic impacts:
  - loss of assets mainly houses
  - loss of livestock or increased diseases
  - health hazards, such as gastroenteritis
  - indebtedness due to the need to seek loans, of from money lenders
  - income loss due to lack of paid employment opportunities mostly in agriculture and destruction of raw material used for idol making
  - crop losses

- Social impacts
  - Need for outmigration mostly of men, increasing vulnerability and workload of women with children and elderly – especially in Parakula
  - Reduced access to education
  - Fatalities – loss of life
  - Increased stress levels
  - Disrupted transport and communication
  - Lack of food

- Environmental impacts
  - Stagnant water and Snake bites
  - Loss of culture fish
  - Contaminated drinking water
  - Lack of sanitation facilities
  - Lack of safety

112. Major differences in the two study areas have been summarised as follows:

Table 11: Comparison of Bihar and Odisha flood damages

Category	Flood Impact	Bihar	Odisha
Economic Impact	Loss of assets	Higher loss of assets especially houses as the water receded in 15-20 days from houses and 4-5 months from fields	2011 floods water receded from houses in 5-6 days and 15-20 days from fields
	Health hazards	Kala Azar in 2008-9 after floods in Chak mahsi	Health hazards mainly Gastroenteritis
	Indebtedness	No SHGs reported in the study area	SHG reported difficulties in selling vegetables in Biroja haat due to poor connectivity affecting their saving and inter loaning situations. As a result there is higher dependence on other market sources for debt
	Loss of Wage	Land holding is poor. Higher migration to urban areas especially in Chak Mahsi. Hence loss of wage mainly in the form of labour opportunities for the non-migrant households	Higher dependence on agriculture for income opportunities as compared to Bihar study sites. Loss of wage reported by agriculture labour. Artisans lose the raw material
	Loss of crop	Communities in Sanyasi Tola did not report any crop loss since they are a non-agricultural community People in Chak Mahsi reported 'sudden rains' as cause of crop loss	2011 floods led to high devastation
Social Impacts	Migration	Higher Migration of men. 80% households in Rajkhand Uttari having men migrated to urban areas	30% households in Parakula reporting male migration to parts of West Bengal, Surat as industrial labour
	Education	Schools remain non-operational for educational activities during the flood period	Schools remain non-operational for educational activities during the flood period. School structures closely situated with the Shelter Homes and served as shelter spaces
	Food Availability	Disorganisation in food distribution during flood relief. Reported air drops as leading to more chaos. Reduce intake despite of storing food items like Chura	Chaos during food distribution during relief Reduce intake portions in spite of storing food items such as Ambul, Bari
Environmental Impacts	Loss of Fish	Fish breeding not major activity Few households get affected when the ponds get overtopped	Fear of cyclones poses constraints to go to sea for fishing. 1-2 SHGs in Parakula involved in fish cultivation reported as affected
	Contamination of drinking water	Source of water mainly hand pumps. Quality affected due to presence of arsenic and iron contents. During floods water is muddy and needs to be boiled and strained for drinking purpose	Source of water mainly tube wells. Quality of water gets affected due to increased salinity

c. Flood Preparation:

113. The communities have multiple ways of preparing themselves for floods. Houses are generally built on higher plinth levels. The plinth levels of the houses in Kendrapada study area were even higher than the ones in Bihar. Like the communities in the Buri Gandhak study area, the communities in Odisha stockpile food and fodder before the floods. They identify shelters, mostly on embankments or at government buildings in case their houses get flooded. The type of house in Odisha is different from those in Bihar. Some of the houses in Parakula (Odisha) have big loft like wooden structures called Aura where grains can be stored. There were also differences in the type of food stockpiled in the two states. While Sattu Chana and Chura were the major food items stockpiled

by the communities in Bihar, food items such as rice, dry mango and spices were largely stored by the communities in Odisha.

114. Cropping patterns and the use of normal and high yield rice varieties by the farmers reflect a risk mix, balancing potential gains versus the risk of losses. About 10% of the rice cropping area is covered with local varieties, which are more resistant to flooding but have comparatively low yield. This notwithstanding, they can provide a minimum harvest when high floods destroy the high yield varieties.

115. During the flood communities follow warnings issued on radio or television and apply indigenous knowledge and techniques to predict floods levels. In addition, communities closely watch the performance of the existing embankments and provide emergency measures, if required.

d. Coping Strategies:

116. Coping Strategies to flood disaster are similar to those reported for Bihar.

117. Starting from the coastal area where cyclone shelters are built, OSDMA has started building flood shelters along the river branches. After construction the shelters are handed over to the registered societies for management. In addition, volunteers are trained to increase the resilience of the local communities. The shelters were built during the last few years but have proven effective to some extent during the 2011 flood season when people used the partly constructed shelter at Parakula.

e. Flood Education:

118. OSDMA carries out capacity building of community and other stakeholders. Under the UNDP (DRR) programmed, Village Disaster Management Plans have been prepared in more than 23,000 villages in 16 districts of the state of Odisha. A modified DRR Programme under UNDP assistance is being implemented from 2012 in Ganjam, Kendrapada and Bolangir districts and three urban areas – Bhubaneshwar, Angul and Talcher on pilot basis. The two villages visited have the village level Flood Shelter Maintenance and Management Committees in place. The members were trained in disaster preparedness measures and rescue operations. OSDMA has developed training material to educate communities on flood management issues. There are handbooks on the management of the Cyclone and Flood Shelters available with OSDMA.

119. More details are provided in Annex J.

Figure 28: Example map from village disaster management planning (Parakula) left, volunteers in Parakula trained by OSDMA right

VI. OUTLINE PHASE 2 ACTIVITIES

A. Identified Gaps and Development Potential

1. Institutions

120. Institutional aspects of Integrated Flood Management (IFM) in Bihar and Odisha are reviewed in Annex D. A key finding is that the institutions involved are not adapted to IFM requirements for various reasons. First, due to lack of understanding and even exposure to IFM principles. Second, because institutional practices, including state budget allocations, address different sectors separately, precluding IFM's more holistic needs. Third, because the main focus remains on structural solutions to flood management, mainly the construction of embankments. Fourth because institutions are typically disconnected from the reality of the communities on the ground, with which they do not maintain a dialog. The rigid hierarchies within each institution, their bureaucratic constraints, their lack of responsiveness to the needs of other institutions, and their disconnect from the communities, render adaptation to IFM requirements very difficult.

121. State Disaster Management Authorities (SDMA), specifically in Bihar – in contrast with the above described behaviour pervasive in most other institutions – have taken a leadership role in drawing up protocols, conducting mass campaigns and training programs. It is also co-ordinating well with other departments on flood mitigation activities. Thus, we recommend that the Phase II team should establish a good working relationship with SDMAs and further strengthen their activities.

122. The above considerations prompt us to propose a more modest, incremental change approach, which balances limited resources, immediate needs and proven interest of institutions and practical opportunities with the objectives of the TA. The strategy does not aim to address high level policy matters, to overhaul existing governmental organisations, or to introduce dramatically new ways of operation. It only supports improved co-ordination between players at all levels and within departments at the state level and field operation level. Past experience indicates that any attempt to introduce systemic changes within the contours of a funded project is traumatic and places heavy stress on the on-going system with no visible results. It is also pertinent to note that WRDs in places have limited ability and willingness to take up new projects because of staff shortage.

123. Therefore, the suggested approach for phase 2 TA is as follows:

- To focus at the basin level and sub-basin level;
- To aim at specific, tangible improvements, rather than higher order RBO approach to address IFM needs. An exception could be to try and revive existing RBO (only in theory) in Baitarani basin. However, it will call for substantial resource and time commitments as well as technical help by the TA team;
- To respond to specific IFM capacity building needs on an intense mode (i.e. to cover all field level WRD staff in both the basins and district revenue staff);
- To place emphasis on actual cooperation with SDMA, R&DMD and local bodies;
- To promote flood related data sharing and communication, with technical departments, CWC, district administration, and local bodies. The regional office of CWC has the potential to lead some of the flood related data collection and flood forecast tasks;
- To make a serious effort to train and motivate WRD staff using WALMI or other institutional platforms, involve SDMA staff in training so as to take a wider look at IFM measures. WALMI, Odisha has a good track record in training the WRD staff and communities;
- To institutionalize specific results focused, time bound outputs on IFM interventions for project staff (this means the tasks will have to be defined in terms of results and targets within a given time frame, with in-built monitoring mechanisms. In the context of current work practices this is a big change and therefore, staff will have to be extensively trained);
- To develop competency maps for WRD and R&DMD staff and invest in their capacity building around IFM and possibly climate change (the competency maps will include specifically defining skills and abilities of IFM staff as against the normal project execution roles of departmental engineers. This can then be used as a bench mark for IFM training).

2. Community-Based Flood Risk Management

124. Community-based aspects of Integrated Flood Management (IFM) in Bihar and Odissa are reviewed in Annex C.

125. Government, at both Central and State level is aware of the importance of a community-centric approach and has put the related institutional mechanisms in place. There is a widespread understanding that complete "flood protection" is not possible, and that higher levels of resilience can only be achieved through active community participation[17] . The existing high population density, its continued growth, and future uncertainties (climate change) indicate the need for an acceleration of a community centric process focussed on prevention and preparedness. A pro-active approach is further supported as communities complain about insufficient government assistance to respond to flood disaster, despite increasing relief expenditure. On a different level, relief expenditures vary substantially on a year-to-year basis and show little correlation with evaluated flood damages, which supports a community view of somewhat erratic compensation.

126. While both states have undertaken efforts to involve communities, villages are not comprehensively involved in IFM planning. It is important to recognize that both states follow a modern approach towards pro-active prevention and preparedness, for example reflected in Odisha by involving 23,000 villages in village disaster management planning. However, there still remains potential to increase the outreach of government institutions, namely SDMAs and WRDs to communities at village level. Part of the gap is certainly associated with staff shortages and on-going institutional restructuring processes.

127. While rural communities apply certain mitigation measures at household level, they largely depend on the produce of the flood prone plains. Most communities depend on crops raised during the flood season on increasingly smaller landholding, which are subjected by unpredictable flood levels. The immediate relief from floods is provided by stable flood embankments, which however only work to specified design levels, and as in the case of "temporary embankments" in Odisha are

[17] Voiced for example by participants of the round table discussion and by the Special Secretary MoWR.

substantially overtopped during higher floods. Reduced risk on household level means involvement in the planning process to optimize the benefits and increases ownership, while exploring flood insurance options for times of failure of the flood protection and a fast return to a normal life.

128. Notwithstanding the lack of broad and comprehensive community involvement in an integrated flood management process at this stage, communities show a high level of resilience to floods. As most directly affected group at the lowest level, communities make preparations for times of duress and observe the environment within their means to understand the day to day risk. It is understood that prevention is the better way, however, limited by the available household resources.

129. In summary, there are a number of pro-active measures as well as those associated with an improved response to be addressed during the second phase for increasing community resilience:

- Baseline Situation:
  - profile community vulnerability, including the gender dimension;
  - identify indigenous knowledge specific to the area;
  - assess risk through community disaster risk mapping;

- Integrated Flood Management at Community Level:
  - Investigate and develop regular and inclusive planning processes between communities and government departments;
  - Increase the coverage of existing flood education programs, such as conducted by the BSDMA,
  - Help communities to tap available program government and other (NGO) resources (for example Indira Awas Yogna for plinth raising, NREGS, or micro-credit facilities);
  - Develop locally relevant water level information and communication methods to the broader public, recognizing the limitations in SMS use;
  - Investigate “climate-smart” crops and cropping patterns

3. The Economics of IFM

130. Economic aspects of Integrated Flood Management (IFM) in Bihar and Odissa are reviewed in Annex E. Analysis of the major research gaps lead us to recommend that Phase 2 can undertake more detailed analysis and derivation of the depth-duration-damage curves for different sectors (agriculture, housing, roads etc.) which will assist in a more scientific assessment of flood damages. This exercise will involve use of hazard data by the hydrology / hydraulics team in Phase 2, and the risk assessments will be done collaboratively between hydrologist and economist. The following table outlines the data requirement for the task of establishing the depth-duration-damage relationship.

Table 12: Data Requirements for Economic Assessment

Parameters	Required Information	Source
Hazard	*Intensity:* River-gauge and Discharge	State Water Resources Dept., CWC Delhi
	Recurrence: Overtime frequency of floods of different intensities (Derived Data)	
Vulnerability	*Exposure:*	
	Cropped Area	Department of Agriculture
	Number of Houses by categories falling in the basin	State Statistical Handbook
	Livestock (chicken, cattle etc.)	Animal Husbandry Department
	Fisheries (stalking density)	Fisheries Department
	Roads and Highways (also Traffic density)	State Transport Department
	Fragility:	
	Number of houses damaged and extent of damage (full/partial...)-(Raw Data)	SDMA Reports
	Extent of damage to crops	Irrigation Commission Report (WRD)
	Loss of public property (roads, buildings etc.) Raw data	
	Loss of human life (Raw data)	
	Cattle- number of total loss (Raw data)	
Total Risk	*Monetised Losses:*	Vulnerability Atlas of India
	Crops and Land	District level Disaster Management Authority
	Houses Damaged (fully/partially)	
	Livestock and Fisheries	
	Roads and Communication	
	Increased Migration (to be imputed)	
	Work Days Lost (to be imputed)	
	Lives Lost (to be imputed)	

131. The procedure for damage estimation can be standardized such that it can be applied to different scenarios. This will help firm up the steps that can be followed for economic appraisal of FMPs.

132. It is important to explore possible ex-ante strategies to strengthen the current mechanism of financing disaster relief and rehabilitation in India. In this context, the option of developing a domestic insurance market in India needs to be assessed. A beginning has been made by the Bihar SDMA which organised a one day workshop during its Flood Safety Week in June 2013 on “Flood Risk Management: Risk Transfer Mechanisms”. An efficient domestic insurance market backed by entities such as the international reinsurers and public sector insurance companies can take a significant part of the burden off the government’s shoulders.

4. Potential Climate Change Impacts

133. In the face of current and anticipated climate change, there is great need for development potential and many gaps to be covered during Phase 2. Some of these needs were identified by the Central Water Commission (CWC) who refer to the as focus issues. These 13 focus issues identified by CWC, on which we commented in the Interim Report’s Appendix D, and are summarized below. In Annex B of the present Final Report, section 4, we additionally identify what in our view are the most pressing research needs leading to improved methods for long-range forecasting of extreme summer

rainfall, and improved methods of projecting for future decades the changes that can be foreseen in frequency, duration and severity of such extremes. Those research needs are not repeated here (see Annex B, section 4).

134. Of the 13 focussed issues identified by CWC, only two (3 and 4) cannot be addressed in some way in Phase 2 of the Technical Assistance study (TA). The issues and the anticipated TA approach to addressing them are summarised below.

Issue 1:

> Review of recommendations of Rashtriya Barh Ayog w.r.t. considering return period of 25 and 100 years for designing flood management structures (embankments etc.) for protecting rural and urban areas respectively, vis-a-vis recommendations in National Water Mission proposing increase to 75 years and 150 years respectively.

Approach:

> This is a topic that can be considered in the two study basins. The return period that flood management structures are designed to should be considered in the context of flood risk, and the consequences of overtopping or a structural failure during an extreme event. Clearly the potential future climate change impact should influence current design standards and freeboard provisions and this too will be considered.

Issue 2:

> Review of keeping a free-board of 1.8/1.5m when the flow is more/less than 3000 cumecs in design of flood embankments as per recommendation of RBA made in 1970s. This high value of free-board was kept to take care of uncertainties in the hydrological data which was available only for about 10-15 years by that time. However, now the data is available for more than 40 years which reduces level of uncertainty and therefore provision of free-board for embankments may be considered in this perspective.

Approach:

> In determining embankment free-board, consideration is given to construction tolerances, rates of future consolidation and settlement, potential wave action, and energy levels. In India typically historic, observed high flood levels (HFL) are used as design base. It is recognized that this approach has a number of limitations. Internationally design water levels are based on return periods, commonly determined through numerical modelling. Hydrological uncertainty and hydraulic uncertainty can be explored through modelling during the design process, and free-board requirements may be adapted to local conditions. Provision of additional free-board at the design stage is of course equivalent to designing for a higher return period (1 above), and free-board, design standard and future climate impact need to be considered together. The Buri Gandak basin should provide a good case study on which to explore these issues.

Issue 3:

One of the likely impacts of climate change is increase in size of glacial lakes leading to situation of GLOF. CWC already have inventory of glacial lakes and water body in Himalayas and also monitoring on monthly basis in the monsoon period. Now the need is to have a system of attaching vulnerability with such water bodies/Glacial lakes with respect to floods.

Approach:

This undoubtedly an important issue, and is one deserving of a detailed study in its own right. It would require significantly more resources than are available through the TA and we do not consider that this topic can be addressed by the TA.

Issue 4:

The phenomenon of flash flooding is not very well understood. What are the models or methods available for prediction of flash floods to minimise the damages globally? Seek recommendations for its implementation in India.

Approach:

This again is an important topic, but perhaps one that is best addressed through an independent academic study through collaboration with an IIT or NIT.

Issue 5:

There are issues related to compensating the upper riparian, who is providing relief to the downstream area by way of flood moderation by creating a reservoir. There are no established methodologies for working out the benefits of such flood management in monetary terms. The consultancy may recommend a set of models to resolve such issues.

Approach:

This is very much an issue that IFM should address. Through the use of hydrological and hydraulic models, linked to flood-depth-damage relationships it should be possible to assess benefits of upstream control in monetary terms. The economic studies intended for the TA will be exploring flood damage frequency assessments that should provide a basis for addressing these issues.

Issue 6:

Flood inundation modelling is becoming a very important tool for flood management in India. Central Water Commission is moving ahead in this direction. The major issue is non-availability of high resolution topographical data for floodplains. In view of this, it would be interesting to know the available methods for flood inundation modelling in the absence of high resolution topographical data.

Approach:

This is an important issue that will be addressed by the TA. In at least one study basins it is intended to research the potential of using localised high resolution LiDAR survey and differential GPS survey to tune the coarser resolution DTMs derived from satellite systems and to explore more advanced 2-D modelling tools.

Issue 7:

CWC has already created a web-based Water Resources Information System (WRIS) on GIS platform. The information regarding flood management both structural and non-structural is required to put on WRIS. The consultancy may suggest ways, extent, formats and sustainable institutional arrangement both in terms of manpower and capacity, and suggest ways for improvement, to put the data in the system.

Approach:

This is very much in tune with the IFM concept. It is envisaged that in the creating of IFM plans in the study basins, asset plans, asset management plans, flood hazard maps, flood risk maps will be created in a GIS format. Ultimately these should be available to the public through a web based portal, and a platform like WRIS provides such a portal. This should be a core research topic for the TA.

Issue 8:

Institutional mechanism: Adequacy of institutional mechanism both at central and state level in terms of manpower and their capacity may be assessed for carrying out flood management works both structural and non-structural right from planning to implementation may be assessed. A comparison with other countries in the world in similar situations may also be made and suggestions for improvements may be made. An earlier proposal of creation of a specific national body to deal with issues related to Flood Management may be reviewed.

Approach:

This has been addressed to some extent in the interim report. As a part of the TA the adequacy of existing institutional arrangements for implementation of IFM will be considered, and different models explored in creation of IFM plans in the study basins. This is a very important aspect of the Phase 2. IFM principles are clearly very well understood, but there do appear to have been difficulties in creating institutional arrangements for their implementation and this must be addressed.

Issue 9:

Vulnerability Atlas: NRSC in coordination with other related agencies including ISRO, NDMA, CWC and Government of Assam had prepared Flood Hazard Atlas using Geo-spatial approach in 2011. The Atlas may be reviewed and similar efforts done elsewhere may be compared with this initiative. Suggestions may be made for up-scaling the initiative.

Approach:

The vulnerability atlas is a useful tool in outline planning and in dissemination of flood hazard and risk based on observed historic floods. Atlases could be viewed as a first step towards creation of more detailed flood hazard and risk mapping as a part of IFM. The TA can and should address this also in view of expanding the information based on modelling.

Issue 10:

Hand Book on Flood Management: CWC has prepared a Handbook for Anti Erosion Flood Protection and River Training Works in 2012. The handbook is first of its kind published mainly for helping practising engineers dealing with flood management works. The book may be reviewed and further suggestions for improvement may be made.

Approach:

One of the research topics that is envisaged for the TA is that of embankment failure mechanisms and the use of rapid appraisal methods for prioritising maintenance and repair activities. The CWC handbook will be an important starting point and its review and possible expansion to cover appraisal methodologies should be considered by the TA. However, it is recognized that the broad topics covered in the handbook provide research opportunities beyond the means of this TA.

Issue 11:

There is a likelihood of delay in communication in reservoir operation on inter-state rivers during the flood period particularly with downstream states. In such situation, the institutional mechanism for reservoir operation as well as communication system may be considered.

Approach:

This may be addressed to some extent in Brahmani basin, but it is a topic that would be worthy of an independent study.

Issue 12:

Modules for the capacity building of the communities with respect to resilience against flood may be assessed and may be developed after assessment of community preparedness for resilience against flood through sample survey.

Approach:

This should be a core focus of the TA and will be addressed.

Issue 13:

The model flood plain zoning bill of the Central Government may be reviewed. Suggestions may be made for modifications in the model bill and also other policy initiatives both at Central and State levels may be suggested.

Approach:

This should be done as part of the TA as part of the institutional reviews and consideration of models for implementation of IFM.

B. Identified IFM Planning Requirements

135. The consultative process, summarized in the previous two sections, identified a range of practical requirements to improve IFM planning at multiple levels. By and large, the IFM framework is understood in India, with policies and tools largely available. What appears to be missing is systematic implementation of an IFM planning process across the multitude of institutions involved, with a community-centred approach.

136. The PATA, Phase 1 team follows the recommendation of the steering committee of the 12th Five-Year Plan towards a holistic flood management approach in line with the IFM concept (WMO, 2009) and the formulated goals and strategies of the National Water Mission, namely attention on vulnerable areas, plus a systematic approach for coping with floods – mapping of areas likely to experience floods and establishing hydraulic and hydrological models. As such the PATA Phase 2 will be oriented towards practical results in the form of IFM plans developed based on an integrated planning process.

137. The PATA team identified the following requirements for Phase 2, at three main levels:

- Central government level :
  - Flood simulation modelling based on digital terrain models, incorporating the latest results from downscaled climate change models;
  - Improvements in the approval process of DPRs in CWC, related to design water levels and freeboards for embankments, and to assessment of infrastructure benefit-cost ratios.
  - Updated Flood Management Plans (Ganga Flood Control Commission) involving flood simulation modelling and a more integrated approach.
- State government level

  - Overcoming the disconnect between central-level basin plans and state level implementation. The latter seems to be often driven by ad-hoc field level decisions.
  - Defining structural and non-structural measures in terms of flood hazard prevention, preparedness and response. The relatively recently established SDMAs do not seem to be fully integrated into state level operations.
  - Dealing with instability of embankment slopes during rapid drawdown of water levels, either from receding floods or tidal action.

- Community level

  - Incorporating their opinions into IFM planning.
  - Establishing early warning information in a manner relevant to communities, for example translating water levels at gauges into local levels at village buildings or other landmarks.
  - Providing tools for disseminating relevant information, given the limitations of mobile phones during times of distress (lack of power for charging batteries, unfamiliarity with SMS, which reduces the effectiveness of "mass-blasting" warning messages etc.)

C. Opportunities for Operational Research

138. During the development of IFM plans, a number of tools and processes will be applied, which provide opportunities for operational research, especially in view of the replication of the applied tools for other sub-basins. In addition, there are concrete research activities related to identify problems at central and state government level. The research topics associated with IFM plans are (Interim Report, Section 8.5):

- review of institutional constraints to implementation of previous initiatives with respect to flood management;
- development of alternative models for river basin organizations that could function within the present inter-state and institutional arrangements;
- development of alternative models for re-structured institutions and institutional arrangements for creating river basin organizations;
- develop design guidance for incorporating potential climate change impacts on flood frequency and magnitude estimates;
- research the use of sample ground based LiDAR to adjust / calibrate digital elevation models created through the NRSC CARTOSAT program;
- research the risk perception of different social groups in flood risk areas with a view to identifying appropriate warning methodologies and approaches to awareness raising and flood preparedness;
- research flood warning mechanisms, awareness raising and flood preparedness approaches appropriate to different social groups and land uses;
- create an integrated flood management dictionary for use by stakeholders in India;
- research embankment failure mechanisms and the potential application of findings from FLOODsite and from the FRMRC, and the use of rapid appraisal methods to prioritize maintenance and repair activities;
- assess the potential application of mathematical models for assessing loss of life through flood, and use of these models in improved flood risk mapping, awareness raising, and emergency planning;
- research the potential application of integrated flood management methodologies for strategy evaluation under climate change;
- research the potential application of the Reframe uncertainty analysis software in integrated flood management in India.
- research alternative approaches to flood damage estimation using currently available data, or data that could easily be collected, and consider what would be possible with more focussed data collection; tangible and intangibles to be considered as well as direct and indirect.

139. It is expected that some of the findings will be published, with at least two papers in peer reviewed journals co-authored by government and consultants.

D. Scope for Phase 2 - Outline

140. Phase 2 will concentrate on three themes, to cover the above requirements and provide opportunities for publications. Aside from a research focus, the development of IFM plans provides opportunities to define investment projects in terms of infrastructure and preparedness measures. The following three mutually exclusive and collectively exhaustive ("MECE" – see Wikipedia) principles are proposed for the Phase 2 scope:

- Demonstrate the use of flood simulation modelling leading to flood hazard/risk mapping for regional and community flood management.

  - Flood simulation modelling will provide the foundation for flood hazard mapping.

    - Hydrological modelling will cover the whole basin.
    - 1-D hydrodynamic models will be run for the flood prone areas, estimated to cover more than 200 km of the downstream river reaches for both basins, and should have the potential for future integration into flood forecasting systems. The modelling will be conducted with active participation of 2-3 CWC officials having working knowledge in mathematical modelling. These officials would be provided with on the job training and support by the consultancy team. The necessary hardware and software support would be provided under the TA.
    - More detailed modelling with 2-D hydrodynamic models will be conducted for selected areas, representative of typical flood problems faced in many areas. The results are expected to provide detailed knowledge of flood inundation patterns for different flood events.

  - The flood hazard maps provide scientific background for a more detailed assessment of the flood hazard at regional and community level and are expected to play a major role in determining local level (district to block) disaster preparedness as well as a more targeted relief and recovery.
  - The introduction of the element of land use and of flood damage values will allow preparation of flood risk maps. These are typically based on depth – damage curves, which indicate the amount of damage to be expected during different floods. In other parts of the world flood risk maps are used by insurance companies to determine the premiums for property experience different levels of flood risk.

- Prepare IFM plans for two selected basins, one intra-state lying within one state and another inter-state covering more than one state.

  - The IFM plans shall be developed based on stakeholder consultation at all levels, with special emphasis on two-way communication from bottom to top and top to bottom.
  - The main purpose of IFM plans will be to:

    - Build capacity for communities to help themselves and return to a normal life after experiencing flood disaster as quickly as possible.
    - Identify, starting from a community perspective, structural and non-structural measures to improve the resilience to flooding.
    - Introduce the missing elements of land-use zoning and explore if additional developments are required to strengthen the community driven approach to building and development controls.
- Develop institutional arrangements for river basin planning and development of river basin organizations (RBO) including intermediate work arrangements between involved stakeholders (central and state agencies/departments, civil society, local communities).

- During Phase 2 the nodal partners and the consulting team shall investigate the policy and legal framework and the role of a River Basin Organization during the establishments of concrete IFM plans.
- Suitable agencies/organizations will be identified to take the lead for developing the missing integrated flood management measure of land-use zoning in a more formal manner.
- Explore a community centric approach in selected divisions, targeting local level organizations for raising awareness, increased resilience, and pro-active integrated flood management.

141. The core objective of Phase 2 is to demonstrate to central and state government the benefits of an integrated planning process (Figure 29). Although there is some scepticism at state level about the relevance of central government planning, it can be shown that collaborative efforts using specialist knowledge are necessary for integrated planning and sound investment programs. The outcome of PATA 8089 is expected to provide guidance on the planning process, and also to translate into updated CWC guidelines and regulations relevant for future DPR approval[18]. In future DPRs flood management could be more prominently featured in the light of Government's Flood Management Program providing backing for large-scale, systematic investment in flood management.

142. The above three principals have been checked against the integrated flood management framework and CWC's requirements. Table 13 lists the five flood risk management measures and four tools (presented in the Inception Report) and outlines potential Phase II work packages related to each of them. Out of 13 identified research issues provided by CWC at inception[19] , eleven will be fully or partly covered (Table 14).

[18] One important aspect that emerged during the field consultations and the review of some DPRs is that the benefits from flood prevention appear to be systematically underestimated. Apart from not using present-value estimates of historic flood damage data, incremental benefits for example from changed cropping patterns are not considered.

[19] The detailed table is provided in the Inception Report.

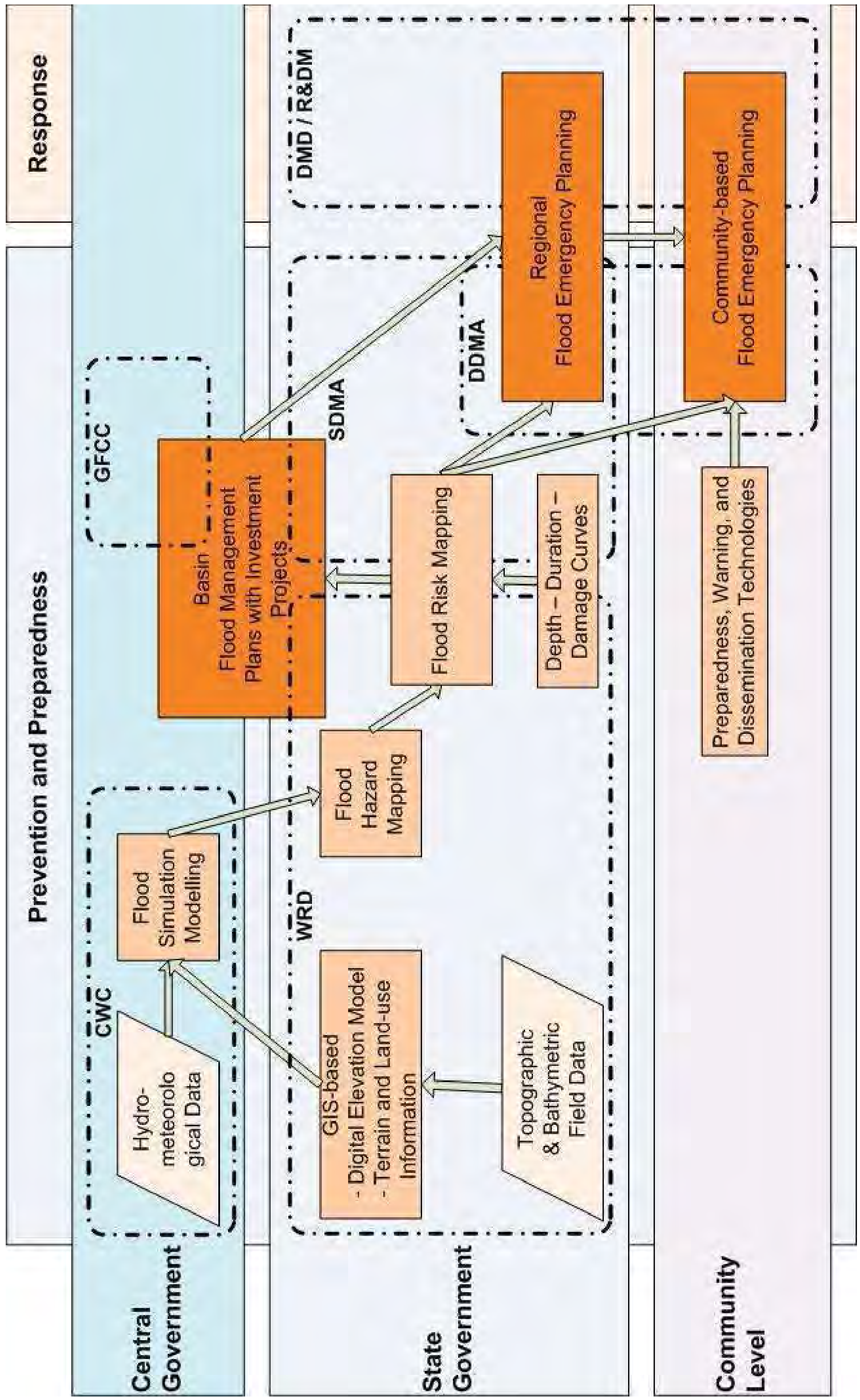


Figure 29: Flow chart of core Phase 2 activities with flood management relevance and involved organizations

Table 13: Flood risk management measures and tools addressed in Phase 2

Flood Risk Management Measure/Tool	Tentative Phase II Intervention in different (Sub)basins
FRM Measures	
Structural Measures	Investigation of free-board and effects of flood level variability on embankment stability Investigation of embankment breach scenarios and implication for embankment stability Investigation of embankment slope stability
Land Use Zoning	Flood hazard and risk mapping for planning purpose; outline of socio-economic, legal, and institutional issues
Building and Development Controls	Flood hazard and risk mapping for planning purpose; outline of legal and institutional issues
Flood Emergency Planning (Regional)	Flood scenarios for prevention, preparedness, and response planning
Flood Emergency Planning (Communities)	Community-based Flood Risk Management, including defining the risk environment, prevention, preparedness, and emergency measures
FRM Tools	
Integrated Land-Use Planning	Form part of basin management plans – outlined
Flood Simulation Modeling	Basin rainfall – runoff model, 1-D and pilot 2-D flood plain modeling incorporating climate change scenarios
Flood Forecasting	Improved background on hydrological parameters (combination of flood relevant factors: rivers, local rainfall, sea levels)
Flood Warning	Developing and piloting application for communities

Table 14: Compliance of PATA 8089 with CWC Identified Flood Management Issues

No.	Issues and Suggested Measures	Phase 1	Phase 2
1	Appropriate return period		√
2	Appropriate freeboard		√
3	Problem of glacial lakes outburst floods		
4	Flash flood studies		
5	Inter-basin coordination and sharing of benefits		√
6	Digital elevation models for flood inundation modeling	√	√
7	Institutional arrangements for data sharing (Water Resources Information System -WRIS)		√
8	Institutional mechanism for structural and non-structural flood management works with respect to international best practice	√	√
9	Assessment of suitability and replicability of Flood Hazard Atlases		√
10	Review of the Hand Book on Flood Management		√
11	institutional mechanism for communicating reservoir operations during the flood season		√
12	Modules for the capacity building of the communities with respect to resilience against flood	√	√
13	Review of the model flood plain zoning bill of the Central Government		√

E. Work Breakdown Structure (WBS)

143. This section describes a proposed work breakdown structure (WBS) for Phase 2, which distinguishes the IFM planning process (Figure 30) and additional research/investigations combining investigations into the potential of RBO but also individual research activities. The WBS lists first order components, second order sub-components and third order tasks, further broken down into detailed activities. The two first-order components relate to (1) flood hazard and risk mapping, and (2) integrated flood management (IFM) planning. Each Component is subdivided into Subcomponents, followed by Tasks and Activities, as described below.

F. Component 1, Flood Hazard and Risk Mapping

1. Component 1, Sub-component 1: Digital Elevation Model (DEM)

Objective:

144. To document floodplain topography and river bathymetry in sufficient detail flood modelling.

Tasks:

- Collect existing topographical data, such as the irrigation maps from Odisha
- Collect information on existing road and flood embankments
- Define survey requirements (refer to Annex H)
- Conduct topographic and bathymetric survey (cross sections)
- Build the DEM

On-going Programs:

- Bihar:
    - The Flood Management Information Support Centre (FMISC) of the WRD has GIS maps and capacity, and will operate until end of 2014
    - The WRD is planning to map the flood way of the Burhi Gandak to determine the need for strengthening of existing embankment lines. The EOI has been invited upon which the budget and further processing will be determined.
- Odisha: ORSAC has completed cross sectional surveys for seven CWC gauge sites consisting of three cross sections each (between the embankments) in April 2013.

Methods:

145. The establishment of the topography in Bihar will largely depend on the survey of cross sections to be done by the Phase 2 team under subcontracting arrangements[20] . As per information from the WRD Odisha, existing irrigation maps are available in the field divisions, with longitudinal profiles of the canal system showing embankment crest level, full supply level, bed level and surrounding terrain level. These maps are expected to cover large areas of the floodplain and allow the establishment of a detailed DEM.

Figure 30: Work Breakdown Structure for Phase 2 IFM Planning Activities

146. The preparation of the DEM in Bihar could be conducted by the FMISC. In Odisha, ORSAC and the GIS cell in the WRD are available for this work. While ORSAC is more established and has a higher level of capacity, the GIS cell will make the data set directly available for future planning and design. It is proposed to involve ORSAC in building the DEM, which will then be transferred to the GIS cell.

147. The establishment of the DEM will be through a combination of existing, satellite based DEMs (for example Cartosat) combined with topographic survey data. The topographic data from a grid of

[20] There are a number of potential firms in Bihar that could conduct the survey: (i) NIRMAN, 4/B, Surya Sen Nagar, Sarsuna, Kolkata-700061, (ii) N K Buildcon Pvt. Ltd., B-62, "UGANTA", University Marg, Bapu Nagar, Jaipur (Rajsthan), PIN: 302015, India, (iii) FUGRO Survey (India) Pvt. Ltd., Fugro House, D-222/30, TTC, Indl Area, MIDC Nerul, Navi Mumbai-400706, India, (iv) RITES Limited, (Schedule 'A' Enterprise of Govt of India), RITES Bhawan, No.1, Sector 29, Gurgaon-122001, (v) WAPCOS Limited, 76-C, Sector-18, Institutional Area, Gurgaon-122015 (Haryana), India, (vi) Sumadhura Geomatica Pvt. Ltd., H No. 1-2-607/5417, SBH colony, Behind DBR Mills, Hyderabad-500080.

long sections are expected to provide a calibration for the otherwise insufficient vertical accuracy. In places, more detailed 2-D modelling can be attempted based on data obtained from vehicle-mounted LIDAR surveys. These data will cover a swath of land in the vicinity of the road network and as such provide detailed information about the terrain as well as the road embankments, which dominantly control the floodplain flows.

Output:

Complete DEM representing the floodplain, river and major embankment infrastructure.

2. Component 1, Sub-component 2: Hydrology and Flood Simulation Modelling

Objective:

148. This subcomponent provides hydro-meteorological parameters for flood simulation modelling, which may be broken down into various scenarios and use different modelling programs

Tasks:

- Validate and frequency-analyse meteorological and river gauge data
- Frequency-analyse sea level data (Odisha)
- Determine relevant combinations of river floods, local rainfall, and sea levels
- Conduct hydrological modelling for the basin
- Establish climate change scenarios
- Conduct hydrological modelling for the basins with climate change impacts
- Conduct 1-D flood modelling for the lower basin for selected observed floods and calibrate the results against Radarsat images
- Conduct 1-D flood modelling for the lower basin and determine flood patterns for different return periods including climate change scenarios
- Conduct 2-D pilot modelling for limited areas in one basin

On-going Programs:

- CWC has experience with NAM and 1-D modelling (Mike 11)

Methods:

149. CWC as the key operator of the main gauging stations in India is the most suitable partner for validating hydro-meteorological data and conducting statistical analyses. Data for the Ganga basin are not in the public domain and their use (water levels, discharges) requires the clearance of the MOWR. It is comparatively easy for CWC to work with these data. To this end CWC will start the approval process as part of the preparation of the preparation work for Phase 2 (also refer to Annex H).

150. CWC is currently building a modelling centre, which is the ideal location for running the hydrology and 1-D flood modelling. In addition, localized 2-D modelling can be conducted here through training on the job. During the consultation CWC agreed to conduct the modelling by providing two to three specialists trained in Mike 11, equipment and, software (Mike 11) during the Phase 2. The PATA consultant will provide additional capacity building support. For more complicated 2-D modelling CWC prefers to use public domain software to avoid the cost of procuring proprietary model programs[21].

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[21] Discussion with Advisor (Technical), CWC on 1 July 2013.

151. Climate change scenarios are expected to be available from research organizations (IITM Pune, IIT Delhi). Given that downscaling efforts are still in progress, the availability of basin-scale data will have to be checked at the beginning of Phase 2.

Output:

- Frequency analysis of hydro-meteorological data
- Calibrated rainfall-runoff model.
- Selected climate change scenarios and downscaled datasets
- Calibrated 1-D floodplain model for different scenarios in Bihar and Odisha
- 2-D floodplain model for one selected area in Odisha.

3. Component 1, Sub-component 3: Flood Hazard Maps

Objective:

152. To superimpose water levels, as predicted by different flood models, on the terrain topography in order to show the extent and depths of flooding in the modelled areas.

Tasks:

- Superimpose flood levels on DEMs for selected return periods
- Provide flood hazard maps for selected scenarios with and without embankment s
- Provide flood hazard maps for selected embankment breach scenarios

On-going Programs:

- Bihar: Preparation of a flood hazard atlas, based on observed flood patterns for around 10 years, was launched in March 2013.
- Odisha: The WRD has classified districts as flood prone with a fixed percentage of the area at risk (independent of the flood) MEANING NOT UNDERSTOOD

Methods:

153. The two basins have different flood characteristics: whereas the Burhi Gandak is mainly determined by river flooding so that flood hazard mapping can be related to definite return periods, Odisha is more complicated because flooding is affected by three factors: (river floods, sea levels, and local rainfall. For Odisha, flood hazard maps may be prepared for individual flood types and combined events (based on analysis of long-term data series). The flood maps for the Burhi Gandak will be taken over by the GFCC as integral part for future updated comprehensive flood management plans and the WRD for planning and maintenance of embankments.

154. Flood hazard maps will be calibrated against observed data in multiple ways. The model runs initially would be based on observed hydrographs of floods of suitable return period, such as 25 or 50 years. An initial calibration takes places against the flood water levels observed in the rivers. In a second step, the model outputs, in the form of inundated areas, will be compared with observed flood patterns from flood season satellite imagery. Especially in Bihar, a number of flood season images are available and where used for the flood atlas. If required the flooded areas from the model can be calibrated against the observed flood areas for selected flood hydrographs. Finally, the models will be run with synthetic floods of specified return periods, such 50 or 100-years and the inundated areas will be established.

155. In both cases GIS capacity is available at State level: in Bihar the Flood Management Improvement Support Centre under the WRD has this capacity, while in Odessa the WRD has a GIS cell with additional high level capacity also available at ORSAC. It is proposed to prepare the flood hazard maps in the GIS cells in order to provide both states with relevant information and training for later replication in other sub-basins.

Output:

156. Flood hazard maps for various return periods and combined flood scenarios.

4. Component 1, Sub-component 4: Flood Risk Mapping

Objective:

157. To show the economic implication of flooding by converting flood hazard maps into flood risk maps[22].

Tasks:

- Collect damage data pertaining to crops, houses and roads
- Map key levels of major infrastructure
- Prepare depth-duration-damage curves for items at risk
- Prepare flood risk maps showing the amount of losses to rice crop and different types of infrastructure for different return periods.

Methods:

158. Flood damage data will focus on crops (essentially rice) and major infrastructure. Infrastructure will distinguish between different types of private and public building and roads. Generally, poorer houses can be expected to be located at lower levels and so prone to more frequent but less costly damages than more expensive houses or public buildings. Similarly, rural roads are generally at lower levels than national highways.

159. Given the GIS capacity at the State levels, it is recommended to conduct the mapping work at the GIS centres of the WRDs.

Output:

Flood risk maps focused on rice crops and different types of infrastructure.

G. Component 2: Integrated Flood Management Planning

1. Component 2, Sub-component 1: Central Flood Management Planning

Objective:

160. To work towards improved IFM planning, discussed and refined during regular consultation meetings between Central and State Government agencies.

Tasks:

- Review of constraints and opportunities with respect to integrated flood management planning and tools;
- Regular, quarterly round-table consultation meetings on flood management issues between Central and State Governments.
- Development of IFM requirements for DPRs, such as flood simulation modelling, relation of the proposed work to flood hazards and IFM plans, and assessment of cost-benefit ratios or economic feasibility.

Methods:

[22] The flood risk maps are based on flood hazard maps, with the element of losses added.

161. The establishment of RBOs requires an understanding of existing institutions in India, the building of trust among potential planning partners, and a definition of an understanding of requirements based on demonstrated approaches. To this end, regular consultation meetings, following the format of the March 2013, Phase 1 round table discussion, are proposed as an appropriate way to build trust and share experience among key players.

Output:

- Mutual understanding about flood management systems at central and state level, focusing on basin states
- Coordinated and agreed DPR requirements for FM programs,

2. Component 2, Sub-component 2: Regional Flood Management Planning

Objective:

162. To prepare integrated flood management plans incorporating central and state-level information and data, as a basis for future investment in both structural and non-structural flood management measures.

Tasks:

- Prepare integrated flood management plans for the selected basins
- Support the preparation of district flood management plans
- Identify future investment potential as an outcome of the plans

On-going or Past Programs:

- Bihar: GFCC has flood management plans for the Burhi Gandak, initially prepared during the 1980s and last updated in the 2000s
- Odisha: Odisha has established RBOs for different basins at regional (DC) level, but those are not presently active.

Methods:

163. The flood management planning process is the vehicle to bring central and state agencies of different disciplines closer. Flood management plans, such as for different tributaries of the Ganga do not seem to play a dominant role for the planning of work of the WRD[23] and the plans do not translate into investment programs, for example the current centrally sponsored Flood Management Program. While basin-wide planning involves central and regional agencies, flood emergency planning and response are coordinated at district level. As such the larger basin plans have to be translated into district plans with the view to improve emergency management but increasingly prevention and preparedness. An important element during the planning process is to incorporate community needs, identified for example; through community disaster management plans (also refer to the next subsection).

164. Under Phase 2 the planning process will be started. In Bihar it will be centred at GFCC with a strong link to structural measures implemented through the WRD and non-structural measures provided by OSDMA. In Odisha the planning will be centred in the WRD with strong involvement of OSDMA.

Output:

- Regional Flood Management Plans;
- State-level RBO requirements

[23] Discussion with Principal Secretary WRD Bihar on 7 June 2013, joined by Engineer in Chief WRD.

3. Component 2, Sub-component 3: Community-level Piloting

Objective:

165. Increase community resilience by helping communities to (i) draw more efficiently on existing programs (ii) contribute to the IFM planning process and (iii) develop and pilot test flood management tools.

Tasks:

- Understand community vulnerability and local community approaches for dealing with floods
- Identify relevant community-based flood management measures
- Strengthen self-help techniques, in coordination with other programs such as NREGS, Indira Awas Yojna, and NGO programs
- Pilot test identified methods to prepare communities for flood disaster, such as
  - communicate local water level information in an appropriate way
  - develop techniques for disseminating flood warnings
  - initiate community-based flood risk planning
- Develop mechanisms for community involvement in the IFM planning process.
- Summarize lessons learned and recommend follow-up activities

On-going Programs:

- Bihar: BSDMA programs on preparedness including flood safety week in early June, insurance workshop, and school curricula.
- Odisha: training communities to use flood shelters.

Methods:

166. Increasing community resilience depends on the understanding of the community risk profile and indigenous and other techniques available to deal with flood disaster. To this end broader and more detailed rural appraisals will be conducted in the flood prone areas of the two sub-basins. The consultative process will provide an understanding of the present situation as well as identify potential for additional support to the communities to increase resilience or reduce the risk. In Odisha, Phase 2 can build on community-based disaster management planning that has taken place in a number of villages. This approach can be broadened but also replicated in Bihar after adaptation to the local conditions.

167. Immediate and pragmatic support can be provided by facilitating the community access to available programs, which have the additional potential to reduce the dependence on government relief Especially with respect to preparedness NREGS and Indira Awas Yojna provide the potential to increase the plinth level of houses or improve existing flood mitigation works. Further potential will be provided through flood insurance and climate smart cropping.

168. The IFM planning process provides scope for developing improved preparedness measures at community level. As a result of flood modelling, flood level warning with locally relevant water level could be established and communicated. Pilot testing of these measures in various areas will further explore the potential of how to improve community resilience in a changing environment. Successfully piloted measures could be adapted for larger-scale application through follow-on programs.

Output:

169. Conclusions and recommendations to increase community preparedness and resilience to flood risks through broader engagement in existing programs and developed and pilot tested new tools and measures.

H. Component 3: Additional Research and Investigations

1. Component 3, Sub-component 1: RBO planning

Objective:

170. To work towards establishing River Basin Organizations (RBOs) in the long-term, by means of investigations into operational aspects of IFM planning and RBO operations, discussed and refined during regular consultation meetings between Central and State Government agencies.

Tasks:

- Review of institutional constraints to implementation of previous initiatives with respect to flood management;
- Development of alternative models for re-structured institutions and institutional arrangements for creating river basin organisations;
- Regular, quarterly round-table consultation meetings on flood management/RBO issues between Central and State Governments.

Methods:

171. The establishment of RBOs requires an understanding of existing institutions in India, the building of trust among potential RBO partners, and a definition of the roles and responsibilities with clear delineations to existing institutions. The establishment of RBOs is a long term process. The initial work will build on the Report of the Committee to study the activities that are required for optimal development of a river basin and changes required in the existing River Board Act, 1956 for achievement of the same and the existing institutional framework including the RBOs in Odessa. Based on this, key requirements for RBOs within one state and covering two states will be outlined and developed. This process will be regularly discussed between central and state organizations involved in IFM planning. The regular consultation meetings will follow the format of the March 2013, Phase 1 round table discussion, and have the purpose to build trust and share experience among key players. At the end of Phase 2 the development and consultation process will be summarized.

Output:

- Mutual understanding about flood management systems at central and state level, focusing on basin planning;
- Outline of RBO framework with involved organizations and linkages

2. Component 3, Sub-component 2: Economic Aspects

Objective:

172. To arrive at comprehensive benefit assessment, for flood management projects.

Tasks:

- Assess potential benefits including direct and indirect flood damages to infrastructure, transport, trade, crops, as well as social costs associated with floods.
- Assess potential incremental benefits associated with crop yields, trade, transport etc. related to improved flood mitigation.
- Assess how the existing benefit-cost approach can be translated into a full economic assessment in line with international best practice.
- Update the cost assessment for disaster response and prevention in this report and develop a simple decision support tool for justifying preventive infrastructure in areas with high cost rescue operations.
- Explore the potential of flood insurance associated with flood risk zones.

Methods:

173. The initial studies of benefit assessment as part of CWC's guideline for Detailed Project Reports revealed some shortcomings in approach, to some part associated with the difficulties of assessing flood damage figures reliably. On another level a number of benefits are not estimated, mostly those associated with indirect cost, for example from transport and trade, and incremental benefits from improved conditions for the "with project" scenarios.

174. We suggest expanding the economic work presented in this report to arrive at a concrete list of benefits to assess the related source of information and assessment procedure. In order to obtain a uniform standard, it is proposed to consider the outcome as part of CWC's process to update the requirements for DPRs.

175. It is international standard to conduct feasibility level studies, with economic internal rates of return. The benefit cost analysis provides an initial step, which can be expanded to the full economic assessment.

Output:

Improved benefit assessment for benefit cost ratio, in updated DPR guidelines and methodology for establishing an economic feasibility approach, building on the updated benefit assessment.

3. Component 3, Sub-component 3: Technical Research

Objective:

To research specific technical issues in order to improve the performance of structural and non-structural flood risk management-integrated flood management measures.

Tasks:

- Assess embankment stability issues related to fast changing water levels (rapid draw down).
- Assess appropriate return periods and freeboards, considering climate change effects, for modern embankments,
- Improve the DEM
- Review the handbook on flood management

On-going Programs:

Building on the Handbook for Flood Management

Methods:

176. The three core technical elements of embankment construction, namely geotechnical engineering, hydrological analysis and hydraulic engineering play together for the assessment of most of the individual research topics. The hydrological work plays into the flood modelling and climate change effect analysis, which are part of component 1.

177. Briefly outlined, the individual tasks can be addressed as follows:

- The embankment stability will be assessed through sample computations on slope stability for a range of typical soil parameters.
- Return periods and associated freeboard require the comparison of present and future water levels including climate change impacts with respect to water levels and wave run-up. Uncertainties are covered by fee board, and it will be discussed if expected climate change impacts are small enough to be included into the freeboard and only translate into concrete changes in design water levels after having more certainty or if

there is enough confidence to change the design water levels at this point in time. The discussion on water levels requires a review of the risk concept, combining water levels with assets at stake. In places it could be justified to increase the return period to offset the increasing assets accumulated on the floodplains.

- The DEM improvement is part of the flood modelling work, as the precision of the DEM depends on the quality of the vertical elevation data. In a first approach it is suggested to use long sections across the floodplain to correct the elevations of existing satellite based DEMs. Ideally the highest possible resolution DEM is used, as the vertical accuracy is a function of the resolution. In a second step, it is suggested to apply vehicle mounted LIDAR for more detailed topographic information in a small and somewhat contained part of the sub-basins. This information along the existing road network is expected to provide a better approach towards building sufficiently precise DEMs for flood modelling.
- The review of the technical oriented handbook requires a general understanding of flood management practices and structural works. Given that the new International Levee Handbook has been launched in August 2013, we recommend to compare the handbook with this international work and to list the differences with concrete recommendations how to close identified gaps.

Output:

Additional insight into technical aspects that are important for integrated flood management planning.

I. Phase 2 Implementation

1. Phase 2 Consulting Resources

178. The proposed consulting resources are generally aligned with the provisions in the TA paper. Based on field visits, however, the State level resources have been increased and the focus has been directed to practical integrated flood management planning at state level. In order to collect the required data and to arrive at an intensive level of cooperation, intensive interaction at the state level will be required. In addition the iFM planning depends on consistent regular interaction with all involved parties. The related changes in consulting resources between the TA paper and the present Phase 1 study are shown in the table below. The proposed responsibility matrix is shown in Table 16 and the schedule in Figure 1.

Table 15: Comparison of proposed consulting resources – TA vs. This Scoping Study

Phase 1 Recommendation		PATA Paper	Flood Mgmt Specialist / TL	Flood Modeller and Climate Change Specialist	land Use and Spatial Planner	Socioeconomist	Remot Sensing GIS	Groundwater Specialist	Agronomist	Legal Institutional Specialist	Social and Community Specialist	Environmentalist	Civil Engineer	Irrigation and Drainage Engineer	total
		international	8	6	2	4				2					22
	intern.	national	17	15	6	6	6	2	3	6	8	4	7	4	84
Flood Mgmt Specialist / TL	6.2	0.0	1												
Flood Management Specialist / National TL	0.0	15.5	⅓												
FM Specialist Bihar	0.0	14.8	⅓												
FM Specialist Odisha	0.0	14.8	⅓												
Hydrology and Flood Modelling Advisor	5.1	0.0		½											
Hydrology and Flood Modeller Bihar CWC	0.0	0.0		⅓											
Hydrology and Flood Modeller Odisha CWC	0.0	0.0		⅓											
2-D Flood Modeller CWC	0.0	0.0		⅓											
Climate Change Specialist	2.1	0.0		½											
Remot Sensing GIS Advisor Bihar	0.0	5.1					½								
Remot Sensing GIS Advisor Odisha	0.0	5.1					½								
Water Resources Economist	0.0	3.0													
Institutional Specialist	0.0	3.0								½					
Legal Specialist	0.0	1.2								½					
Social and Community Specialist Bihar	0.0	8.8									½				
Social and Community Specialist Odisha	0.0	8.8									½				
Economist	0.0	1.8													
Agronomist	0.0	1.6							1						
Environmentalist	0.0	2.1										1			
Geotechnical Engineer	0.0	3.0											1		
FM and Drainage Engineer	0.0	3.0												1	
total	13.4	91.4													

Table 16: Responsibility Matrix – consulting team vs. tasks

Component	Flood Hazard and Risk Mapping																								Integrated Flood Mangement Planning													Add. Research and Investigations																						
Sub-component	DEM					Hydrology & Flood Modelling											Flood Haz. Map.				Flood Risk Mapping				Central				Regional				Community					RBOs			Economics				Research														
Position / Task	Collect topo data	collect embankment data	define survey requirements	conduct topo and bathy surveys	build DEM	collect hydro-met data	validate and analyse data	collect and analyse sea level data	conduct hydrological modelling	identify climate change scenarios	model climate change scenarios	1-D flood modelling of observed floods	calibrate floods against Radarsat images	Model Scenarios	1-D models for return periods	2-D model for one area	Superimpose Flood Levels on DEM	Prepare maps for no embankment scenario	Prepare maps for with embankment scenario	prepare maps for embankment breach scenarios	Collect damage data for crops/houses/infrastructure	prepare depth-duration-damage curves	map location of main infrastructure	prepare flood risk maps	round table consultation meetings	IFM requirements for DPRs	IFM requirements	Research (flood water levels, embankment stability)	Prepare Basin Flood Management Plans	Prepare District Flood Management Plans	IFM requirements	Identify future investment potential	Identify community-based FM issues	identify community-based FM measures	Select FM measures for Piloting	potential pilot tests	IFM requirements	Review Institutional constraints	Develop alternative RBO models	Round table consultation	Assess direct and indirect benefits	Develop steps towards full feasibility	Provie summary cost for disaster mitigation	Explore flood insurance	Embankment stability	design flood and freeboard	improve DEM	Review Handbook	Reporting	Team Management	Client Coordination	total tasks per person	subtotal	international	national	CWC	international person months	national person months	CWC person months
																																																									0	0	0
Flood Mgmt Specialist / TL																									2	4	3				2	2					1	1	1	1								1	3	3	3	27		27			6	0	0
Delhi Coordinator / National TL	2	2	2	2		2	2	2																	4	4	4		4	3	3																3		4	12	12	67			67		0	14.9	0
Regional Coordination and FM Specialist Bihar	1	1	1	3																	6				3	2	1		5	3	1	2	2	2	1	3	1			1								1		12	12	64			64		0	14.2	0
Regional Coordination and FM Specialist Odisha	1	1	1	3				1													6				3	2	1		4	3	1	2	2	2	1	3	1			1								1		12	12	64	222		64		0	14.2	0
Hydrology and Flood Modelling Advisor							1	1	1		1	1	1	4	1	4	1	2	2	2																																22		22			4.89	0	0
Hydrology and Flood Modeller Bihar CWC						2	2		8		4	4	3	15	3																																					41				41	0	0	9.11
Hydrology and Flood Modeller Odisha CWC						2	2		8		4	4	3	15	3																																					41				41	0	0	9.11
2-D Flood Modeller CWC																23																																				23				23	0	0	5.11
Climate Change Specialist										9																																										9		9			2	0	0
Remot Sensing GIS Advisor Bihar					4												3	3	2	3			4	3																												22			22		0	4.89	0
Remot Sensing GIS Advisor Odisha					4												3	3	2	3			4	3																												22			22		0	4.89	0
Water Resources Economist																					4	4		5																												13	193		13		0	2.89	0
Institutional Specialist																											5				1						1	2	3	1												13			13		0	2.89	0
Legal Specialist																											2											1	2													5			5		0	1.11	0
Social and Community Specialist Bihar																									3								8	11	2	12	2															38			38		0	8.44	0
Social and Community Specialist Odisha																									3								8	11	2	12	2															38			38		0	8.44	0
Economist																																									2	2	2	2								8			8		0	1.78	0
Agronomist																																					1				2	2	2									7			7		0	1.56	0
Environmentalist																										2	1		2	2	1						1															9			9		0	2	0
Geotechnical Engineer																																													11			2				13			13		0	2.89	0
FM and Drainage Engineer																																														9		4				13	144		13		0	2.89	0
total staff working per task	3	3	3	3	3	6	7	4	17	9	9	9	7	34	7	27	7	8	6	8	16	4	8	11	18	14	17	0	15	11	9	6	20	26	6	30	10	3	3	4	4	4	4	2	11	9	3	9	7	39	39	547	559	58	396	105			

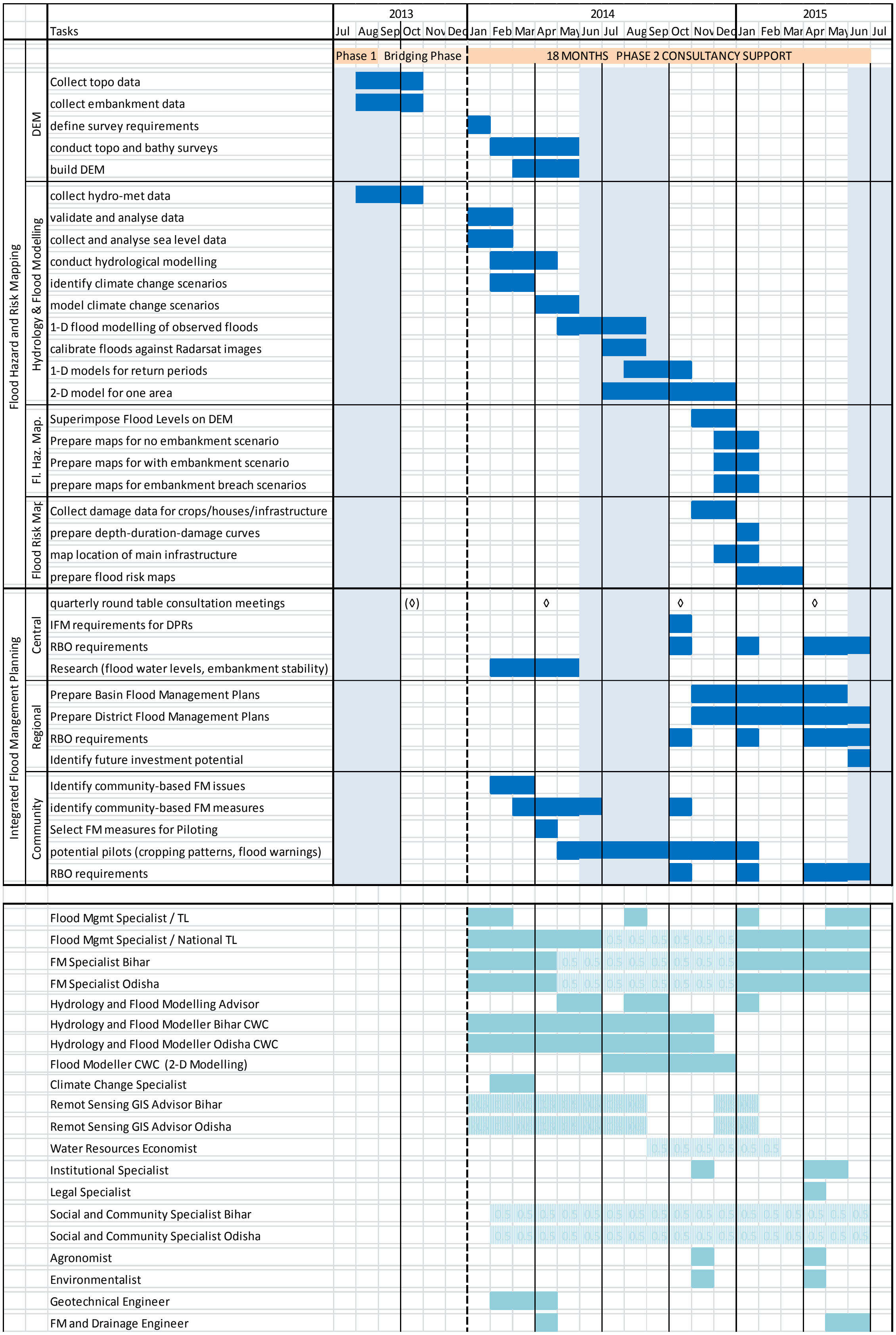

Figure 31: Proposed schedule

2. Milestones

179. The Phase 2 work will be guided by several milestones:

- Reports
  - inception: 1 month after work start
  - interim (flood simulation modelling and hazard mapping) 13 months after work start,
  - draft final: 17 months after work start,
  - final: 18 months after work start

- Round table discussions
  - April 2014: work program and data collection
  - October 2014: flood simulation modelling, conclusions on inter-institutional collaboration
  - April 2015: flood risk mapping and RBO needs

J. Counterpart Facilities

180. CWC will provide counterpart facilities. These involve:

- Furnished office space in Delhi
- Two to three modellers to conduct the hydrological analyses and flood simulation modelling

181. GIS activities, to some extent supported by the Phase 2 team, should ideally be housed in state level institutions such as WRDs or SDMAs, which could also provide office space for consulting team members in Patna and Bhubaneswar.

VII. OUTLOOK

A. Phase 1

182. Phase 1 of PATA 8089 will end in September 2013. Between mid-July and mid-September the following activities are expected:

- Receipt of final comments on the Interim Report and issuance of the Draft Final Report;
- Technical review of the Draft Final report, incorporation of comments and presentation of results during a workshop in early September;
- Data collection and related field work. In order to facilitate Phase 2 start-up, first data and data clearance requests have been communicated (Annex H). It is expected that a bridging phase following Phase 1 (see below) can obtain the next level of more detailed data, such as outlined in the Interim Report.

B. Project Steering Panel Meeting

183. The first Project Steering Panel Meeting discussed the draft final report on 27 January 2014 under the chairmanship of Shri Alok Rawat, Secretary (WR). The meeting accepted the draft final report and suggest several measures for Phase II:

- All data generated or procured for the study shall remain in the domain of the Government of India;
- Community participation in existing flood management practices shall be elaborated;
- The data documentation shall make use of data bases and GIS;
- Recommendations for the Buri-Gandak sub-basin shall be prepared in two reports, one for the Indian part of the basin, the other for the Nepali part.

C. Bridging Phase

184. Between mid-September and the start of Phase 2 the Member Adviser (Technical), NWM & Chief Engineer (P&D), CWC will pursue data assembly and initiate field work after the flood season, as follows:

- Data assembly:
  - Hydro-meteorological data from CWC stations can be compiled, after obtaining Ministry clearance for Ganga basin data.
  - Terrain data from Bihar and Odisha are expected to be collected by WRD GIS cells.
- The CWC modelling centre is expected to be developed.
- Field data: The Odisha Government indicated its willingness to survey cross sections of Brahmani/Baitarani channels in the delta. In addition, the Phase 2 team has to organize river and floodplain surveys in Bihar, expected to start in February 2014. A total allocation of USD 150,000 has been made, including vehicle-mounted LIDAR equipment for 2-D flood modelling.

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