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Research Article

Enhancing Climate Change Adaptation & Disaster Risk Reduction in Gorakhpur

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I N F O

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A B S T R A C T

District Gorakhpur possess severe vulnerability to earthquake and climatologically induced hazards such as drought, heat wave, cold wave, flood, hailstorm, untimely and incessant rainfall. This article gives an in-depth perspective of the need for formation of Climate Cell in Gorakhpur followed by emphasizing the ongoing and futuristic targeted approaches of District Disaster Management Authority of Gorakhpur (DDMA) for enhancing Climate Change Adaptation & Disaster Risk Reduction. Apart from the above-mentioned measures, the workshop on 'Formation and Activation of Climate Cell in Gorakhpur' has been discussed comprehensively in this article that led to the adoption of 'Gorakhpur Declaration' which is a brief outcome of the workshop. The ongoing & targeted efforts of DDMA-Gorakhpur mentioned in this article are wide expansion of green infrastructure in the district focusing on adequate plantation at adequate places; adoption of pervious pavements for urban flood mitigation; outcome of the Installation of Automatic Weather Station in SADAR sub-division of Gorakhpur; all the above mentioned activities are identified & executed by Climate Cell under the aegis of DDMA-Gorakhpur and other activity that is being done in expeditious way is formation of School Disaster Management Plan (SDMP) in Gorakhpur. In light of the vulnerability of Gorakhpur, on November 16, 2018, various stakeholders concerned with Disaster Risk Reduction (DRR) & Climate Change Adaptation (CCA) met and identified a common goal to work out for the strengthening of climate cell in Gorakhpur at the occasion of workshop. All the sessions that led to exploration of precise outcome in the workshop for enhancing the framework of CCA & DRR have been discussed in this article.

Keywords: Climate, Adaptation & Disaster, Gorakhpur, Risk

Introduction

Climate Change Adaptation (CCA) can be defined as a change in natural or human ecosystem for ensuring an efficacious response to the adverse impact of climate change, thereby offsets the impact of Global warming.

Disaster Risk Reduction (DRR) can be defined as a proactive response to mitigate the impact of disaster by managing the key factors responsible for occurrence of disaster in a specific area by incorporating measures for reduction of vulnerability & exposure of the concerned & enhancing the coping capacity of the exposed community.[13]

Table 1.Ideally Considered documents for the integration of CCA & DRR

Topic	Ideally Considered Documents
Disaster Risk Reduction (DRR)	Sendai Framework (2015-30)
Climate Change Adaptation (CCA)	UNFCC's Paris Agreement

Table 2.Differences between CCA & DRR

Climate Change Adaptation	Disaster Risk Reduction
Focuses on the reduction of risk associated with hydro-climatological hazards.	Focuses on the reduction of risk associated with hazards of all types.
Originates from scientific plinth by emphasizing physical exposure.	Originates from humanitarian and historical plinth by emphasizing physical exposure.
CCA focuses on long timeframes for HVRA analysis implementation of practices for disaster management.	DRR focuses on short timeframes for HVRA analysis & implementation of practices for disaster management.
Vulnerable community-based disaster management processes formulated by correlating past and current events.	Vulnerable community-based disaster management plan framed by emphasizing on policy agenda & DM act, 2005.

The above mentioned are the two areas that have been identified & are being focused by DDMA-Gorakhpur for disaster mitigation through enhanced climate change adaptation and enhancing the disaster preparedness of vulnerable communities of Gorakhpur. For ensuring DRR of Climate Induced disaster, DDMA-Gorakhpur did HRVA of the entire Gorakhpur by zonfying an area on basis of its vulnerability towards a particular hazard followed by exploring the measure needed to enhance the coping capacity of the vulnerable community for reduction of risk of hazard possessed by that community.

$$Risk = \frac{Hazard * Exposure * Vulnerability}{Coping\ Capacity} \quad (1)$$

The above equation 1 signifies 3 basic valued things that needs to be kept in an optimum limit by.

a. Lesser is the exposed community or unplanned infrastructure in an area lesser is the risk
b. Lesser is the vulnerability, lesser is the associated risk
c. Greater is the coping capacity of vulnerable community, lesser is the risk.

Measures identified by DDMA for ensuring an effective Climate Change Adaptation are:

- Identification of the vulnerable areas through Hazard Risk Vulnerabilty Assessment (HRVA) technique.
- Capacity building of the stakeholders (laying down the actions for strengthening of governance to deal with the climate change).
- Confrontation of Climate Change by making ways for rehabilitating or relocating a vulnerable community.

Gorakhpur is a district which is highly exposed to floods because of its exposure towards six major river-convergence river map of Gorakhpur has been mentioned below in Figure 2.

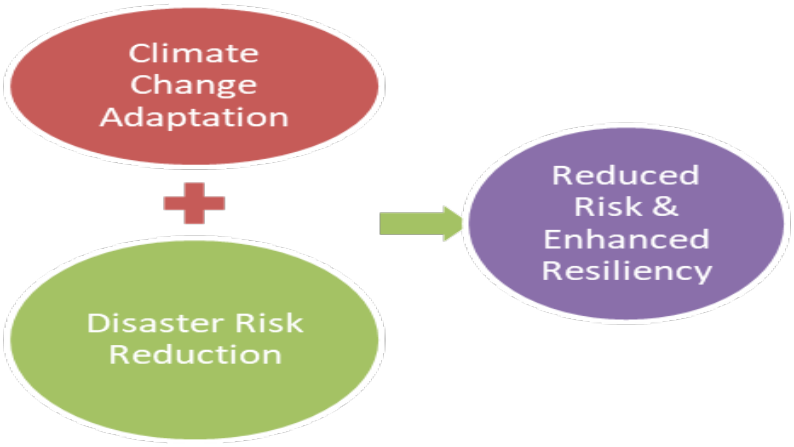

Figure 1.Results obtained after Integration of DRR & CCA

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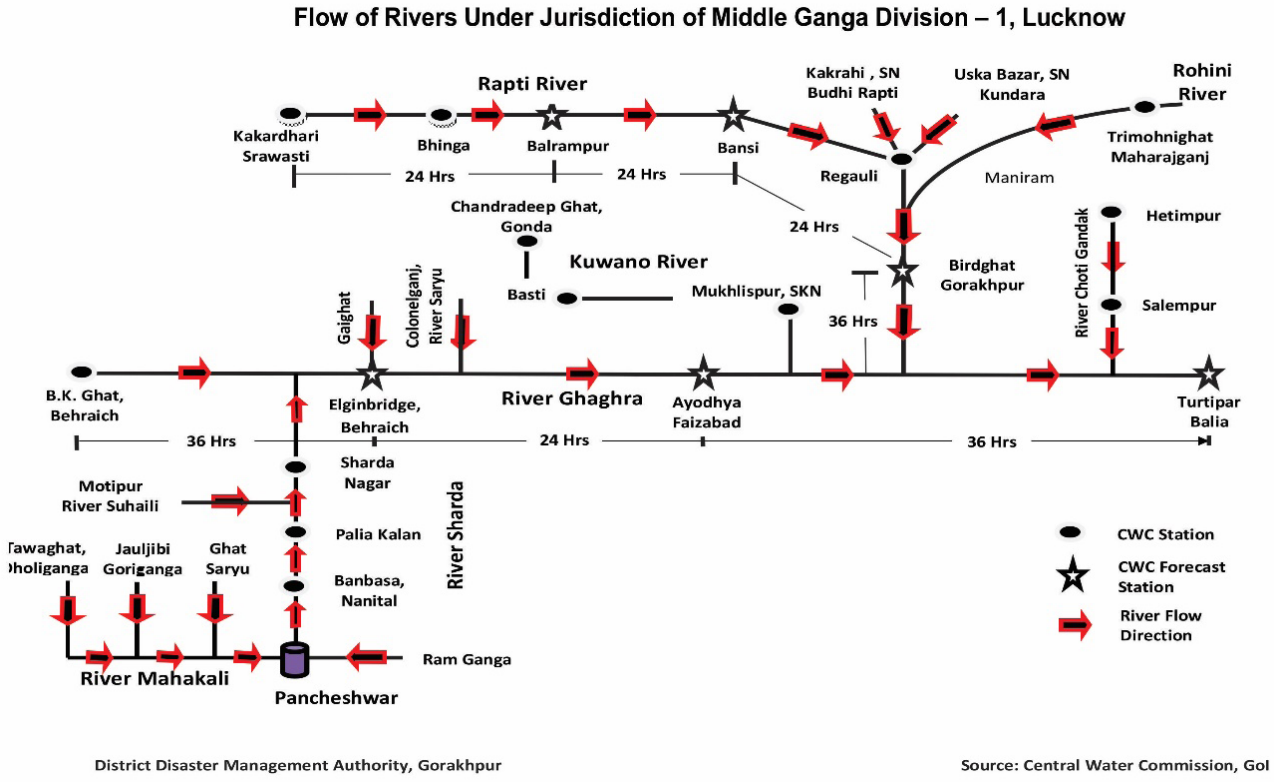

Figure 2.Flow of rivers under jurisdiction of Middle Ganga Division-I, Lucknow

Need for Integration of CCA and DRR in India

India submitted an Intended Nationally Determined Contributions (INDC-A contribution submitted majorly with a view for reducing the greenhouse gas emissions in domain of respective nations) in United Nations Framework Convention on Climate Change (UNFCC) Paris Agreement - which is a benchmark that can be achieved by 2030 with the incorporation of research & advocacy in the area of climate change & disaster risk reduction.[14] Major aspects of INDC submitted by India during Paris Agreement are:

- Reduce the emission intensity of its GDP by 33 to 35 percent by 2030 from 2005 level.
- Achieve 40% percent of electric power from an installed capacity of non-fossil fuel based energy resources by 2030 with the help of technology transfer and low-cost international finance.
- Create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through an additional forest and tree cover by 2030.

Integration of Climate change adaptation and Disaster Risk Reduction is the most promising step that can effectively monitor & control the greenhouse gas emissions such as carbon dioxide, methane, water vapor, CFC, HCFC, freon, oxides of nitrogen & sulfur and can help in achieving the target of Paris Agreement, 2015 to limit the global temperature rise for this century by 1.5^{0}C above pre-industrial level by this century.

Measures Identified for Enhancing CCA & DRR in Gorakhpur

Background for Measures identification

UNFCC Paris Agreement, 2015-objective is to limit the global temperature rise to 1.5^{0}C by this century below pre-industrial levels, which would substantially reduce the risks of climate change. According to various published news report & article, Gorakhpur is one of the most polluted cities of UP (City having pollution level even more than Lucknow) having concentration of $PM_{2.5}$ (the most significant pollutant responsible for causing respiratory and cardiac problems) as 225 $\mu g/m^3$ as per the report of Climate Agenda Group in which is more than 4 times of the permissible level of 60 $\mu g/m^3$ as prescribed by Indian standards.[1,3,11,12] Areas that contribute in reduction of greenhouse gases are mentioned in this article.

An upside variation in minimum temperature of the Sadar (Subdivision of Gorakhpur) can be observed when compared with the overall minimum temperature of district Gorakhpur & the same is continuously being deduced from the recorded values of AWS. The above graph implicates that amount of greenhouse gases, or atmospheric pollutants present in the Sadar sub-division of Gorakhpur are higher when compared to the rest of the Gorakhpur. Also, Gorakhpur in its past had experienced severe variations in the rainfall pattern.

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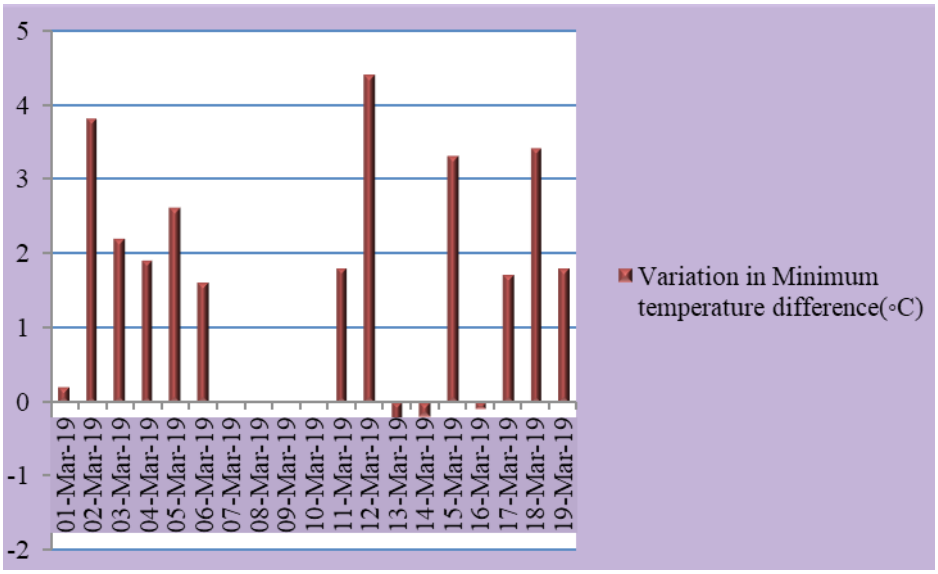

Figure 3.Dominated upside variation in minimum temperature of the Sadar area of Gorakhpur & rest of the Gorakhpur recorded by climate cell

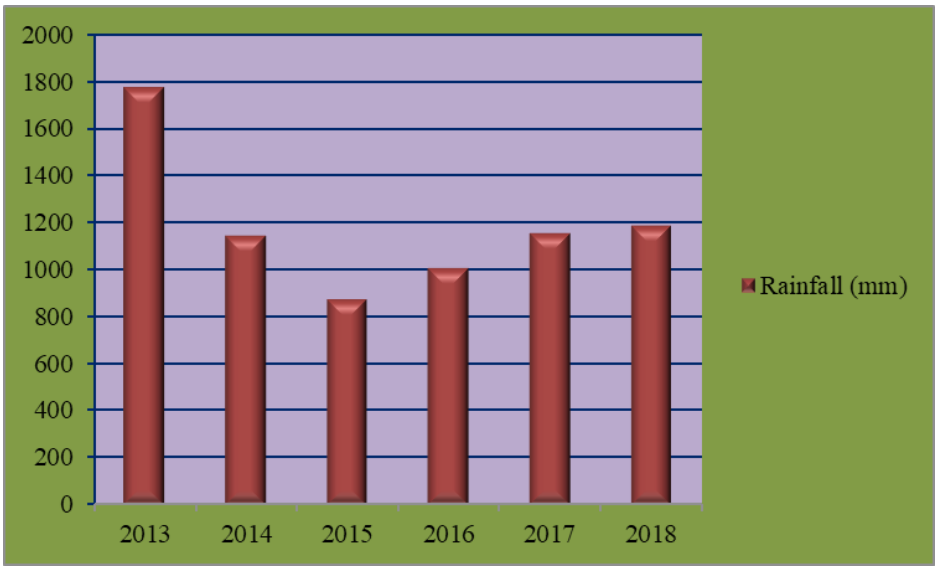

Figure 4.Variation in rainfall pattern of Gorakhpur (Source: IMD, Gorakhpur)

Targeted Areas

Plants Causing Mitigation of Air Pollution

DDMA-Gorakhpur in collaboration with Horticulture department is sensitizing local communities of Gorakhpur and is doing plantation within the district to enable substantial reduction in greenhouse gases (GHGs) - majorly in SADAR subdivision of Gorakhpur as SADAR has maximum level of GHGs because of excessive urbanization as justified by the Climate Cell. For reduction of GHGs-DDMA is doing adequate plantation of Outdoor Plants at outdoor places as suggested by the researchers of Delhi University[10] & promoting usage of Indoors Plants as suggested by WHO.[9] Plants absorb more than 25 % emissions of carbon released in the atmosphere generated after the consumption of fossil fuels, which helps in reducing the concentration of greenhouse gases in the atmosphere. As per shattering findings of some researchers, a mature tree of 100 feet and 18 inches in diameter produces 6000 pounds of oxygen yearly.[6]

Greenhouse gases in an atmosphere is majorly generated due to the atmospheric pollution due to excessive industrial & automobile concerned activities. Apart from outdoor activities there are various indoor activities too that are responsible for releasing pollutants in the atmosphere. According to a research conducted in Delhi by a team from the University of Delhi for exploring the trees responsible for the reduction in particulate matter & outdoor pollutants revealed that Ficus religiosa (Peepal), Alstonia scholaris (Saptparni), Syzygium cumini (Jamun), Cedrus deodara (Devdar) & Magnolia champaca (Champa) contributes

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to absorption of O_3, SO_2, NO_2, _$PM_{2.5}$ & PM_{10}, CO & Pb.[10] Their result obtained after explthe oratory design of research technique can be used in the form of roadside trees to minimize the air pollution in Gorakhpur. There are several plants responsible for mitigating the adverse effect of pollutants in & around the ecosystem such as Aloe barbadensis (Aloe vera), Chlorophytum comosum (Spider), Bambusa vulgaris (Bamboo), Sansevieria trifasciata (Snake) & Warneck dracaena.[9] The above mentioned five plants play a vital role in purifying the inside air by absorption of below mentioned pollutants:

- Formaldehyde from carpets, plywood, wall insulation, glues, adhesives & tobacco
- Tetrachloroethylene is a chemical released from dry cleaning of fabrics and metal-degreasing operations.
- Benzene from detergents, paints, furniture wax, thinner, etc.
- Xylene and Toluene from coloring pens, markers, spray paints, shoe polishes & adhesives.
- Carbon monoxide and nitrogen dioxides come majorly from automobile exhaust, burning of fossil fuel & industrial effluents.
- Volatile Organic Compounds (VOCs) from perfumes, hair sprays, air fresheners, and furniture polish, tobacco & mothballs.
- Biological pollutants which comprise mainly of dust, fungi, allergens, formaldehyde.

Figure 5. Indoor plants for mitigation of indoor pollutants[9]

Green roof is a network of green spaces utilized in an optimum way for plantation or making green infrastructures with a view of benefitting the concerned stakeholders & contributing in the nature conservation.[5] This concept of green roofs has been planned for implementation on the roofs of government authorities, in-line government departments, schools, and institutions in Gorakhpur to enhance the adaptation to climate change leading to increased disaster resiliency.

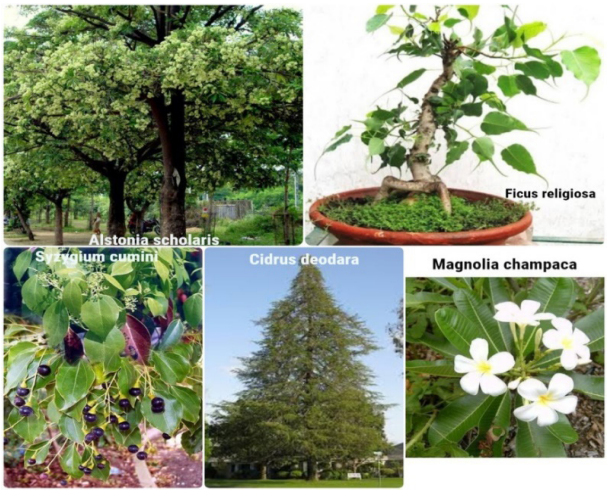

Figure 6.Outdoor Plants for Mitigation of Outdoor Pollutants

Figure 7.Green Roof[5]

On basis of the above identified measures for mitigation of greenhouse gases, DDMA-Gorakhpur has prepared an action plan to ensure its implementation at public places in an efficacious way. Apart from implementation of action plan, DDMA has also conducted various capacity building workshop among the concerned stakeholders on measures for mitigation of the impact of indoor pollutant & outdoor pollutants, creation of kitchen garden in schools of Gorakhpur & sensitizing communities on benefits of roof gardening at houses which leads to mitigation of exposure of an house towards heat wave & absorbs GHGs.

Pervious Pavements

Pervious pavements is an another concept that has been identified by DDMA-Gorakhpur for mitigation of urban flooding & air pollution. Concrete roads or impervious pavements restricts the passage of water and nutrients to the roots of trees, which further limits the growth of plants followed by a reduction in absorption of major greenhouse gas (Carbon-dioxide) having maximum Global warming potential found in abundance on the earth. A pervious pavement system is a Low-Impact

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Development (LID) structural practice which generally consists of a permeable pavement layer underneath the stone. Permeable pavements have emerged as a widely used technology for on-site stormwater control.[2,7,8] The runoff decrement rate of a pavement system which is permeable is defined as the fractional part or percentage reduction in runoff volume by the concerned system in a long period.[4] Impervious pavement when used in close intact with each other around a tree -leads immature growth of a tree followed by a reduction in the absorption of Greenhouse gases. Pervious pavement should be placed at a radial distance of 1.5 meters away from the saplings of an immature tree and at a radial distance of 1.25 meters away from the trunk of a mature tree.

Figure 8.Real-time detailing of the scenarios in Gorakhpur

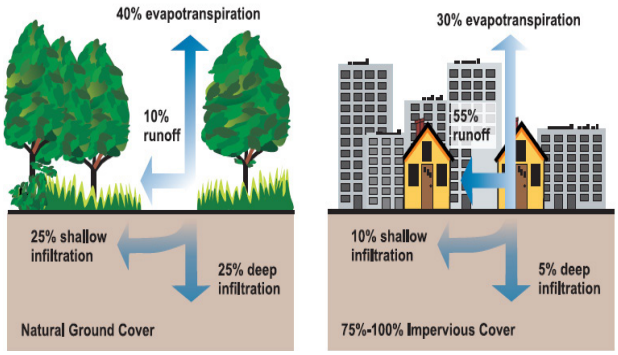

Figure 9.Comparison between Impervious and Pervious surfaces[8]

Ongoing Implementation of Measure for Enhancing CCA & DRR in Gorakhpur

Developing WASH, Nutrition & Education focused Standard Operating Procedures (SOP) for Hazards of Gorakhpur

DDMA-Gorakhpur in close coordination and after doing liaising with district stakeholders has developed SOP for Fire, Flood & Heat wave-focusing on Nutrition, Education and Water, Sanitation & Hygiene (WASH) is the basic need of each living entity that needs to strengthened & ensured by all countries to affected community during disaster. The developed SOP for various hazards is common to all and is present on the directory of Disaster Management of NIC-Gorakhpur. SOP clearly identifies the roles and responsibilities of various stakeholders of district Gorakhpur in terms of their do's & dont's for stages concerned with Pre, During and Post disaster cases.

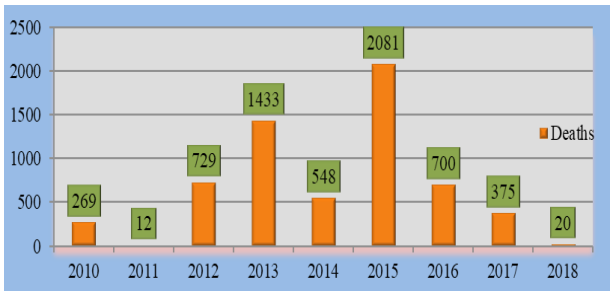

Figure 10.Deaths due to the heat wave in India from 2010-2018[15]

India being an equatorial country is severely exposed to heat waves during the season heat wave (March-July). Major states & UT of India exposed to heat waves are Odisha, Telangana, Bihar, Maharashtra, Gujarat, Andhra Pradesh, Jharkhand, Karnataka, Haryana, and Delhi & Uttar Pradesh. Major areas of UP possessing risk to heat waves are Allahabad, Varanasi, Gorakhpur, Bareilly & Lucknow. Figure 7, depicts the significant losses that India had gone through in the recent past due to heat waves. In terms

Automatic Weather Station (AWS) of Climate Cell

IMD is the apex body for monitoring of weather and publishing information related to daily weather conditions. In case of any impending natural disaster due to adverse weather condition in parts of Indian mainland or surrounding atmosphere, IMD issues timely advisories to the concerned departments to provide them specific lead time for adoption of disaster preparedness and disaster response measures. After analyzing & considering the past timeline of sequential extreme weather events that caused substantial disruption in social & environmental system of Gorakhpur, DDMA-Gorakhpur on a pilot basis with a view for monitoring the prevailing atmospheric condition in SADAR sub-division of Gorakhpur-installed Automatic Weather Stations (AWS) in the collectorate canpus of Gorakhpur. Installation of AWS was the very initial initiative of Climate Cell of DDMA-Gorakhpur & the same is being used for regular issuance of adverse weather advisories. Weather advisories are frequently being uploaded on the NIC portal of Gorakhpur & in case of any forthcoming extreme weather events; weather forecast is immediately disseminated to identified major stakeholders such as:

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- Chief Medical Officer, Gorakhpur
- Sub-Divisional Magistrates of Gorakhpur
- Chief Veterinary Officer, Gorakhpur
- Chief Agriculture Officer, Gorakhpur
- District Information officer, Gorakhpur

In response to the above issued forecast, a response report is submitted by stakeholders regarding damage caused in their specific domain. Apart from AWS installation & simulation of the variables by it, a deep exploratory design of research technique is continuously being used by Climate Cell to enhance the efficacious implementation of green infrastructure within the district. A glimpse of the shattering findings being recorded by Climate Cell to expand the green infrastructure has been shown below. In Figure 6, one can easily identify the increase in greenhouse gases in the atmosphere of Tehsil-SADAR (Most Urbanized sub-division of Gorakhpur) of Gorakhpur as greenhouse gases are the major cause behind the increase in minimum temperature of an area.

Figure 11.AWS installed at Tehsil-SADAR of Gorakhpur

Features of AWS

- Consist of set of sensor & sub-assemblies for measurement of atmospheric variables like wind wane for determining wind direction, anemometer for measuring wind velocity, hygrometer for measuring relative humidity, air temperature sensor, tipping bucket rain gauge for measuring rainfall etc.
- AWS for ensuring its effective climatological analysis uses the real time-in field data.
- AWS updates itself after each 2.5 seconds in the context of prevailing weather parameters & weather forecast for next 7 days.

Developing School Disaster Management Plan

DDMA, Gorakhpur on pilot basis has prepared School Disaster Management Plan (SDMP) of 30 schools from Sadar & Sahjanwa sub-division of Gorakhpur - after providing a sequential phase of training to the school trainers by experts of DDMA on Disaster Risk Reduction, Climate Change Adaptation, do's & don'ts during various disasters, method of doing HRVCA of schools, roles & responsibility of various committee formed as per the SDMP for ensuring safety of schools in case of disaster.

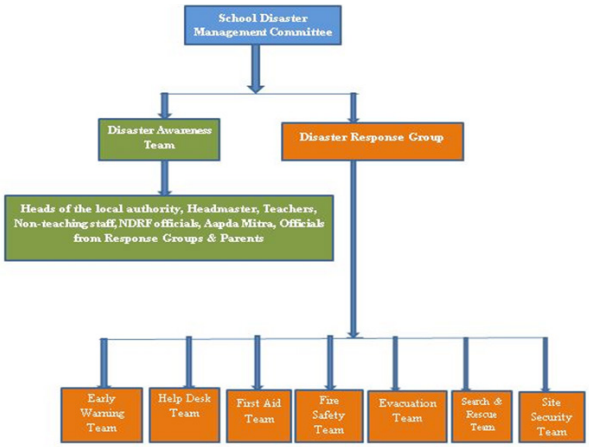

Figure 12.School Teams formed as per School Disaster Management Plan

Procedure for Formation of SDMP

Trainers were distributed with SDMP format for conducting training within the schools after completing HRVA of the respective schools to fill the SDMP format effectively. A total of ten batches of the trainers were made with each batch comprising of 2 - an Aapda Mitra & a Civil Defense volunteer under the mentorship of a member from DDMA team. Training of the schools started from January 22, 2019, and got completed by January 30, 2019 whereby the stakeholders were instructed by the trainers in an audio-visual format. Though trainers are providing their training only in 30 schools but school staffs (Teaching as well as Non-Teaching) from 56 more schools are participating in the training programme for enhancing their disaster resiliency. Trainers, while instructing and providing training to the stakeholders, are emphasizing on the following issues:

- Training of school staff & children on do's & don'ts during various disaster-focusing on flood
- Measures for utilizing local resources for making life saving equipment during the phase of disaster like making life jacket by utilizing plastic bottles, jute and rope; making raft boat by utilizing water drums & wood etc.
- Exploration of needed non-structural & structural measures for ensuring an enhanced disaster resiliency of the schools & unanimously deciding (trainers &

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school staff) the deadline for achieving the needed measures.
- Sensitization of school staff on government resources that can be utilized for enhancing the disaster resiliency of the schools.
- Enhancing climate change adaptation in schools by adoption of indoor & outdoor plants, making compost within the schools, formation of kitchen gardens within the schools, sensitizing children on measures for reducing the impacts of global warming in their domain.

Objective of the School Safety Plan

- Formation of a unique & effective School Disaster Management Plan.
- Sensitization of children on importance of nature & ensuring their effective response during disaster.
- Deliverance of mock for training of stakeholders for enhancing their disaster preparedness measures
- Identification of the resource inventory that needs to be created for enhancing the coping capacity of children.
- Identification of the loopholes that need to get filled either regarding structural or non-structural measures to enhance the preparedness & responsive measure for saving the children from brutal aftermath of the disaster. Elimination of loopholes urges for investment for strengthening of Disaster Risk Reduction by inviting funds for investing in Disaster Risk Reduction from government agencies & NGO.

Figure 13.Few activities conducted in school while preparing SDMP

Formation of Climate Cell

Due to the critical vulnerability of Gorakhpur, a vast amount of population of Gorakhpur district is at risk majorly due to floods, heat wave, cold wave, drought, lightning due to adverse impacts of the climate change & earthquake leading to the socio-economic disruption and environmental degradation. Gorakhpur is one of the heavily flooded districts of Uttar Pradesh due to the convergence of 6 rivers (Rapti, Ami, Ghaghara, Kuano, Gorra & Rohin) into it, which causes the flood in case of heavy rainfall or any other probable cause. Apart from the flood, Gorakhpur lies in seismic zone IV of an earthquake & is subjected to cyclone too. All the above-mentioned vulnerabilities gave a call for the establishment of Climate Cell in Gorakhpur to collect & simulate the weather-based information followed by the issuance of precise weather-based advisories & advocacy on the strengthening of CCA in Gorakhpur. As per the outcome of Idea Generation Workshop mentioned below, a climate cell committee has been formed in DDMA-Gorakhpur from various stakeholder district level departments responsible for disaster management of any hazard in Gorakhpur and 'Gorakhpur Declaration' has been adopted. DDMA-Gorakhpur too had achieved some of its outcome of the workshop such as dissemination of flood preparedness measures on radio channels of Gorakhpur in August,2019. Other outcomes of the workshop are in the implementation phase.

Objectives of the Climate Cell Committee

- Mainstreaming hydro-climatological hazards with their disaster management strategies by integrating the timeline of hazards and recent technological advancements leading to Disaster Risk Reduction in Gorakhpur.
- Liaison with concerned departments such as health sector, agriculture sector, veterinary sector for drawing up an emergency action plan for the vulnerable communities to tackle an impending hazard.
- Simulation & sharing of the atmospheric variables (Dry bulb temperature, relative humidity, air velocity gathered, etc.) gathered from AWS to the concerned departments to increase their respective disaster preparedness measures.
- Issuance of timely advisories/ bulletins to concerned departments for the dissemination of information to the public through the medium used for mass communication such as Radio frequencies, Newspaper, Electronic media, Television broadcasting & Fax.
- Creating awareness through training campaign among the vulnerable section of society (civil defense societies, local authorities, NGO, children, women & farmers), regarding the method for withstanding the adverse impact due to climate change.
- Documentation & dissemination of lessons learned by the addressed actions within the Gorakhpur, with a view of developing a standard capacity building programme for other districts.

Idea Generation Workshop

A workshop was organized on November 16, 2018 with the title as 'Formation & Activation of Climate Cell in Gorakhpur'.

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An exploratory module-based technique was adopted in the workshop. The exploratory sessions were a form of two-way sessions-first was the discussion of speaker on a particular session in the context of Gorakhpur and the second was an incited open house discussion- whereby workshop participants discussed their problems with concerned district level top notch authorities for exploring a solution for enhancing Climate Change Adaptation in Gorakhpur. The workshop was inaugurated by the Hon'ble VC of UPSDMA by the lightening of the lamp along with Project Director of Emergency Response-UPSDMA, ADM-(F/R)/CEO of DDMA-Gorakhpur, Project Director-UPSDMA, A.S.P-Crime-Gorakhpur (Representative of Operation Chief and Safety Chief as per Incident Response System).

- The welcome speech was conferred by ADM (F/R)/ CEO, DDMA, Gorakhpur. CEO of DDMA apprised the workshop participants about the adverse impacts of climate change on communities of Gorakhpur & elaborated the works of DDMA, Gorakhpur till date for climate change adaptation. Activties elaborated by him were Installation of Automatic Weather Station, awareness campaign on flood preparedness focusing majorly at village level, training of Aapda Mitra as per scheme of NDMA, training campaign among all tehsils & the village (Kaili & Banauda) for ensuring an effective climate change adaptation in Gorakhpur.
- Also, CEO mentioned the ongoing formulation of the Village Disaster Management Plan (VDMP) of Kaili & Banauda.
- Honorable VC of UPSDMA finally conferred the concluding speech of the Inaugural session by emphasizing on the measures to effective workout for SENDAI Framework for DRR and Paris Agreement, 2015. He discussed the impacts of drought, floods, shrinkage of natural water reservoirs, global warming. Further, discussed the impact of untimely & incessant rainfall happening in Gorakhpur.

Session I: Climate Risk & Early Warning System: For Effective Response

Developing Strategy for Integrating Climate Risk & EWS in DDMP by Sendai Framework: By Project Director of Emergency Response-UPSDMA

Project Director (PD)-Emergency Response, UPSDMA gave her valuable views on the importance of integration of Climate Change Adaptation & Disaster Risk Reduction in the vicinity of Gorakhpur. PD-Emergency Response described the disasters being created due to water scarcity, irregular rainfall pattern, flash floods leading to damaging of crops & identified the poor people living in the remote areas of Gorakhpur as the ultimate stakeholders of the risks. Project Director of Emergency Response from UPSDMA too demonstrated the weather pattern leading to extreme weather events by enumerating numerous logical examples:

- Realization of the early warning by elaborating the same through comparison between 1999 Odisha Cyclone & Cyclone Hudhud,2014, which were of the same scale but Hudhud caused the least damage to the society.
- Discussion on the major challenge in the form of developmental/ infrastructure related projects, that are being faced while working on the integration of DRR & CCA.
- Need for the creation of relief shelters at an elevated spot within the hazard-prone villages after analyzing the impacts of the past timeline of hazards at the same places for ensuring an effective disaster response operation & role of NGO's in the integration of CCA & DRR.
- Need for developing a Village Disaster Management Plan (VDMP) by involving the villagers & officials from the concerned authority during the preparatory phase of VDMP.
- Discussion on inviting CSR initiatives by the various reputed organization by emphasizing on pre-disaster

Table 3.Outcome of the Inaugural Session

S. No.	Result of the inaugural session
1.	Realization of the vulnerability of Gorakhpur regarding areas requiring major concern for effective implementation of CCA & DRR.
2.	Importance of School Safety Programme for strengthening of the community as though the children are most vulnerable, but they are also the nerve center of their parents which ultimately compels them to follow all the reasonable & logical sayings of the children's.
3.	Realization & Identification of measures leading to a lag in Sustainable Development Goal.
4.	Need for the formulation of a master Village Disaster Management that can be used by other hazard-prone villages for replication.
5.	Need for the creation of awareness among various government machinery regarding the importance of environment & atmosphere thereby leading to avoidance of unplanned convergence of infrastructure by making compromise nature.

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measures rather than focusing on traditionally followed post-disaster measures.

Open House Discussion (Session 1)

A panel convened by PD of Emergency Response-UPSDMA, Deputy Commandant of 11Bn of NDRF & Retired Assistant Engineer of Lower Rapti-Ghaghra Sub. Div. from Central Water Commission presided the open house discussion. During the open house discussion all the participants discussed their views regarding integration of measures of climate change adaptation in developing Early Warning System for probable hazards of Gorakhpur.

Climate-Smart Agriculture/ Horticulture: Reduced Impact of Disaster (Session 2)

Impact of Climate Change on Agriculture: By Project Director of UPSDMA

Project Director of UPSDMA gave his views for an efficacious formation & strengthening of climate cell. He demonstrated the changing weather pattern leading to floods & droughts by enumerating the parametric analysis and expected the cooperation of various authorities during a calamity. Issues highlighted by him are mentioned as:

- Realization of the severity of drought in Indo-Gangetic plains after describing the parameters for issuing forecast and declaration of drought in an area.
- Improvement in drought preparedness by disseminating timely bulletins to stakeholders after simulating information from crop weather watch groups.
- Usage of disinfectant like chlorine in water majorly during floods by Jal Nigam in consultation with health department to avoid water-borne diseases.
- Awareness among common by agriculture department regarding PMFBY, crop insurance subsidies, seeds, chemical & fertilizer that can be used specifically during a season.
- Vaccination of children & women against various diseases by organizing medical camps in universities/ colleges during their identified period of occurrence.

Open House Discussion (Session 2)

A panel convened by Project Director of UPSDMA, District Agriculture Officer of Gorakhpur, Senior Scientist from Krishi Vigyan Kendra- Gorakhpur presided the open house discussion.

Table 4.Outcome of the session on climate risk & early warning system: for effective response

S. No.	Result of session 1
1.	Developing Village Disaster Management Plan for knowledge management by involving huge efforts of communities/ villagers during its preparatory phase.
2.	Improvisation of the government policies, rules & regulation for delivery of adequate measures of disaster mitigation and preparedness in a district such as revision of pension schemes majorly in hazard pone areas by proper identification of the victims of past hazards.
3.	Issuing Do's & Don'ts on various disasters among the concerned stakeholders.
4.	Imparting adequate disaster response training to the concerned stakeholders by focusing on the limited domain for carrying out an effective disaster response operation.
5.	Utilizing competency of Aapda Mitras, in-line government department employees to coordinate an effective disaster response operation.
6.	Sending a text message to the concerned stakeholders through a Non-DND number for issuing a timely early warning during a disaster situation.
7.	Usage of radio frequencies for disseminating disaster early warning.

Table 5.Outcome of the session on climate - smart horticulture/ agriculture: reduce impact of disaster

S. No.	Result of session 2
1.	Promotion of green infrastructure.
2.	Development & Integration of Agricultural Action plan in VDMP.
3.	Coordinating with trained local authority heads through social media groups.
4.	Preparation of action plan for floods & drought by agriculture, irrigation, veterinary & development boards.
5.	Awareness campaign among farmers regarding PMFBY & usage of particular chemical & fertilizer in a specified area during a particular season.
6.	Development of emergency action plan by sectors of health, developmental board, irrigation & Jal Nigam.
7.	Training of priest & saints for disseminating early warning to the stakeholders/ followers through social media.

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Conclusion

Climate Change being the reason behind most of the hazards of Gorakhpur causes substantial level of socio-economic disruption and environmental degradation due to the occurrence of flood, heat wave, cold wave, drought, hailstorm & untimely and incessant rainfall. As an effort of Climate Cell established as a part of idea generation workshop organized by DDMA-Gorakhpur, it is expediting the efforts related to Climate Change Adaptation in Gorakhpur. Some major achievements of Climate Cell is installation of Automatic Weather Station in SADAR sub-division of Gorakhpur had saved substantial amount of crops by disseminating early weather warnings to farmers during harvesting season of Rabi season. Now, as a part of enhancing Climate Change Adaptation- DDMA is planning for installation of Automatic Weather Station in the remaining 6 sub-divisions of Gorakhpur. Also, various other research-oriented measures concerned with mitigation of Air Pollution leading to mitigation of greenhouse gases have been planned such as utilization of SAFAR (System for Air Quality Forecasting and Research) developed by IITM-Pune for developing a policy brief on mitigation measures of Air Pollution. In an all the disaster prevention can be most efficaciously achieved by enhancing the Climate Change Adaptation in an area leading to Disaster Risk Reduction in Gorakhpur. The title of article when gets justified may become a benchmark in the path for enhancing the Sendai Framework for Disaster Risk Reduction (2015-2030) & India's submitted INDC in Paris Climate Agreement, 2015.

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Annexure 1: Members of the Climate Cell

Table 6.Departments for advocacy in the committee

S. No.	Institutions	Reason behind consideration	Expected contribution
1.	Indian Meteorological Department, Gorakhpur	IMD has the mandate to consider meteorological observations and issue forecast for weather.	Forecast timely warnings with adequate lead time to deal with weather phenomenon like heavy rainfalls, tropical cyclones etc.
2.	Agriculture & Horticulture Deptt.	Objective of the two departments for giving pace to the growth of agricultural productivity and enhance the production of all horticulture products (fruits, vegetable, flower, spices e.t.c) in the nation & assisting the farmers regarding disaster preparedness measures by incorporating the proper usage of chemicals & fertilizer.	Promotion of dry land agriculture & horticultural practices. Capacity building of the vulnerable community by the promotion of soil & water conservation strategies, sustainable harvesting, use of adequate fertilizers. Training of agricultural graduates with scientific, analytical & business skills for the betterment of crop yield & quality. Plantation of effective plants along the roadside & in the schools for reduction of greenhouse gas emissions & particulates.
3.	Health & Family Welfare	Objective to provide adequate health services & facilities to the weaker section of society, thereby ensuring their healthy life.	Provision for proper delivery of medical aid during the response & relief phase of a disaster.
4.	Information & Public relation department, Print & Electronics-Media	Great experience in prevention of rumors & broadcasting the information necessary for creating awareness in the public domain is the reason behind consideration	Simulation of the information followed by issuing advisories concerned with the relevant forecast for the adoption of disaster preparedness & response measure.
5.	Veterinary Department	Long proven experience for providing vaccination & treatments to the cattle depending upon their breed quality & the weather conditions.	Provision for adequate delivery of medical aid to the cattle during the response & relief phase of a disaster.
6.	Public Works Department (PWD), Gorakhpur Industrial Development Authority (GIDA) & Irrigation Department.	Proven experience of the departments in constructing exemplary infrastructures as per rules & regulations for the benefit of mankind, is the reason for consideration.	Provision for assisting & providing adequate space to the horticulture & agriculture department for creation of required green space per capita leading to mitigation of Greenhouse gases. Construction of the infrastructures after considering the necessary guidelines for an earthquake-prone area and building significant structural measures to mitigate the aftermath of the flood.

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7.	Central Pollution Control Board (CPCB)	Effective monitoring and categorization of various pollutants in air & water since it's the date of formation, followed by spreading the awareness & training programs for increasing the coping capacity of the community to deal with harmful pollutants by taking preventive measures is the reason behind the consideration.	Implementation of a comprehensive plan for mitigation of release of pollutants in the air & thereby providing adequate green space to the citizens in Gorakhpur. Collection & Dissemination of information related to air pollution followed by effective implementation of NAMP.
8.	Educational Departments & Institutes	A school or an educational institution is solely responsible for molding the mindset of the future generation and enhancing the coping capacity of a child- especially while facing a challenge requiring intelligence with human effort as is observed in the aspect when dealing with a severe calamity.	Creating awareness among students as the increasing vulnerability in the rural and remote areas emphasizes on the call for an awareness program at an institutional level to deal with the increasing climatological hazards in Gorakhpur.

Table 7.Institutions for consultation in the documentation

S. No.	Institutions	Reason behind consideration	Expected contribution
1.	Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur	Successfully running the postgraduate programme in 'Disaster & National Security Management' with a distinguished alumnus network working in the concerned field.	Relevant case-studies by the students of concerned disciplines followed by exploratory design of research technique to propose a practical and feasible mitigation strategy for disaster mitigation and disaster preparedness. Liaison with concerned departments for simulation of various environmental variables ensuring effective working of climate cell committee in issuing adequate guidelines for disaster mitigation & preparedness measures.
2.	MMMUT University, Gorakhpur	Successfully running the programme on Environment engineering by the Civil engineering department. Environment Engg. Deptt of MMM University, Gorakhpur is significantly active in providing advocacy for the mitigation of risk associated with an environmental hazard	

Table 8.Organizations providing technical advocacy & support

S. No.	Organizations/ Institutions	Reason behind consideration	Expected contribution
1.	NABARD, Gorakhpur	It is the apex body having the power to deal with the matters concerned with planning, policy & operations while giving credits for the betterment of agriculture & other economic conditions in rural areas. It is the institute working with full dignity & efficiency since 1982 for transforming the impoverished sections of rural India into a developed India	Installation of Automatic Weather Station (AWS) at Sadar to all tehsil /block with support from Institute for issuing a precise & accurate forecast of adverse weather in a confined area, thereby improving the disaster preparedness strategies for the rescuers and farmers to deal with the climatological hazard.

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Figure 14.Glimpse of the members of Climate Cell from various Boards as mentioned in the Annexure: I

Annexure 2: Gorakhpur Declaration, 2018

(Outcome of the workshop on Climate Cell: Formation & Activation)

We, the heads of authorities & delegates from reputed agencies responsible for Disaster Management having met in Gorakhpur, Uttar Pradesh on November 16, 2018 on the occasion of workshop on 'Formation & Activation of Climate Cell', which has demonstrated the vigorous measures for Integration of Climate Change Adaptation & Disaster Risk Reduction in Gorakhpur.

Realization

Realization of the severe risks in Gorakhpur associated with the flood in Rapti & Ami river, incessant & untimely rainfall, lightning, earthquake & drought leading to the devastation of the exposed community. Expressing deep concern on the unplanned convergence of Infrastructure & Industrialization in Gorakhpur leading to widening of the risk concerned with exposed community.

Identification & Assessment

Identification & Assessment of the factors responsible for increasing the exposure of the community to various calamities in the vicinity of Gorakhpur. Identification & Assessment of risk must be done after keeping in mind the effective way forward for integration of Climate Change Adaption & Disaster Risk Reduction.

Mitigation

Mitigation of the risks associated with adverse impacts of climate change by the inclusion of Green Infrastructure, an adequate plantation in indoors (Schools, Government department, In-line government department & houses) & outdoors, measures to face ongoing & expected viral & bacterial diseases. Also, an organization of awareness campaign majorly among the child, women, elderly people & farmers on the aspect of training on climate change, crop insurance

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subsidies, promotion of agroforestry in flood & drought-prone area.

Alertness

Alertness of the disaster responsive agencies depending on the timely advisories with obtained after simulation of atmospheric variables done by the effective support of concerned agencies, contributing towards an efficacious working of climate cell.

Acknowledge & Adapt

Acknowledge & adapt the feasible & economical researches done in the context of climate change adaptation and disaster risk reduction to minimize the risk of calamities in Gorakhpur.

Contribution

The contribution of needed supports by agencies working solely for the welfare of the weaker & vulnerable section of society-contribution in the context of measures for catalyzing the work of climate cell by incorporation of structural & non-structural measures.

Revision

Revision of the climate cell by meeting/workshop at regular interval to ensure the effective working of climate cell by integrating Disaster Risk Reduction & Climate Change Adaptation. Revision is needed for continuing the partnership of government authorities, assisting agencies with stakeholders for the fulfillment of the objective of climate cell in Gorakhpur.

Adopted on November 16, 2018, in Gorakhpur, Uttar Pradesh.

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