A Model Integrating Flood Disaster Resilience into Developmental Plans for Adaptation to Climate Change: A Case Study from Northern India

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Abstract

India is prone to several hydro-meteorological disasters, viz. floods, cyclone, drought and disease epidemics, known to have been aggravated under the impact of climate change. Disaster Management Plan at District level (DDMP) prepared as per statutory requirement, seldom envisaged risk mitigation or role of developmental activities, and remained a contingency coordination charter, due to lack of orientation to consider climatic scenarios and consequences relevant to development and disaster preparedness. Flood vulnerability of land and people in North India remained un-attenuated with resultant disaster situations almost every year due to uncertain and frequent climate hazards in the Districts like Gorakhpur in Uttar Pradesh. A pilot action research was undertaken by the team comprising of NIDM, GEAG and ISET (US), in collaboration with District Disaster Management Authority during 2012-13, to understand prevailing and emerging risks in the light of climatic projections, and their relevance to department-wise developmental activities and plans. The process involved series of workshops, consultations and shared leanings, which led to improved and climate resilient developmental plans at district level, and finally a climate-sensitive and adaptive DDMP as a model. A Training Manual based on Gorakhpur model of CCA-DRR integration at district level, and a Delhi declaration on 'Resilient Housing' (2014) were other outcomes. This paper discusses the approach and process, enabling factors and outcome, comparing with other approaches and pathways of integrating CCA and DRR at different levels.

Keywords: *Climate projections, Flood vulnerability, District plans, Disaster Management Plan.*

Introduction

India, like other countries of the region, has its land and inhabiting people vulnerable to a range of hydro-meteorological disasters, effects of which supersede any other

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category of disasters, for example, earthquakes or industrial mishaps. Northern India, chronically facing floods and drought proneness, witnesses scientifically and statistically evident impacts of climate change. Episodes of flood disaster are usually an annual feature in areas like Gorakhpur. Floods associate with emergencies for water, sanitation and medical response, besides temporarily evacuating, relocating and relief to flood affected populations. Disaster management in India has been 'relief- and response- centric' till past decade with, however, focus shifting to disaster mitigation-preparedness (DPR) in early 2000s, and now toward 'long-term DRR' integrating component of Climate Change Adaptation. Disaster Management Act 2005 (Chapter 4) mandates setting up of district level District Disaster Management Authority and preparation of District Disaster Management Plans. Hyogo Framework of Action (HFA) 2005-15, and following Bangkok Declaration on Disaster Risk Reduction (DRR) in Asia & Pacific, in the backdrop of Sustainable Development Goals (SDGs) strongly advocate mainstream Disaster Risk Reduction and Climate change adaptation into local development processes.

'Multi-hazard' disaster management plans to deal with prevailing disaster risks and emerging risks (evolving) due to changing climate conditions attained special emphasis in India's National Policy on Disaster Management 2009 (NDMA, 2009). However, the Disaster Management Plan developed at district level as a statutory requirement (as per DM Act), hardly focuses on risk mitigation or role of developmental activities, but rather remained a contingency coordination charter. Lack of orientation of key professionals to consider climatic scenarios and consequences relevant to development and disaster preparedness was a critical challenge. Considering the gaps and importance of mainstreaming DRR and Climate Change Adaptation (CCA) in developmental planning process at district level a pilot action research study was undertaken in Gorakhpur district by NIDM, ISET-US and GEAG during 2012-13 with the support of Climate Development Knowledge Network (CDKN), and in collaboration with District Disaster Management Authority.

The Climate Resilience Framework (CRF) developed initially for resilient urban areas (developed by ISET) has been referred to in drawing the vulnerability analysis approach in the present study as well (Figure 1).

This study aimed to understand prevailing and emerging risks in the light of climatic projections, and their relevance to department-wise developmental activities and plans. The process involved detailed literature review, analysis of existing data on disasters and climatic factors and review of existing plans. This was followed by a series of workshops, consultations and Shared Learning Dialogues (SLDs), which led to the development of improved and climate resilient developmental plans at district level (GEAG, NIDM & ISET, 2013). This served DDMA to come out with a climate sensitive model DDMP for Gorakhpur District (DDMA, Gorakhpur, 2013).

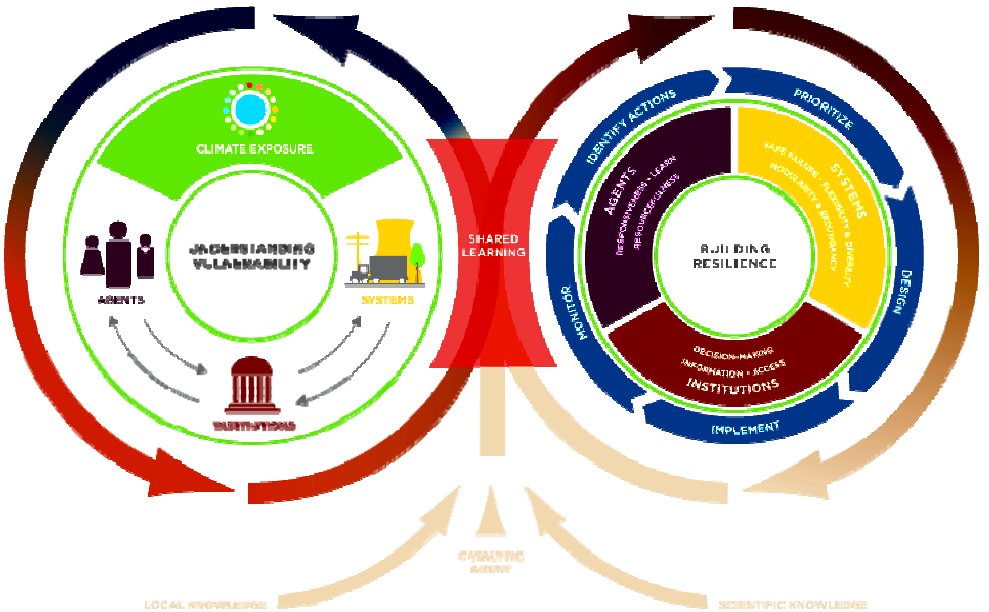


Figure: Climate Resilience Framework (Source: ISET International. http://i-s-e-t.org/projects/crf.html)

Study Area Description

Gorakhpur is one of the flood prone districts situated in the eastern corner of Uttar Pradesh. It lies between Lat. 26°13´N and 27°29´N and Long. 83°05´ and 83°56´. The district has 3,321 sq km geographical area and is located in the '*Terai Belt*'. It has cup-shaped topography that increases the risk of flood during monsoon season. Approx 70% population is living in rural area dominated by the agriculture as the main occupation (Wajih et al., 2010). Presence of several rivers in the Gorakhpur district increases the risk of flooding. Rapti river covered the largest part of Gorakhpur and it has tendency of overflow during the monsoon season. Gorakhpur has a population of 4,436,275 with 51.43% male and 48.56% females. Population density in the district is 1,336 per sq. km.

Approach and Methodology

Aim of the study was to understand prevailing and emerging risks in the light of climatic projections, and induce the component of Climate Change Adaptation and DRR in preparation of climate-sensitive department-wise developmental plans and District Disaster Management Plan. Key objectives were following:

To understand existing and emerging risk of disasters in the district with special focus on floods under changing climatic conditions,

- To understand systemic factors within the flood-prone Gorakhpur district which can exacerbate vulnerability and hamper resilience against flood disasters, and
- To understand specific policy innovations that could help bridge the vertical gap between integrated national policy framework and local contexts and the horizontal gap between actions within sectoral development programme to integrate DRR and CCA practice in departmental plans. This involved:
  - (a) Analysis of exiting departmental plans and district DM plans and identification of the gaps, and
  - (b) Identification of pathways of integration and inducing CCA-DRR in developmental plans, through inclusion of measures (short-term and long-term) into Departmental plans.

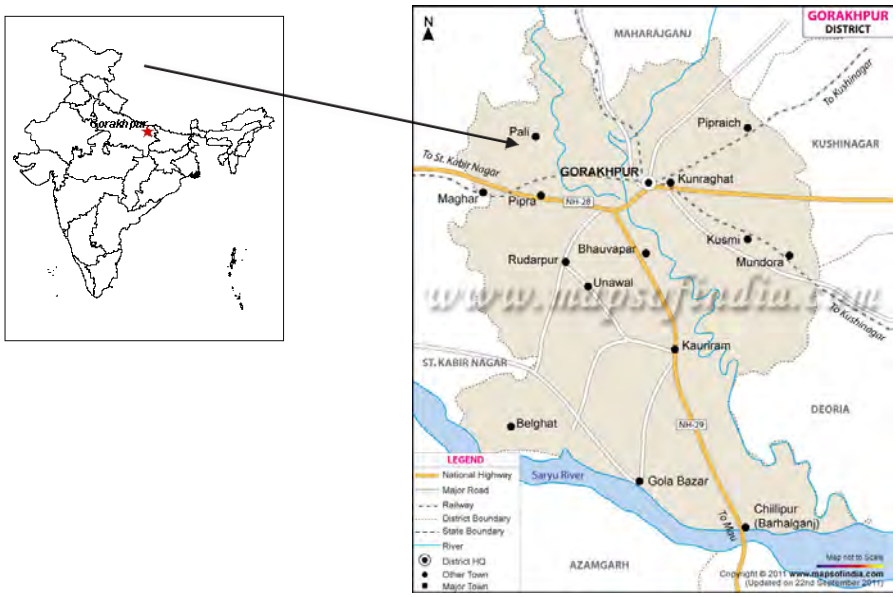


Figure 2: Location of Gorakhpur in India

- The study was an action research and approach was "Practice to Policy" orientation. Data on various hazards, disasters and climatic factors were analysed based on the available scientific datasets. Remote Sensing data and GIS were used extensively in mapping and analysis. Downscaling Climate Change Projections for Gorakhpur and Extreme Event Analysis were also carried out. A detailed downscaling of Climate Projections was carried out for Gorakhpur's rainfall in 2050's. Subsequently, to capture changes in extreme precipitation events Intensity-Duration-Frequency (IDF) curves were developed for key duration and intensities (Opitz-Stapleton, 2013).

The process diagram of the study is given as figure 3. Outcome of the study also included a training manual on mainstreaming CCA-DRR integration and policy intervention in the form of State level Government Orders (GOs) and a 'Delhi Declaration on Resilient Housing', besides a Model of climate resilient District Disaster Management Plan (crDDMP). Key agencies involved in the process were following:

- Research Institution (NGO) – Gorakhpur Environmental Action Group,
- Institute of Social & Environment Transition (ISET), US – an International Research Organisation,

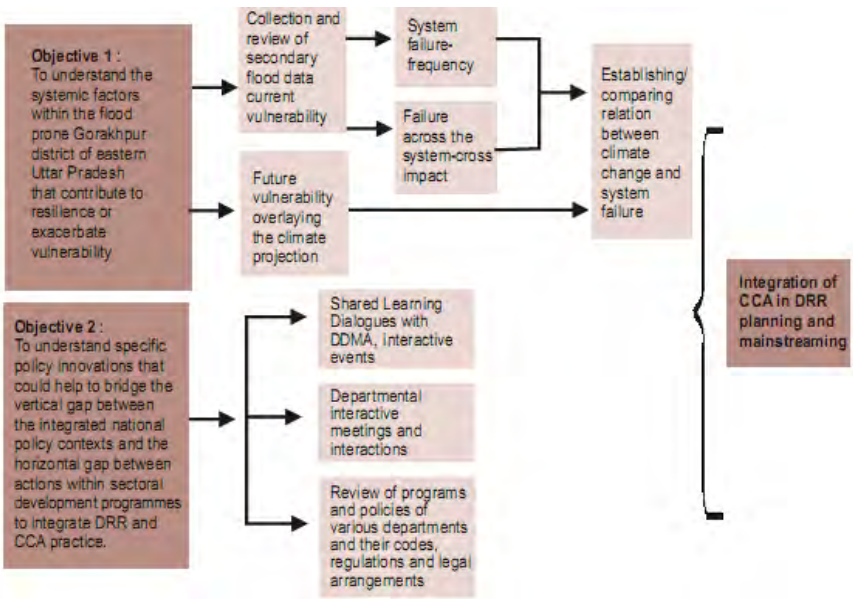
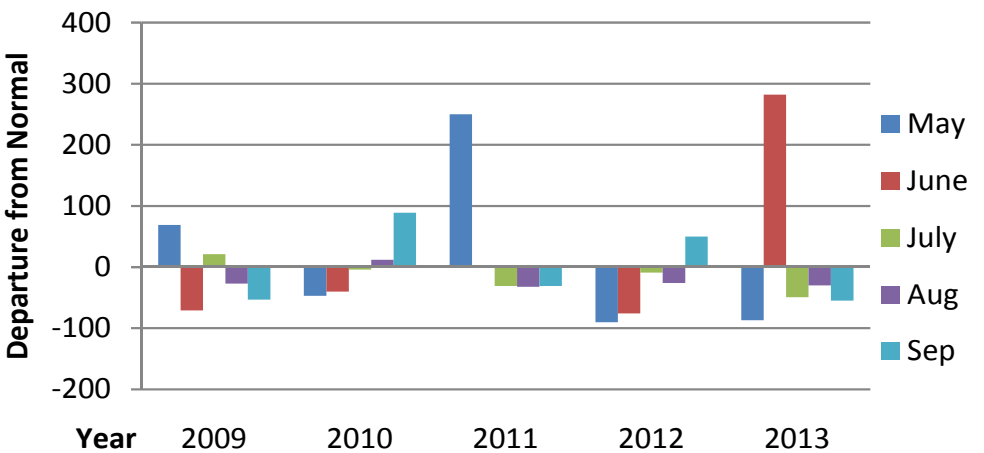


Figure 3: Methodology flowchart detailing the steps towards integrating CCA DRR in developmental planning (Source: GEAG, NIDM & ISET, 2013)

- National Institute of Disaster Management (NIDM) – apex institute of Government of India on disaster management capacity development, research and training,
- District Disaster Management Authority (DDMA) – statutory agency constituted as per Disaster Management Act 2005, at district level, and
- District Departments, like Nagar Vikas (Urban Development) - Local Bodies, Jal Nigam; Department of Environment & Forest, Dairy Development, Revenue, Fisheries, Horticulture, Remote Sensing Application Centre, Health, State Disaster Management Authority, Rural Development, State Institute of Health & Family Welfare, Animal Husbandry, etc.

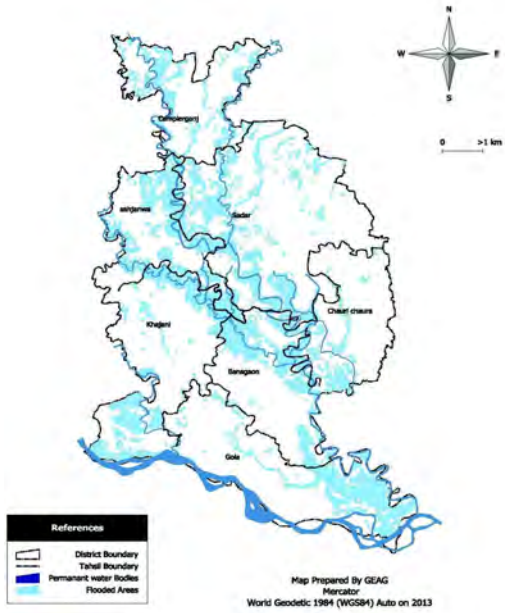
Results and Discussion

Unplanned urbanisation coupled with poor land use planning and encroachment in the river channels increased the flood risk (Arya et al., 2012). Gorakhpur is experiencing climatic variability, which is quite evident from the monsoon rainfall. Number of rainy days in the season is decreasing and 80% of the rainfall was received in the months of May 2011 and June 2013. Gorakhpur is now experiencing perennial flood challenges.



(Source: IMD, Govt. of India)

Figure 4: Departure from Normal Rainfall (May-September) 2009-2013



(Source: GEAG)

Figure 5: Gorakhpur district Flood-Prone Area

Downscaling Climatic Projections

Global circulation models (GCMs) project how the climate might change, given changes to these human-controlled factors, which are accounted for as representative concentration pathways (RCPs) in the IPCC 5th Assessment models (van Vuuren et al., 2011). Because no single model can project exact changes to an area's climate, it is necessary to use projections from multiple GCMs, each driven by a couple of RCPs, to capture the possible range and trend of changes. Furthermore, climate is a description of an area's average weather over a period of time, typically 30 years. Therefore, climate change analysis involves comparing the statistics of an area's particular weather as projected for a period in the future that is at least 30 years long, with a period of historical climate of the same length.

With these two caveats, ISET obtained the daily precipitation data (simulated historical and projected future) from the CMIP5 Multi-Model Ensemble Database (http://pcmdi9.llnl.gov/esgf-web-fe/). The ensemble set of projected daily rainfall was formed using projections from 9 GCMs, each running the RCP 4.5, for a total of 9 ensemble members against which to compare future rainfall with past rainfall. Simulated historical rainfall by the GCMs covered the period 1961–2005, whereas future projected rainfall spanned 2006–2055. At the time of data access from the

CMIP5 Database (November 2012), only projections from RCP 4.5 were available, precluding the use of other RCPs for comparison.

A 'super' historical daily rainfall dataset for Gorakhpur was compiled and interpolated from a number of data sources due to the incompleteness of available records. Additional historical data covering the period of 1961–2005 were accessed from the APHRODITE project database (Yatagai et al., 2012) to validate and supplement gaps in the sparse station records. The data were cleaned and underwent several quality control checks that are standard for meteorological and climatological analysis.

Six out of the nine GCMs were able to reasonably replicate the seasonality of Gorakhpur's rainfall, as well as the median and standard deviation (the first and second moments) of monthly rainfall totals. Hence, these 6 models were used for Climate Projections downscaling.

Possible Changes to Gorakhpur's Extreme Rainfall by 2050s

In the future, according to a range of a combination of different climate models and emission scenarios, the intensity and frequency characteristics of rainfall events for Gorakhpur are likely to change. For 24-hour and longer duration events of all return periods, all of the models project a potential increase in precipitation intensity. That all models are in agreement about the direction of the change in trend (increasing) provides some measure of confidence in the projections.

Table 1: Percentage change in rainfall intensity for 24-hour duration events between multi-model projected (2006-2055) and historically observed (1961-2005) events for Gorakhpur

	Return Period (in years)			
Model	**2**	**10**	**20**	**50**
HadGEM2	9.6%	4.3%	3.4%	2.2%
NCAR-CCSM4	10.0%	19.1%	20.1%	22.5%
BCC-CSM1.1M	20.4%	23.4%	24.1%	24.8%

Table 2: Percentage change in rainfall intensity for events of select durations (1, 12 and 24 hours) for select return periods (2, 10 and 50 years).

Duration (hrs)	Return Period (Years)		
	2	**10**	**50**
1	11 to 18%	-12 to 52%	-22 to 68%
12	10 to 17%	1 to 30%	-4 to 33%
24	10 to 20%	4 to 23%	2 to 25%

Percent changes are derived from comparing IDF curves from multiple GCMs for the future (2006-2050) with historical IDF curves (1961-2005).

There is greater uncertainty (larger spread in the model projections and/or unclear direction of increasing or decreasing intensity) in how climate change might alter short duration events—those lasting less than 12 hours—than in events lasting longer than 12 hours as shown in (Table 1 and 2). Some of this uncertainty is due to gaps in the historical observation records that affected the statistical distributions and will improve with time through efforts such as GEAG's automatic weather station, and coordination with the local Indian Meteorological Department office. Other sources of uncertainty are due to natural climate variability (not influenced by climate change), the differences between GCMs in how they model interactions between the land, ocean, and atmosphere to influence climate, and the fact that no-one really knows what the world's population, energy use, greenhouse gas emissions, and land-use will look like in 2050. This is why it is important to use projections from multiple models, and build cities smartly to reduce natural hazard risks.

Scientific analysis was coupled with Social Science methods. Shared Learning Dialogues (SLDs) were a central component in the research approach. Different techniques of shared learning bring together knowledge from different disciplines with that held by individuals and organisations in communities, the government, and other sectors.

Shared learning involves structured one-to-one and small group interactions that elicit insights from participants and build their understanding of the views of others and their implications. Many of the techniques are similar to those used in participatory research, but they stand out for their ability to build new knowledge and common understanding. Shared learning processes move research away from outsider-driven, top-down, extractive information gathering towards participatory, bottom-up, and inclusive knowledge generation.

Process of Integration of CCA –DRR in Departmental Plans and DDMP

Analysis of Vulnerability

Data and documents related to the hazard and disaster profile, climatic conditions etc. were collated and analysed. Spatio-temporal analysis of floods, location of water logging sites, rainfall and flood level data etc. were carried out. Special focus was given on analysing the systemic vulnerability in the area. Various data and documents related to flood damage, relief distribution, disaster response planning were collected. Several Government Orders from the DDMA were collected and thoroughly analysed to identify gaps at departmental level. Along with the observation of shared learning

dialogues, identified points were used to prepare guiding documents or departments for preparing effective plan.

Series of Dialogues

Project Launching Dialogue

In July 2012, a project launching dialogue was organised by GEAG and DDMA at DDMA office to share the project purpose, implementation plan and expected outcomes with the concerned line departments; 54 government officials from various departments participated in the workshop and expressed their viewpoints on the process. On behalf of District Magistrate, Additional District Magistrate-Finance Revenue (ADM-FR) chaired the workshop and facilitated the discussion. Representatives from NIDM, ISET and GEAG were present in the workshop. Key outcomes of the workshop were (i) nomination of ADM-FR as Nodal officer for anchoring the project from DDMA Gorakhpur (ii) placing of a representative from NIDM and GEAG in DDMA to manage the project and coordinate with various departments (iii) formation of Project Steering Committee at district level (iv) progress review meeting to be held quarterly (v) provision of separate meetings at all departments from time to time to make department wise preparedness and response plan for District.

Departmental Shared Learning Dialogue

The Shared Learning Dialogue was organised by DDMA and GEAG under the title - Climate Change - District Disaster Management and Reduction Management Workshop to prepare Guidelines with different Departments: Problems & Opportunities. Details of department wise identified gaps and recommendations are listed in Table 3.

State Level Sharing at Top Policy level and State Disaster Management Authority (SDMA)

This process, thus, was shared with the Minister of Revenue and Relief Commissioner of Uttar Pradesh in a state level dialogue in Lucknow where process and outcomes were presented before them. ADM-FR from 24 districts were also present during the sharing. The prime purpose of sharing the process was not only to make them aware of it but also getting the process recognised at state level so that it can be scaled up at larger level though SDMA in other districts. As a result, Relief Commissioner instructed district representatives to follow the process undertaken in Gorakhpur in DDMP preparation.

Table 3: Department-wise identified gaps and recommendations

Department	Gaps Identified	Recommendations to Departments
Rural Development/ Distt. Administration	• Lack of adequate human resources • Lack of information on fund disbursal to the beneficiaries under the disaster relief fund • Non-utilisation of funds due to lack of information on disaster management relief fund	• Development programmes should be designed keeping in mind the local disaster threats and disaster reduction should be an integral part of the development programmes • Coordination between governmental planning and development projects should be established • MGNREGA scheme should be utilised for cleaning of rivers and removal of silt. Several other developmental works can be done through MGNREGA funds.
Health Department	• Connecting road to PHCs/CHCs gets damaged during rainy season-Long duration power cuts creates problems in attending the patients in the PHCs/CHCs • Women employees feel unsafe working in the late evening hours in the centres because there is no adequate arrangement of lights on the roads • Caution before floods are not given due to which adequate preparations are not made • Most of the health centres get water logged due to heavy rain	• In the construction of PHCs/CHCs, it is important to include flood resistant techniques along with earthquake resistant techniques • Training on DO's and DONT's at times of disaster should be organised for the members of Village Health and Sanitation Committee
Education	• School premises is often used for shelter and relief centres during flood disaster • Lack of knowledge in students regarding basic disaster preparedness and safety • Many of the schools are not located at elevated land	• In the construction of schools, it is important to include flood-resistant techniques along with earthquake-resistant techniques • Site selection for construction of schools should be done at a safe and elevated place • In the school campus, the Mark-ll hand pumps should have proper water outlet arrangements • Information and awareness on use and management of fire extinguishers installed in the schools should be given not only to the teachers but also to accountants and employees of other departments • Mock programmes in the schools should be organised on relief and management of disasters; the schools should not be used as disaster relief camps or for storage of food grains. This adversely affects education

Agriculture/ Agriculture Protection Department	• Crops get affected due to untimely rains, extreme cold and hot temperatures • The situation of agriculture go-downs at the block level are not good due to which flood water enters the godowns and causes damage to the chemicals stored there • Water logging in the crop fields causes problems in controlling pests, insects and diseases. Also, application of pesticides in water logged areas causes water pollution • Problems in storage of crops • Soil structure gets affected and amount of silt increases. Floods negatively affect crop cycles	• Works related to land levelling and construction of farm bunds for the conservation of soil can be done under the MGNREGA programme • Promotion of vermin compost and Nadep compost structures under MGNREGA programme • Effective coordination should be established between soil conservation department, agriculture department and agriculture protection department • There is a need to bring about awareness among farmers from the flood-affected areas to use flood resilient varieties of crops
Animal Husbandry	• Infertility problem in animals due to extreme temperatures • Non-availability of fodder because of water logging • Shelter problem for animals during rains and water logging - Water logging leads to diseases • Animals suffer because of unavailability of medicines at veterinary hospitals	• Pre-flood vaccination of animals • Shelter and fodder for animals should be the part of relief package • Ensure availability of medicines at village level
Jal Nigam	• Most of India Mark-ll pumps are not functional during disaster in India • Funds for installing hand pumps at elevated lands are not sufficient • The plan for establishing sewerage system for the city of Gorakhpur is ready but due to non-allocation of funds, the work has not yet started • For every scheme, there should be adequate number of regular staff to carry out the tasks	• The India Mark-ll hand pumps should be installed at a high elevated and safe place with the support of Panchayats • In construction of buildings, problem of flood should be kept in mind • Renovation of water sources to enable access to water for everybody in the village and ward • The Panchayat (local body) should get the defunct hand pumps repaired in time • For the implementation of schemes, the funds should be made available before the actual work on the ground starts • System of quick communication, decision and implementation should be established in order to manage disasters effectively

Panchayati Raj Department	• Lack of resources for repair of destroyed public properties • Lack of active involvement in planning and implementation process • Capacity building of Pradhans and other members are not done at local level • Lack of infrastructures and other facilities	• Assessment of flood and other disasters in local areas should be done according to which provision for funds should be made for the maintenance of Panchayat bhawan and other public buildings • Awareness should be brought among villagers to keep their village surroundings clean and usage of individual, school, Anganwadi and community toilets should be promoted • Awareness campaigns can be done by using motivation groups, nukkad natak, media, etc. • For the repair of India Mark hand pumps for drinking water, funds under Panchayati Raj, 13th Finance Commission should be increased • Assessment of damage caused to public properties should be done and accordingly the demand for renovation/repair of these properties should be made. This should be implemented at the Gram Panchayat level for which adequate funds should be allocated
Flood Division and Drainage Division	• Less number of work supervisors in the departments • The embankments get cracked in summer season due to high temperatures. Situation becomes even worse if this is immediately followed by heavy rains • Pressure on the embankments increases when all of a sudden, water increases in the rivers which are on the way to Nepal • Lack of support and cooperation from Tehsil and local government	• As per the State Disaster Response Fund (SDRF) guidelines, the embankments should be re-established within 45 days. It becomes very difficult to get the work completed within this deadline • It is important to activate the flood protection committees
Saryu Canal Division	• Heavy rains rupture the branch-lets of canals which hampers irrigation facilities - Depletion in the groundwater levels due to which the discharge from tube wells is decreased • Low electricity voltage because of which the tube wells get defunct in the Kharif season, the pipelines are destroyed at some places by the farmers	• Construction and re-establishment-related works are done during a fixed time. Considering the geographical and environmental situation of an area, it is important to place bans and restrictions on cultivation of water-intensive crops such as peppermint, etc. • Diversity in cropping systems should be strictly implemented • The structural designs of various infrastructures which are related to canals are done as per the orders of respective departments. These infrastructures should also be made earthquake-proof and flood-resistant • As a mechanism to adapt to drought and flood situations, various rivers should be joined so that they prevent floods and help in increasing the groundwater table levels • It is important to have convergence between various departments and Panchayats in order to prevent encroachment

Second Round of Dialogues with Departments

Second round interaction was held with all the department to facilitate the planning and document preparation. Fifteen dialogues were organised with the departments under the guidance of district magistrate and ADM-FR. As a result of these dialogues, various points related to climate change were integrated in department level plan. Further these plans were integrated in district plan document.

Trainings on CCA and DRR

Training programme on *CCA and DRR* was organised to build capacity of young researchers and scholars from reputed institutions promoting DRR and CCA by seeking contribution to and sharing development of the knowledge. The Training provided an opportunity to young people to discuss and understand climate change and the need for risk reduction and adaptation

Guideline Preparation and Planning at Department Level

A guideline was prepared for all departments based on the various Government Orders and sectoral workshops experiences. This guideline was circulated along with government planning format. Even District Nodal Officer-Disaster Management provided every required support to the project as he had already realised the gaps in the government planning and potential changes out of this project. He has significantly acknowledged research team's effort in developing DDMP, which is now in printed and ready-to-use form. DDMA Gorakhpur has adopted Mahewa Ward of Gorakhpur city as model ward for participatory resilience planning. Mahewa ward is GEAG's intervention model of people-centred climate resilience plan.

Conclusion

Integration of scientific analyses of existing and emerging risks under changing climatic conditions was carried out under this study. This study integrated both the scientific methods and social science methods viz. Participatory Assessments and Shared Learning Dialogues. SLDs helped in identifying the gaps and also the possible corrective actions. Such interactions between the departments helped in reducing the horizontal gaps by engaging departments in making the plans integrating CCA and DRR issues. This led to improved understanding of three corners: Communication, Coordination and Convergence within organisation, right from planning to implementation level. This climate-sensitive departmental plans indeed led to the development of District Disaster Management Plan with inclusion of climate change issue. A new paradigm in planning process and content in DDMP, will possibly contribute to state and national planning framework in context of DRR and CCA considering climate change adaptation issue.

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