

CASE
STUDY

Climate-resilient farming practices adopted by vulnerable communities in Supaul District, Bihar





Kosi is a trans-boundary river which flows across China, Nepal and India. It is estimated that the river has shifted over 133 km from east to west during the last 200 years. The Kosi River is known as the ‘Sorrow of Bihar’ because it destroys over 21,000 square kilometers of agricultural land in floods annually.

Following the devastating floods of 1954 in the Kosi river basin, the Bihar Government constructed embankments along the Kosi river to prevent its course from shifting. Though the embankments came as a respite for many, these structures have affected the lives and livelihoods of thousands of people living inside them. For those living inside the embankments there is a constant fear of floods and water logging since flood water does not drain out of the embanked area. Furthermore, the changing climatic conditions are leading to a change in number of dry and wet days that causes untimely rainfall and flood events.

Climatic and non-climatic factors lay a direct impact on agriculture. The case study highlights the wide range of resilient measures, implemented by small and marginal farmers of five villages in Nirmali block of Supaul district, Bihar to combat climate change related losses and damages to agriculture from flooding and water logging.

Key challenges in the Kosi Basin

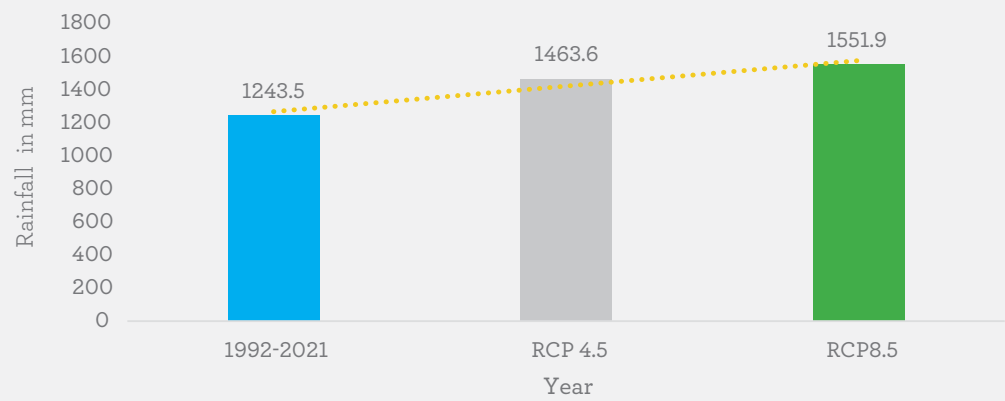
The Kosi project and the series of constructions that took place over the last seven decades have severely impacted the Kosi River ecology. There is a wide variety of ecological imbalances caused by the construction of embankments in the entire river basin area. There are two embankments built, locally known as *Purvi Tat Bandhs* (Eastern Embankment) and *Paschimi Tat Bandhs* (Western Embankment).

Floods affect both people living inside and outside the embankments. The challenges of seepage, waterlogging and flooding threaten their primary

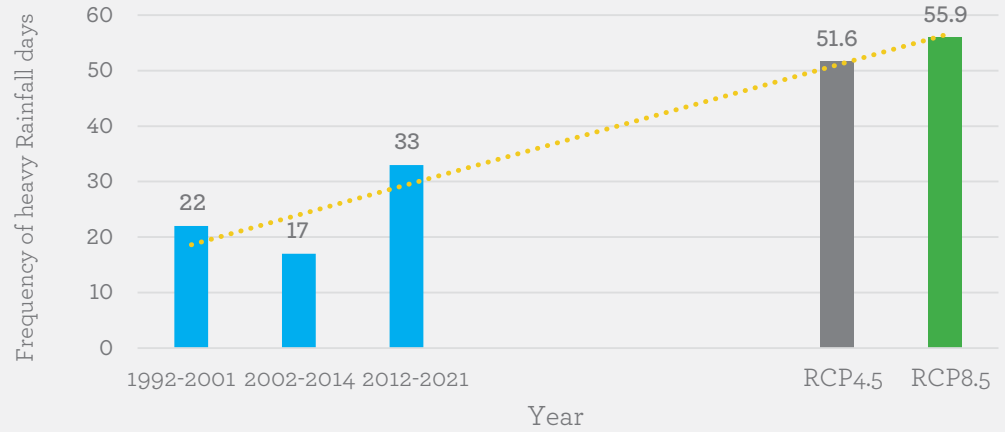
source of livelihood- agriculture. As a result of floods, people are displaced, their property is damaged, and silt is deposited, rendering their land unusable. The climate variabilities are further exacerbating the impacts of flooding.

In Supaul district, climate change conditions have been intense for the past three decades. There has been a change in the rainfall pattern and temperature profile, which has aggravated floods. Climate change trends and future projections predict a significant change in the precipitation and temperature indices for the district. The following are projections for precipitation and temperature in Supaul district, in brief:

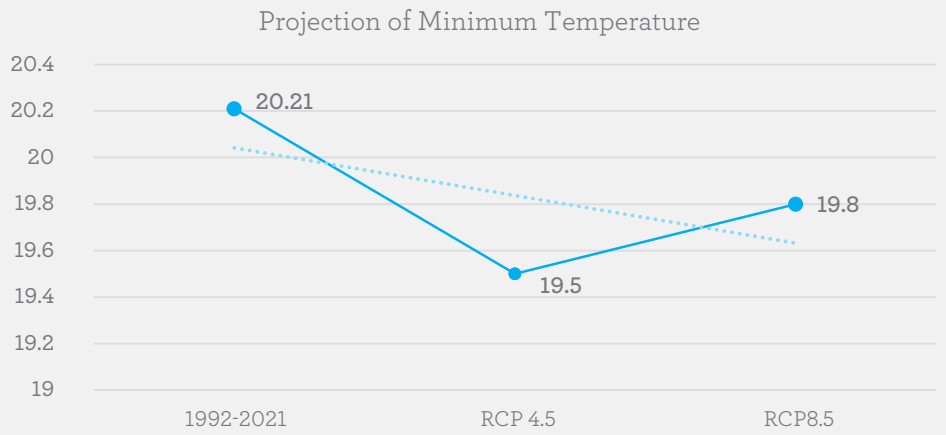
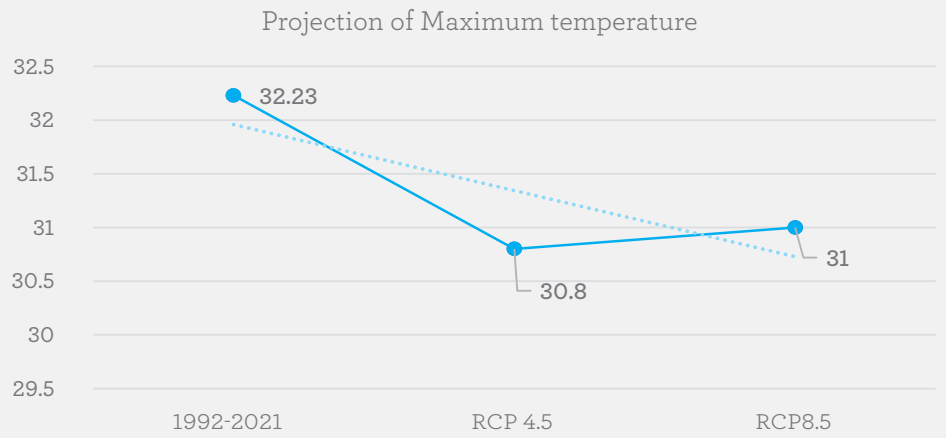
A. By mid-21st century, the tri-decadal rainfall is projected to increase significantly from 1243 mm to 1551.9 mm.



B. During the period of 2021-2050, the frequency of heavy rainfall days is projected to increase to 51.2 and 55.9 days in two different scenarios, RCP 4.5 and RCP 8.5 respectively.



By 2050, both the Maximum and Minimum temperatures are projected to decline in both the scenarios, RCP 4.5 and RCP 8.5, respectively.



Gorakhpur Environmental Action Group (GEAG), in collaboration with The Asia Foundation (TAF), has been working with the small and marginal farmers in five villages of Nirmali block, Supaul district. Three of the five villages where GEAG has intervened are resettled ones.

In August 2008, a massive flood occurred after the Kosi River diverted its course to take an old channel it had abandoned over 100 years back. It caused widespread destruction forcing people to leave their permanent settlements and resettle on government-owned land. A large portion of rich and fertile agricultural land got completely submerged in the floodwaters.

Practicing agriculture became arduous and less profitable. Those who left behind their land inside the embankments continue to farm it since there is no alternate source of livelihood. Every day they had to cross the river to reach their farmland. Moreover, the land remains cultivable only for five to six months. To cope with the impacts of flooding, people look for alternative sources of livelihood, however, with no or minimal education and livelihood skills, many young individuals and men choose seasonal migration as a livelihood strategy.

The recurring floods have also affected the availability of food in the region. Shri Ram Charit Pandit, a school teacher of Bathnaha village shared that earlier flood water receded after three to four days or a maximum of ten days but now it stays for more than four months. While there is no source of food as the agricultural land gets waterlogged, even the roads and communication channels get severely damaged making it difficult for the villagers to access the market for essential services during the flooding months.



Transition towards Resilient Agriculture Practices

To mitigate the impacts of flooding on people's lives, livelihood and food security, there is a need to adapt climate resilient and sustainable farming practices. With the support of Asia Foundation, GEAG is implementing the project, 'Community Engagement for Climate Resilient Villages' in five selected villages of Nirmali Block, Supaul district. The intervention primarily targets marginal, women and migrant farmers and provides them with handholding support to adapt to climate resilient agriculture practices.

The small landholding farming, which includes both agriculture and livestock rearing, largely depends on the local natural resources such as freshwater streams, ponds, green areas etc. Fuel, fodder, food and other inputs for farming are derived from these natural ecosystems. They also provide the capacity to deal with climate shocks.

The basic purpose of climate resilient farming is to minimize crop losses owing to floods, water logging and extreme weather events and enhance agricultural productivity. The focus, however, remains on enhancing crop yields by optimizing the cropping cycles; understanding soil, water and land management; selection of crop and vegetable varieties on the basis of soil and rainfall pattern; enhancing soil nutrition and pest management; and adopting farming practices suitable for waterlogged and flood-prone regions. Overall, such interventions recognise the role of natural ecosystems in providing nature-based solutions to resilient farming.

Agricultural fields are used to demonstrate and train the farmers on various aspects of resilient farming practices. With constant training and handholding support, farmers in the project villages have now adopted the following transformative practices to deal with floods and water logging:

Machaan Farming or multi-layer system of farming

Many people living within Kosi embankments have shifted from being landowners to being landless cultivators. Their status has now changed to that of tenant farmers. A majority of the houses have small homestead areas, but they rarely remain productive during the rainy season due to heavy water-logging and silt accumulation. Therefore, *Machaan* farming is an ideal way to increase crop



Backyard space covered with silt

production in areas with limited space and that are severely affected by flooding and waterlogging.

Farmers in the region have set up *Machaans* to grow multiple crops. In *Machaan* farming, a trellis structure is constructed using long and thin pieces of wood that are placed in a criss-cross arrangement. This frame is built to support climbing plants. On top, creepers such as bitter guard, bottle guard, pointed guard grow, while on the ground, shade-loving vegetables such as tomato, brinjal, lady finger, chillies and green leafy vegetables grow.

Multilayer cropping system is suitable for all seasons. Following is the combination of various crops grown on the same piece of land simultaneously. However, two to three crops/plants are selected, in any given layer, to maintain optimum level of sunlight, soil nutrient, water and space density,

Machaan farming can be practiced both on farmland as well as in backyard. During the rainy season, a planting bed is created above the existing level of soil by placing mud-filled jute sacks. Raised beds are then covered with plastic mulch. The method reduces plant stress caused by waterlogging and also maintains the aeration of the soil. As a result, the soil's nutrients and moisture are retained, which would otherwise be washed away by flooding. The plants remain healthy and the crop losses are negligible. Efforts are being made to use compost for enhancing soil nutrient levels which keeps the soil porous and humid, requiring less irrigation in such intensive farming.

One of the biggest benefits of *Machaan* farming is its ability to address flooding-related food security issues. Even those who are landless and live with small backyard are able to cultivate vegetables during the rainy season. For some farmers, small financial gains were possible due to the yield they produced.

Layers	Name of crop/plants in Rabi	Name of crop/plants in Kharif	Name of crop/plants in Zaid
Ground Layer	Radish, carrot, potato, garlic, yam	Radish, ginger, turmeric	Radish
Middle Layer	Leafy vegetables like, methi, coriander, <i>lafa</i> (a local variety of leafy vegetable), mustard; green pea, tomato, chilli, brinjal, cabbage	Coriander, fresh bean(<i>bora</i>), tomato, <i>lafa</i>	Coriander, spinach, tomato, amaranthus
Upper layer	Bottle gourd, sponge gourd	Bottle gourd, sponge gourd, bitter gourd	Bottle gourd, sponge gourd, bitter gourd, ridge gourd



Mixed Cropping

To minimise the threats and impacts associated with flood and water logging, the farmers in the region have adopted a diversified cropping system as a coping mechanism. Small landholders and farmers with homestead spaces use the mixed cropping system, in which multiple crops with varying maturation time are grown at the same time on the same field. This helps them utilize their land more productively. In the project villages, mixed cropping is practiced mainly in the Rabi season when there are no floods and water logging. It is also beneficial in enhancing the soil nutrient levels. For instance, when wheat, mustard and legumes are grown together in a combination, then legumes enrich the soil with nitrogen which promotes plant growth while suppressing the growth of weed.



Legume with cereals – a combination best suited to reduce weed and enrich the soil

Some common mixed-cropping combinations are following:

- Wheat + Mustard
- Wheat + Pea
- Wheat + Mustard+ Pea
- Jute + Sisbania
- Jute (leafy) + Lady Finger
- Lentil + Mustard
- Green Gram + til
- Potato + Radish + Mustard (leafy)

Inter Cropping

Inter Cropping is another way to utilise the limited land resource by cultivating two or more crops in the same piece of land in a distinct row arrangement. The practice of inter cropping allows farmers to maximize their yield by utilizing limited resources in a more efficient way in comparison to cultivating a single crop alone.

In Bathnaha and Sikarhatta villages, farmers have scaled up the practice of inter cropping by sowing short duration crops immediately after harvesting the *rabi* crops. In the month of March, 60-days period crop and vegetable varieties are sown and are harvested before the arrival of the monsoon. During this period, crops and vegetables with high market value are grown including lady fingers, brinjal, maize, and green gram. Besides getting better yields and returns, farmers also get a good stock of food grain and fodder for their livestock and the risk of crop loss is reduced.



Model Farmer in Dighiya Village



Relay Cropping

In a relay cropping system, farmers begin preparing for the second crop even before harvesting the first one. They take into account cyclic flooding and the plants' life cycle. Nursery beds are created and as soon as the first crop is harvested, the plant saplings of the second crop that have been grown in the nursery are planted on the farm land.

Economic and other co-benefits of different cropping systems:

Machan farming, mixed cropping, inter cropping, and relay cropping involve growing multiple crops simultaneously. The system has the potential

to increase productivity and reduce the risk of crop losses. By bringing crop diversity through intercropping and mixed cropping systems, farmers can increase their returns.

Farmers who have instituted crop diversity have countered the problem of food scarcity, especially during monsoon season when floods inundate the area. Farming and homestead lands are no longer left unused and even during the rainy season one can find varieties of vegetables being grown using *Machaans* or trellis.

Rajdev Mehta, a farmer from Bathnaha village has leased 3 acres of land, along the riverbank. Since the land gets submerged during the rainy season, he gets roughly seven to eight months for cultivation. However, after learning about diversified cropping system, he meticulously plans crop production and utilises the land most effectively. Implementing these techniques leads to a higher yield and good returns, according to Rajdev. By cultivating coriander, he made a good profit in the off-season for the first time.

There are several other benefits of carefully planned land utilisation. For instance, during the rainy season, he prepares nursery beds on un-inundated small patches of land and by the time floodwater recedes, plant saplings are ready for sowing.



Rajdev Mehta of Bathnaha Village

Promotion of bio-fertilizers and bio-pesticides for nutrient and disease management

In order to enhance the crop yields and control pathogen growth on plants, the farmers in the project area are trained to prepare bio-fertilizers/composts and bio-pesticides using raw materials available locally. Matka Khad, a semi-liquid compost is prepared with fresh cow dung, cow urine, jaggery and gram flour. The mixture is stored in an earthen pot for 15 days to allow bacterial culture. Once it is prepared, it is transferred and mixed with 200 litres of water which is sprinkled over the crops. Similarly, bio-pesticide is prepared using locally available raw materials like cow urine, green chilli, neem leaves and garlic. Model farmers are also trained in preparing vermicompost, another method of preparing bio-fertilizer.

There are many benefits of using bio-fertilizers and bio-pesticides. According to Amresh, a model farmer from Bela Shringarmoti village, *Matka Khad* works as effectively as chemical fertilizers. Besides improving the crop yield, it also acts as a pest repellent. Along with this, it also reduces the input costs by eliminating the need to buy chemical fertilizers and pesticides.

Following several experiential learning processes, farmers have now realized the benefits of crop diversification. In order to gain profits, few model farmers have taken the unconventional route. For example, after experiencing the advantages of resilient farming, Amresh has leased two acres of land at an annual rate of Rs 2200 per acre. The land was left fallow as it was swampy and unfit

for cultivation. However, after obtaining the land, Amresh immediately began to prepare it through mulching and treated it with Matka Khad. Since the land required water-tolerant plants, he arranged good quality pumpkin seeds and sowed them using the broadcasting method. The production and quality both were unexpectedly high. He has already recovered the input costs and is expecting a high margin profit by selling them in the market.

Indoor Oyster Mushroom Cultivation

Indoor oyster mushroom cultivation is being promoted to support small and marginal farmers for a diversified livelihood opportunities and thus making them resilient. Farmers from Bathnaha and Sikarhatta were trained in mushroom cultivation during the winter season. The farmers interested in cultivating mushroom were provided with spawns after the training.

At first only 10 farmers expressed interest in cultivating mushrooms as it was a very new crop and its market potential was not known. However, after the first round of production, 20 to 25 farmers from both the villages came forward to start mushroom farming. The rate of availing spawns increased from 10 to 75 per cent and during the last season, the total production of mushroom in Bathnaha village crossed one quintal. As a result, the traders visited the village to buy them at a price of Rs 200 per kg.

Weather based advisory and forecast services for farmers

The small landholders bear the maximum losses from climate change induced natural disaster, in comparison to the medium and big landholders. However, to cope with the impacts of climate change, weather forecasts and advisories are shared with the farmers regularly. The forecasts on various weather parameters such as rainfall, temperature, and wind speed etc are displayed on a bulletin board conveniently placed in a public area where community members can easily view it. Weather advisories are also communicated through mobiles message services. Farmers' knowledge and understandings are built to read and analyse the information/advisories so that they can prepare themselves and suffer minimum loss of agricultural yields, livestock and personal assets.





Mr Ram Charit Pandit is a model farmer of Bathnaha village near the Nepal border. The village is just 100 meters away from the Kosi embankment, which makes it vulnerable to inundation even with small amounts of rainfall. Mr Pandit has informed that the farmers in the region are highly dependent on rabi crop as the kharif crop never provides significant returns. However, in the recent years, the rabi yields is severely getting affected due to the uncertain weather events.

He also mentioned that many a times sudden rains have ruined the ready-to-harvest rabi crops that the farmers left in the field for little more drying. As a result, the standing crops fall and the harvested one lie on the waterlogged fields.

The farmers have acknowledged that on having received weather forecast information support, they are able to enhance their learning and understanding about weather events and their implications. They are gradually building their resilience capacity because the forecasts allow them to immediately take action if there are predictions of unfavourable weather events.

Protection of natural resources that contribute to ecosystem services

The local natural environment plays a crucial role to build resilient farming. The protection and conservation of natural resources also strengthens their ability to provide ecosystem services to small landholders.

Fresh water streams and ponds: In the project area, there are several small and large freshwater streams that provide irrigation water, as well as drainage channels for draining the water after a flood event. A proper drainage prevents water logging, which results in fewer crop damages and helps sow crops on time.

Ponds are helpful in enhancing the water holding capacity of the region, during or after floods. They also provide fishes, aquatic crops like makhana, fodder, etc. Ponds allow recycling of domestic sewage, however, excessive pollution load is posing a negative impact on these water sources.

With the help of resilient farming, farmers are able to understand the importance of the local water bodies and thus, they are making efforts to protect and rejuvenate them.

Soil: Mechanisms such as composting have contributed to the enhancement of nutrients in the soil. The organically rich soil results in better crop yield and requires less irrigation during dry periods. Overall, a better soil reduces the input costs for farmers.

Green areas/Orchards: Bamboo plants, trees, and green areas provide materials for thatches used in re-building of Kucha houses after floods; additional income; food items, fodder, and fuel during periods of flooding.

Impacts

In the midst of climate change and its impending effects, resilient farming practices have emerged as a support mechanism, especially for displaced, small, and migrant farmers. Farming practices that are resilient can contribute to higher farm productivity and income over the long term. The productivity rates have increased by 30 to 40 percent in any given cycle while pest and fungal infestations declined because of the use of bio-fertilizers and bio-pesticides. Farmers who were

previously suffering from climate change are able to make more profit by producing a better yield.

Resilient agriculture practices are also supporting women farmers in many ways. Due to declining farm incomes, men are forced to migrate leaving women behind, compounding the socio-economic challenges that women face every day. Nevertheless, many women farmers have successfully adopted resilient farming practices through mobilization and capacity building.

By acquiring farm management skills and learning various techniques, women are able to not only cope with flood inundation, but also use their small plots of land to earn an extra income. According to Malti Devi of Sikarhatta village, her crop yield has improved by practicing resilient farming. The farmers receive good market rates for their vegetables and, most importantly, the *Machaan* farming provides them with enough vegetables to meet their personal needs. There is no longer any fear of going hungry during the rainy season, especially when flooding strikes.



Progressive Women Farmers of Sikarhatta Village

Sangeeta Devi and Lalita Devi

A key outcome of the project has been the increase of women's access to skill development and technologies, resulting in many women taking resilient agricultural practices to a new level. Sikarhatta village's Sangeeta Devi and Lalita Devi have upgraded the farm production and are also learning entrepreneurial skills.



Lalita Devi lives with her children in the village as her husband works in Punjab as a daily wage laborer. She says, "I am supporting my family and my children's education through selling vegetables in the market." She has also set up a small food stall to sell tea and evening snacks. During the winter season, with the help of the GEAG team she also started mushroom cultivation. The production of mushrooms was very high. Instead of selling her product to the local trader, she added Mushroom Pakoda as a snack item on her food stall menu. While she was initially apprehensive, it turned out to be the most lucrative business.

Sangeeta Devi, is a women farmer. She and her husband own around two acres of land. She mentioned that the diversified cropping system and use of bio-fertiliser and bio-pesticide have not only increased the total yields but have also reduced the labour required to remove weeds and procure chemical fertilizers and pesticides, resulting in a reduction in input cost and time. A clear-cut calculation of the economic benefits she gained after adapting resilient farming is presented by her. She gives an example to support her statement. After harvesting the Rabi season crop, she used one acre of land to produce green chili, which sells for Rs 40 per Kg in the market. In total, one quintal was produced, which is 50% more than what was produced in the previous years. There is a huge market demand for the red ones that have dried up but are yet to be harvested. They would fetch her Rs 100 to Rs 120 per Kg. She has planned to keep aside Rs 5,000 for her children's education out of her total profit of Rs 10,000.



WAY FORWARD

Resilient agricultural practices can deliver a number of benefits to small landholders. Due to its ability to generate livelihoods and food security, the practice can help build socioeconomic resilience to climate change. By using the local ecosystem as a resource, the interventions improved farming prospects and mobilized small and marginal landholders to adopt practices and innovations that provide resilient solutions to specific problems. Based on the initial response and results, it is expected that resilient agricultural practices can change the current situation and provide long-term stability to farmers and the agriculture sector.

