

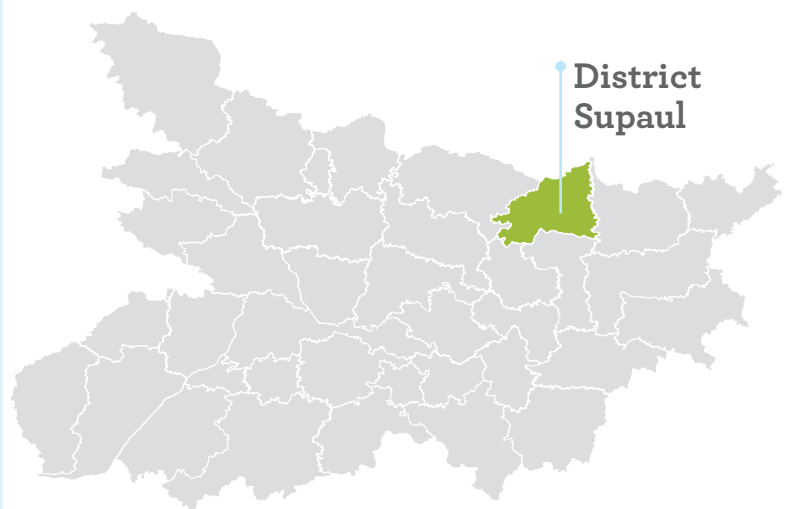
Combating climate change

Resilient agricultural practices in Kosi Basin



KEY MESSAGES

- The Kosi basin in Bihar has been facing climate change extremes which is adversely affecting the agricultural yields, food security, and incomes of smallholder farmers.
- To cope with the impacts of climate change, there is a need to build the resilience capacities of small and marginal farmers and promote resilient agricultural practices that can make agriculture sustainable.
- A comprehensive policy and legislative framework can adequately address the requirements of financing, increase the adaptive capacities of small and marginal farmers and help scale up the policy framework in other similar areas.



Area



2,420 sq km

Average
annual
rainfall



1243 mm

Maximum
temperature



31°C

District Supaul: Climate change and its impacts

Covering an area of 2,420 sq km, Supaul district in Bihar is situated adjacent to the flood plain terai region of Nepal. The district is a part of the Kosi division and the Kosi river flows through the western part of the district. One of the development blocks of the district is Nirmali block, situated upstream of the Kosi bridge on NH-57.

Majority of the people living in Kosi basin in Bihar depend upon agriculture for their livelihoods, of which majority of them belong to small and marginal category. After agriculture, livestock is another potential source of livelihood for the local communities. During the last two to three decades, agriculture in Kosi region has been severely affected due to the climatic changes. Five of the project villages in Nirmali block experienced significant changes in agriculture and livelihood patterns due to climate change.

According to the analysis of the climate trends of the district, rainfall and temperature profiles have significantly changed over the last two to three decades. Below is the summary of the trend in precipitation and temperature indices of the district.

PRECIPITATION INDICES

- The average annual rainfall of the district is 1243 mm. The last decade (2012–2021) has experienced a significant increasing trend in the annual rainfall, with the highest rainfall observed in the month of July.
- Even the average rainfall in pre-monsoon period has shown a significant increasing trend in last 30 years. The contribution of pre monsoon rainfall, which occurs from April to June, has increased from 21.14% in the decade of 1992–2001 to 28.76% in 2012–2021.
- Rainy days have increased significantly during the pre-monsoon period over the past 30 years, while they have decreased slightly during monsoon and annual periods. Heavy rainfall also increased during this period, with extreme rainfall events occurring in 2020 and 2021.

TEMPERATURE INDICES

- In comparison to other parts of the state, Supaul is experiencing a significantly declining trend in maximum and average temperatures.
- In last 30 years, the maximum temperature has declined from 34°C to 31°C.
- It is also important to note that in the district the frequency of warm days has also declined from 68 days to less than 20 days in the past 30 years.

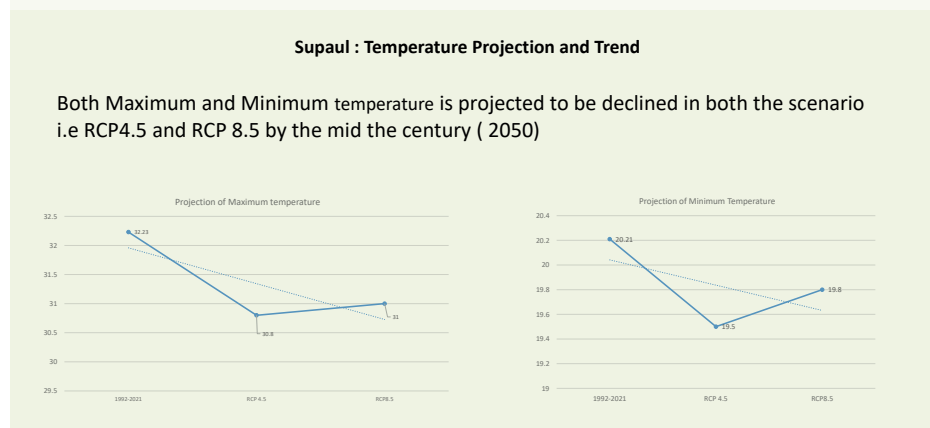
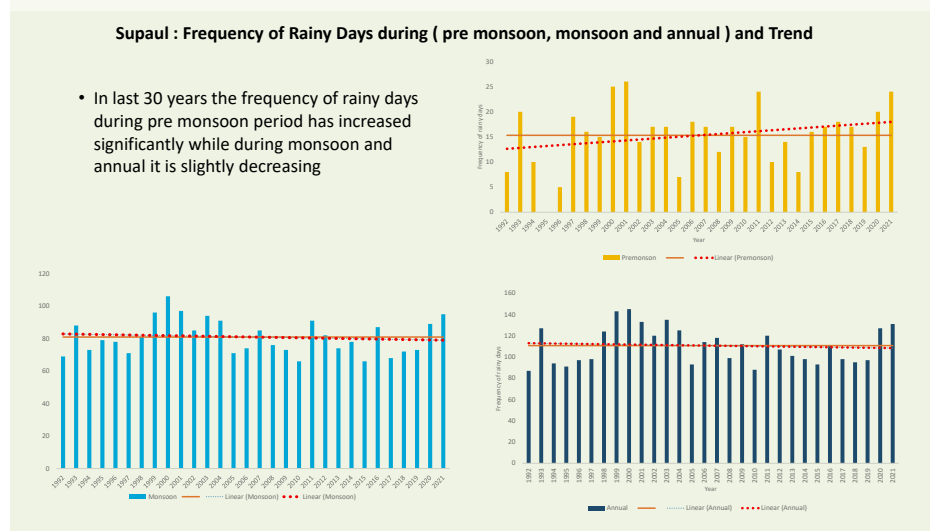
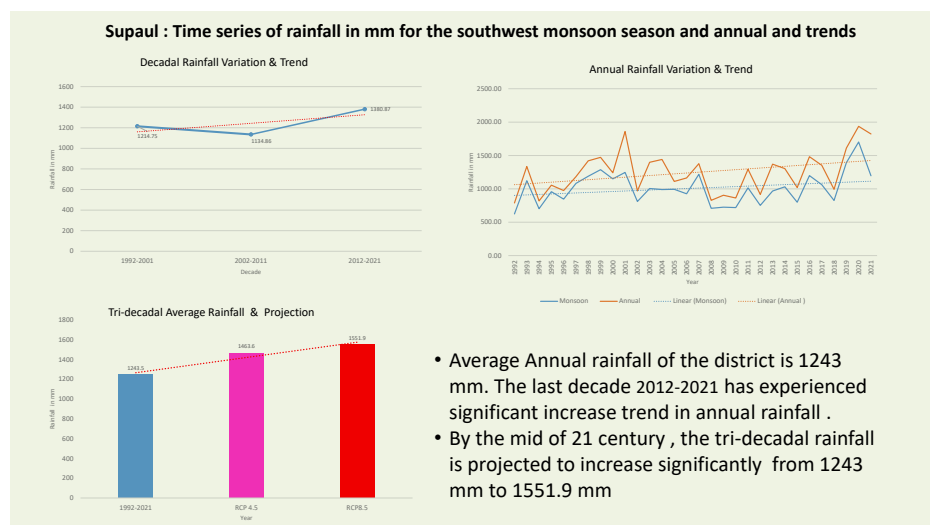


FUTURE CLIMATE SCENARIO

Considering the impacts of climate change, there is a growing need to plan for climate resilience while strengthening disaster risk reduction measures keeping in mind the socio-economic dimensions. The historical data analysis shows increased precipitation and temperature variation in the Kosi basin area. In combination with future climate projections, these trends indicate that flood events are likely to increase. Below are the climate change trends observed during the past three decades and projections in precipitation and temperature for Supaul district.

CLIMATE CHANGE IMPACTS ON AGRICULTURE

Agriculture is the primary source of income for the people living in the Kosi basin area. Since agriculture depends on climatic conditions, people who depend on farm-based livelihoods are directly affected by climate change. The increasing trend of heavy rainfall in the pre-monsoon period results in unseasonal long-duration floods. The frequent flooding in the district causes damage to a large portion of agricultural and non-agricultural land.



During the heavy rainfall events, the Kosi River has a high sediment load due to the high velocity water flow that comes down from the hill-crossing terai region of Nepal. Therefore, the river water with heavy silt load reaches to the embankments (Paschimi Tatbandhs and Purvi Tatbandhs). Silt accumulation raises the riverbed, reduces the embankments' water retention capacity, and causes overflow of water into the adjoining areas. Furthermore, the embankments also restrict the floodwaters within the structure as it doesn't drain out completely. So, every year villages located inside and outside the embankments experience water-logged conditions for three to four months. In 2021, villages and agricultural lands were waterlogged continuously from July to October.

Mostly all the villages in Nirmali block are suitable for crop production and livestock rearing due to the availability of fertile and grazing land. However, floods, water-logging, river bank erosion and soil deposition on farm lands have resulted in substantial reduction in the agricultural productivity of the region. On the whole, community gets only six to eight months' time for cultivation. Moreover, the surface soil run-off and pest attacks have further reduced the land fertility. Therefore, the local community experiences acute food shortage during the rainy season.

People living inside the embankments have been forced to move from their permanent settlements into government-owned land because of floods and the destruction they cause. The land has become distant for those who own agricultural land inside the embankments (also known as Palar area) as they have to cross the river every day to reach their farmland.

Agriculture has become arduous and less profitable as the impacts of climate change has made the farm management complex. For small and marginal farmers, out-migration has become an alternate livelihood strategy. With women left behind, there is a change in gender roles as they are burdened with multiple responsibilities of household chores, care giving to children and elderly, agriculture and livestock management. Along with this, they are faced with several other challenges like water scarcity, inadequate availability of food, lack of nutritious food, health problems etc. Floods exacerbate these challenges, forcing women to share the workload with their children, which affects the learning and development of these children.

Keeping these challenges in mind, it is of utmost importance for the policy makers, agriculture experts and social development practitioners to develop

alternative strategies that will enable farmers and community members to maintain their traditional livelihood practices, as well as their assets and long-established social ties. While identifying climate induced risks in future, the climate adaptive resilient agriculture practices are tailored to context specific environmental and climatic conditions. These practices include selection of suitable crop varieties; planning of cropping cycles; soil, weed and pest management organically; etc.

CLIMATE RESILIENT AGRICULTURE

The climate resilient agriculture adopted by the farmers in the Kosi basin under the initiatives of Gorakhpur Environmental Action Group (GEAG), supported by The Asia Foundation, indicate the urgent actions taken at two levels: 1) at the production level wherein the focus has been on lowering of input costs, strengthening of ecological processes, enhanced net gains, market linkages, etc and 2) at the production system level towards strengthening of ecosystem services, evolving nature-based solutions, encouraging diversity and complexity, appropriate resilient inputs (like seeds) etc. A third level of policies and legal measures are also crucial in this direction, which recognizes the role of small-marginal and landless farmers in general and the woman farmers in particular and helps in developing a pro-women farmer's environment in agriculture.

NATURE BASED SOLUTIONS FOR BUILDING AGRICULTURAL RESILIENCE

The viability of small landholding farms has been traditionally based on the principles of 'Farm as a System'. Farm system primarily includes a farmer's household, livestock and agriculture field (traditionally known as Ghar-Khet-Ghari). There may also be the presence of other elements like farm pond, composting, trees, backyard poultry, fishery etc. in the farm system. All these components of a farm system are inter-linked, providing functionality to the system. The output of one component can act as an input for another, for example dung from livestock provides compost to agricultural field while the agricultural field provides fodder to livestock. There are several such input-output flows in any farm system.

The inter-linkages lower the need to rely on market sources or outside inputs and thus reduce market dependency and costs. Furthermore, the inter-linkages provide a robustness to the farm, which can bear shocks and stresses caused by disasters and climate change. Farm related measures like multi-

tier cropping, mixed and inter-cropping, resilient seeds, increased soil fertility etc. have been quite helpful in developing resilience capacity of farm system.

The natural ecosystems within the farm sub-systems provide provisioning, supporting and regulating services, as explained earlier, to make the farms self-reliant and robust. However, these measures are largely dependent on natural ecosystems within the farm system (quality of soil, orchards, waterbody etc.) and any impact on these ecosystems adversely affects resilience building capacities of farms. Therefore, it is imperative to protect the ecosystems within the farm system.

In addition to the farm system, there are other ecosystems that are not part of the farm system (landscape level), but are crucial to farm productivity

and resilience. Such ecosystems exist both at micro level (ponds, lakes, orchards, water, streams, opened/green land or grazing land etc.) in the village/ nearby areas and at macro level (rivers, canals, waterbodies, orchards, pasture land etc) involving several villages. During climate-induced disasters, these ecosystems serve as a nature-based solution.

CLIMATE RESILIENT AGRICULTURAL INTERVENTIONS IN NIRMALI BLOCK, SUPAUL DISTRICT

In five villages of Nirmali block, 75 marginal farmers that include small landholders, women farmers, and migrants have adopted resilient agricultural practices to tackle the impacts of climate stresses. The key practices and their benefits during the various hazards are described below:

Practices	Benefits
Floods and water logging	
<p>Machaan Farming</p> <p>Trellis structure is built using long and thin pieces of wood that cross each other. This frame is built to support the growth of climbing plants. At the top, creepers like bitter guard, bottle guard, pointed guard are grown; and at the ground, shade-loving vegetables like tomato, brinjal, lady finger, chilli, green leafy vegetables are grown.</p> <p>During the rainy season, a planting bed is created above the existing level of soil by placing mud-filled jute sacks. The raised beds are then covered with plastic mulch and vegetables are grown on the beds.</p>	<ul style="list-style-type: none"> Landless and small farmers are using backyard spaces productively. Better managed cropping system deliver surplus products which are taken to the market to gain returns. Availability of food during the rainy season.
<p>Mixed Cropping</p> <p>In a mixed cropping system farmers with small landholding and homestead land grow multiple crops or vegetables simultaneously on the same field with varying maturation times.</p>	<ul style="list-style-type: none"> The practice of mixed cropping provides opportunity to the small farmers to use their land in a most productive way, since the time duration for cultivation is limited Crop failure losses are minimised Whenever legumes are grown together with other crops, they enrich the soil with nitrogen, which promotes plant growth and also suppresses weed growth
<p>Inter Cropping</p> <p>Inter Cropping is another way to utilise a limited land resource by cultivating two or more crops in the same piece of land in a distinct row arrangement.</p> <p>Selection of Short Cycle Varieties</p> <p>In order to make the best use of dry period, short cycle crop varieties are selected. For example, in the month of March, 60-days period crop and vegetable varieties such as lady finger, brinjal, maize, green gram are sown and are harvested before the arrival of monsoon.</p>	<ul style="list-style-type: none"> In contrast to cultivating one crop, farmers are able to produce greater varieties of yield Short cycle variety crops have following benefits: <ul style="list-style-type: none"> Farmers get good returns due to the production of high market value crops. Availability of food and fodder stock for the monsoon period Crop failure losses are minimised.

Relay Cropping Keeping the cyclic flood and plants' life cycle into consideration, farmers start preparing for the second crop before the first crop/vegetables are harvested. For this, nursery beds are created and as soon as the first crop is harvested, the plant saplings of the second crop which are grown in the nursery are planted in the farm land	Best way to utilise the time and resources.
Mulching The soil bed is covered with the help of un-decomposed organic materials like hay, straw to protect the soil from erosion, maintain soil fertility and moisture and suppress weed growth	Mulching helps in reducing the water stress at the plant roots and maintains flow of oxygen.
Restoration of Ecosystem Structures The water bodies such as lakes, ponds and fresh water streams provide regulatory and many other ecosystem services to the people. These water bodies allow drainage of floodwaters, thus protecting the area from getting waterlogged. However, these stream are now laden with domestic waste, water hyacinth and other non-beneficial aquatic plants, which disrupt their natural flow. In order to restore the fresh water streams, community led clean-up drives are conducted.	<ul style="list-style-type: none"> • Cleaning of water streams, increases their water holding capacities, allows the run-off to flow and prevent the agriculture lands from getting waterlogged. • Fresh water streams provides water for irrigation and allows fish farming. • Water hyacinth collected while cleaning the streams, are being used to make composts. This weed is used in many other ways. It is also useful in strengthening the farm bunds.
Land degradation /reduction in soil fertility due to water logging, surface runoff, weed growth and pest attack	
Application of Bio-Fertilizer 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.	<ul style="list-style-type: none"> • Increased crop yield • The bio-fertilizer also act as a pest repellent • Controls weed growth • Cost effective as local and easily available raw materials are used • Reduced input costs as farmers producing Matka Khad, do not have the need to use chemical fertilizers. • The organic composition poses minimal risk on human health
Bio-Pesticide Similar to Matka Khad, bio-pesticide is prepared using locally available raw materials like cow urine, green chilli, neem leaves and garlic.	<ul style="list-style-type: none"> • Cost effective way to control pests and diseases • The cost of producing bio-pesticide is significantly low • Reduces the environmental impact as it is organic and biodegradable.
Weather extremes	
Sharing of weather forecasts and early warning system The weather forecasts of rainfall, temperature, and wind speed etc are displayed on a board placed at a common place which can be easily viewed by the community members. Weather advisories are communicated through mobile message services. Farmers' knowledge and understandings are build to read and analyse the information/advisories.	Farmers make necessary preparations so that there are no or minimum losses to agricultural yields, livestock and personal assets. Examples: <ul style="list-style-type: none"> • Crops are harvested as soon as they mature • Harvested crops which many a times are stored on agricultural land, are taken to a safer place • Livestock are taken to a safer place • Food stocks are made in advance



GENDER DIMENSION IN CLIMATE RESILIENT AGRICULTURE

The massive floods of August 2008 affected several villages which were inside the embankments, forcing thousands of people to abandon their homes and agricultural land. Those who were displaced live between the land they left behind (locally called Palar) and the land where they are now settled. Some farmers still use the Palar land they left behind for cultivation and cattle grazing.

Such a scenario has forced men to migrate from the region, adding to more burden and drudgery on women. It is even more difficult for women living outside the embankments to tend to their fields and livestock, as they have to cross the Kosi River several times a day to reach their Palar area. However, since the introduction of climate resilient agriculture practices in the study area, a gradual shift is observed in women's role and identity.

Climate change and scarce ecosystem services have adversely affected agriculture, family nutrition, income, education, child and elderly care, but evidence suggests that when women participation in climate resilient agriculture practices is encouraged these consequences can reverse steadily.

Through training and capacity building processes and by implementing resilient agriculture practices on their farmlands, women engage in climate resilient agriculture practices when the male members of their family migrate out in search of

work. Moreover, they support and encourage other women of their community to adapt to this new practice.

WOMEN PARTICIPATING IN AGRICULTURE TRAINING

The benefits of women's participation as resilient agriculture practitioners are (a) it ensures food and nutrition security of the family, and (b) the increased crop productivity provides enhanced livelihood opportunities. There are women farmers selling vegetables at the market regularly. Also, the learning process empowers them, since they are now capable of making decisions and expressing their opinions on familial and social issues. It is evident that women are taking the lead in making decisions on crop diversification, adding non-traditional varieties like mushrooms, using organic products, supporting the education of their children, and marketing their products.

A resilient agriculture practice can also reduce drudgery for women in general. Agriculture is a labor-intensive activity and apart from land preparation, sowing and harvesting, there are many associated activities like weeding, manuring, pest control, storage etc. which are traditionally performed by women. However, climate resilient agriculture practices not only increase crop productivity, but also reduce women's labor of weed control and health risks associated with chemical products used in pest control.

KEY RECOMMENDATIONS

The recommendations of mainstreaming the climate adaptive resilient agriculture on the basis of evidence-based assessment are provided below:

- a. Farmers from 75 project villages have implemented the climate-adaptive resilient agriculture practices that provide firsthand information and evidence of their benefits. Although these are small-scale and local evidence, they are nonetheless significant. In order to mainstream and upscale resilient agricultural practices to other regions of the Kosi basin, a scientific assessment must be conducted to determine the rationale and outcomes of such practices. Researchers, agriculture institutions, and universities, both government and non-government, are recommended to be involved.
- b. An integrated approach would support mainstreaming of resilient practices. In order to empower small farmers and communities, policies on agriculture, livelihoods, poverty reduction, and food security must include resilient agriculture practices. Also, by revising the existing policies, various government departments and programmes can be better coordinated.
- c. The state and local governments can play a strategic role in scaling up resilient agriculture practices. An institutional framework can facilitate scaling up by establishing enabling conditions. A legislative framework-backed policies enable long-term decisions on financing, agricultural extension services, capacity building of extension staff, and monitoring.

Panchayati Raj Institutions (PRIs) need to be empowered to play a constructive role in promoting resilient agricultural practices at the local level. By establishing

coordination with Krishi Vigyan Kendras and local agricultural extension offices, PRIs can help train farmers and make resilient agriculture inputs available to them; disseminate information in accordance with weather advisories; integrate resilience agriculture into panchayat development plans; and build and repair flood regulation structures using MNREGA funds.

- d. Protection and Conservation of Natural Ecosystems: It is necessary to provide support to encourage the diversity of ecosystems in the farm system through ponds, tree plantings, and bunds, as well as protection of orchards, green/pasture land, waterbodies, and freshwater streams at the local level. By enhancing buffering, water holding, drainage of excess water, soil conservation, etc., these ecosystems will not only provide inputs to farming but will also help cope with climate stress.
- e. Building a strong support mechanism can enhance farmers' adaptive capacity. Farmers should have better access to:
 - i. Information on weather advisories, resilient practices, market;
 - ii. Timely and need based agriculture extension services;
 - iii. Access to good quality and water-resistant seeds, organic inputs, farm equipment;
 - iv. Credit, market linkage;
 - v. Veterinary services.

A policy directive should be in place so that different departments and concerned ministries work together in a coordinated and coherent manner, in order to make all above stated services available to farmers.

- f. Women's participation is essential to the adaptation of climate resilient agriculture practices and to the sustainable ecosystems management. It is possible to mainstream their participation by integrating gender into every relevant policy, particularly those related to agriculture, ecosystem management, climate change adaptation, and disaster risk reduction.

Their role in agriculture and natural resource management is immense, so it is crucial that their opinions are sought and they are involved in decision-making processes. This includes matters such as maintaining and revitalizing ecosystem structures, establishing community-based forums, constructing/repairing community assets, and implementing PRI's development plan.

Resilient agriculture should also be integrated with existing women's empowerment programmes such as JEEVIKA in order to increase their access to financing.

The policies and programs should address women's drudgery concerns equally. Providing them with easy access to, (a) information that will enable them to comprehend and discuss policies, government extension services, market, (b) agricultural tools and technology, (c) agricultural extension services and inputs, and (d) ecosystem structures that can reduce the burden on them for collecting fuel, fodder, and water should be developed/revived.

- g. It is important to explore alternate sources of livelihood to build community's resilient capacity. Livestock can provide a significant income source as community members in the Kosi region are adept at rearing livestock. Moreover, it can significantly contribute to livelihood and food security.

