

System diversification for sustainable livelihoods

in the north eastern Himalayan region of India

Sanjeev Kumar¹, Ruchika Chaudhary², Aastika Pandey³, Khushboo Devi³ and Subhash Babu^{3*}

¹Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh 250 110

²Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan 313 001

³ICAR-Indian Agricultural Research Institute, New Delhi 110 012

About 72% area of the north eastern region is covered with hills and mountains. The effective land holding available for agriculture (~15%) in the region is much less than India's national average (~45%). Hilly land is ~ 3-4 times poor in production compared to the plain fertile land. This poses a great challenge to the livelihood of hill farmers. To overcome these challenges, there is an urgent need to design sustainable crop production models, which minimize the farming risk and ensures livelihood security. The most innovative approach to enhance the agricultural productivity is system diversification which includes practices like sustainable intensification, moisture conservation measures, agroforestry, integrated farming systems and organic farming.

Keywords: Crop, Diversification, Farming system, Hilly terrain

THE north eastern region (NER) of India spans ~ 26.3 Mha. The region's landscape is a blend of about 18.37 Mha of hilly terrain and 7.84 Mha of plains. The distinctive geography of the northeast region (NER) showcases a variety of altitudinal zones: low-altitude areas comprise an impressive 56% of the region, mid-altitude regions make up 33%, and high-altitude zones account for the remaining portion. Rainfed agriculture, predominantly centered around rice monocropping, covers over 80% of the cultivated land. Approximately, 84% of the soil in the region is acidic and low in available phosphorus and zinc but high to medium in available nitrogen and potash, further complicating the agricultural productivity. Surface water is the primary source of irrigation in the region, leading to a lower water-use efficiency. The region's agriculture is mostly rainfed, with many areas experiencing only one cropping cycle per year, often during the *kharif* season. As a result, the cropping intensity is low, at approximately 131.4%, primarily due to mono-cropping and subsistence farming. Hence, system diversification presents a potential solution to address these challenges by reducing the reliance on monocropping, enhancing ecological resilience, promoting higher income and improving the food security of the region. Introduction of high-value crops can enhance the productivity, while adoption of traditional practices such as crop

rotation can improve soil health and pest management. Furthermore, some crops like buckwheat, with relatively higher stress tolerance, are emerging as key players in boosting the winter productivity. Enhancing agricultural productivity in the NER can help address the anticipated demand-supply gap, boost rural farm incomes, and support the overall socio-economic development of the region.

To navigate these interconnected challenges, a comprehensive strategy emphasizing system diversification is crucial. This involves promoting crop diversification to enhance food security, implementing sustainable farming practices that foster soil health and biodiversity, improving irrigation and water management, and developing strategies to increase climate resilience. Capacity building initiatives and the establishment of market oriented agriculture can empower farmers, facilitating the transition from subsistence practices to economically viable farming.

Agronomic interventions for productivity and income enhancement in the region

Diversification/intensification of rice fallow lands: Crop diversification is an innovative approach to sustainable agriculture often serving as a safeguard against the vagaries of nature. The primary factors contributing to lower agricultural productivity in



the region are low cropping intensity, inefficient on-farm input management, use of late-maturing and low yielding crop varieties, declining soil fertility and winter fallowing. Key challenges in rice cultivation includes receding moisture content in the soil profile after rice harvest creating moisture stress condition for the subsequent crop, excessive moisture in the low-lying areas creating waterlogged condition and poor plant stand in rice fallows resulting in poor crop establishment. To sustain productivity and profitability in the face of climate change, it is crucial to diversify the rice-based system by replacing some of the crops with millets, fodders, pulses, oilseeds, maize, and pulses like, lentil and chickpea are the most potent candidate crops for these regions. Lentil could be preferred over other crops due to its short duration and low water requirement. Additionally, the crops selected for rice fallows must be fast growing with early and wide canopy coverage to minimize evaporation losses while improving water-use efficiency. After harvesting rice, grown either by lowland transplanting or upland direct seeding, results into stubbles standing in the field to support crops like pea, lentil, and rapeseed. Sowing of subsequent *rabi* crops begins by late November, accompanied by weed management through systemic herbicides or manual weeding. Tailored fertilizer doses are applied within the furrows, with nitrogen sourced from farmyard manure for organic production. This approach allows harvesting before the April rains, resulting in impressive yields (green peas producing 5.0-8.0 t/ha, lentil 1.0-1.2 t/ha, and rapeseed 0.50-0.85 t/ha). Overall, no-till cultivation enhances land-use and significantly boosts productivity while addressing moisture related challenges for farmers in the region.

Diversification/intensification of maize fallow land:

In the North eastern Himalayan region of India, maize is the second most important crop, next to the rice and is mostly grown under rainfed hilly upland conditions. Maize is sown in the pre-*kharif* season starting from February to mid-March after which the field is generally left vacant as a result of excessive soil moisture causing waterlogged situation during the sowing time, and water scarce condition at later stages of crop development. In some areas, it is grown in *kharif* season, however due to unavailability of moisture in the post *kharif* season, the field is left vacant. Hence, there is a need to diversify maize based cropping system to enhance the profitability and productivity of the hill agriculture. Some of the novel approaches for diversification includes cultivation of short duration pulses like black gram, pea and *rajmah* in the cropping system along with maize in rainfed areas to increase the cropping intensity. Additionally, growing these crops with no-till technology helps farmers in timely sowing, saving in input resources. Short-duration variety of *rajmah* can be grown in a maize-fallow rotation under rainfed conditions as it can tolerate initial moisture stress conditions arising in winter season thus increasing the overall cropping intensity after maize harvest. Maize based sequential cropping as maize-pea, maize-rapeseed & mustard, maize-lentil, maize-lathyrus, maize-vegetables, maize-beans or maize based intercropping as maize+groundnut, maize+ricebean and maize+mung bean/urid bean should be promoted in this region.

Agronomy for *jhum* improvement: Shifting cultivation, or '*jhuming*,' occupies around 0.76 million hectares in the North eastern hill region of India. To enhance the sustainability and income of *jhum* farmers, some key strategies like adoption of high-yielding varieties, and promotion of improved soil

fertility management can be adopted. The soil health can be maintained by extending the cropping periods, rather than frequently shifting the site. Land should be allocated such that the upland one-third portions gets utilized for traditional forests, the midland third for growing erosion-tolerant crops (cowpea, rice bean, soybean, groundnut), and the lowland one-third for growing crops like rice, maize, vegetables, and spices. Additionally, contour cultivation and bund farming with Tephrosia further reduces the soil erosion.

Enhancing cropping intensity through raised and sunken bed systems: The permanent raised and sunken bed (RSB) system followed in the lowland rice areas of this region emerges as a transformative agricultural approach. This innovative system improves the production and productivity of vegetables and cereals while significantly enhancing cropping intensity. In the RSB system, the raised beds are allocated for high-value crops, such as vegetables, while the sunken areas are optimized for double cropping of rice, achieving nearly 100% land productivity. The RSB framework enables a diversified cropping combinations, such as rice-lentil and rice-pea in sunken beds, alongside vegetables like tomato, brinjal, and broccoli on raised beds. This technology improves the water-use efficiency, with productivity rates three to four times higher than traditional rice mono-cropping. With approximately 100,000 hectares of marshy land available in the NEH region, the RSB system has an immense potential for optimizing the land use, increasing the income for small and marginal farmers, and improving their overall livelihoods.

Integrated farming systems (IFS): IFS provides a holistic approach and can play a significant role in achieving self-reliance in agriculture and building resilience among small and marginal farmers. IFS promotes scientific agronomic practices and advanced technologies, effectively meeting the household needs for food, feed, fodder and fibre. By efficient utilization of the on-farm resources, IFS incorporates diverse cropping methods, such as agri-horti-silvi-pastoral systems, to minimize crop failure risks in hilly regions by repurposing waste products. Water harvesting structures aid irrigation and livestock rearing, while composting and vermicomposting enrich soil nutrients.

Promotion of organic farming: Organic agriculture in NEH region is a blend of traditional practices with scientific principles, capitalizing on abundant soil organic carbon, biomass, and livestock. With an estimated 46 million tonnes of manure available, this region is well-suited for organic farming, which not only enhances food quality but also provides profitable livelihoods. The successful transition of Sikkim's to a fully organic state describes the benefits of organic farming, along

with the additional benefits of reduced greenhouse gas emissions and improved carbon sequestration, which bolster resilience to climate change. The Indian Council of Agricultural Research (ICAR) supports these efforts through the Network Project on Organic Farming (NPOF), while the Ministry of Development of North Eastern Region (DoNER) promotes Mission Organic for sustainable practices. Integrated Organic Farming Systems (IOFS) offer a sustainable solution by utilizing both on-farm and off-farm resources. Water scarcity during winters is a significant challenge, making water harvesting structures essential. Farmers can implement *jalkund*-based IOFS models that include various vegetables, spices, fruits, livestock, and compost units, with effective pest management techniques.

Land shaping and development: Soil conservation methods like bunding and terracing are essential for preventing soil erosion, maintaining soil health, and promoting water conservation. Effective practices include capturing rainwater, managing water resources with dams and tanks, and minimizing losses through efficient crop and soil management. Land levelling with a gentle slope of 1-2% reduces runoff and improves water efficiency. Contour bunding and trenching trap the soil particles carried along with runoff, thus aiding soil infiltration and replenishment of soil moisture. Making terraces on slopes of 8% conserves soil and water while reducing the slope. Additional practices, such as contour cultivation, stabilized drains, strip cropping, seasonal land fallowing, mixed cropping, and mulch application, further support the soil and water conservation. By adopting these techniques, farmers in the Eastern Himalayan region can establish a sustainable agricultural framework, ensuring long-term productivity and environmental health.

Strengthening water harvesting capacity and irrigation infrastructure: The North Eastern Region (NER) of India has approximately 34% of the country's water resources, yet only 0.85 million hectares land are irrigated, far below its potential of 4.26 million hectares. The region faces unique water dynamics, experiencing heavy rainfall in monsoon season followed by severe shortages in pre- and post-monsoon periods. To address these challenges, promoting rainwater harvesting





(RWH) and efficient water management is essential. RWH can reduce reliance on groundwater and enhance irrigation capabilities. In hilly areas, RWH structures not only mitigate floods but also provide irrigation and drinking water during dry spells. Constructing low-cost polylined tanks allows for effective water collection and storage, facilitating gravity-fed flow or small pump use. Traditional practices, such as *jalkund* (30,000 L polylined tanks) and farm ponds, have proven to be successful in conserving rainwater and creating livelihood opportunities. Additionally, adopting micro-irrigation methods like drip and sprinkler irrigation will improve water productivity and resource efficiency in the region.

Agroforestry measures: The hilly landscapes face significant biotic pressures from factors like shifting cultivation, deforestation, and commercial exploitation, thus making the adoption of sustainable agricultural practices essential. Agroforestry offers a solution by enhancing the crop production while addressing challenges like soil erosion and timber shortages. It mitigates erosion through improved canopy coverage, providing surface litter, and root binding, improving the soil properties. While hilly terrain limits individual adoption, community lands and wastelands can be used for cultivating multipurpose trees, aiding slope management and erosion control. The effective agroforestry practices include alley cropping with *Leucaena* and *Gliricidia* on slopes, contour planting with *Leucaena* and *Eucalyptus* to reduce runoff, rainfed agro-horticulture (peach and turmeric) and integrating trees like *Morus alba* on bunds. *Alder* cultivation in Nagaland has been successful in controlling erosion and maintaining soil fertility. Further, the vegetative barriers offer a cost-effective alternative to traditional soil and water conservation methods. Similarly, native grasses like citronella reduce soil erosion in Assam's Diphu

hills. Agroforestry barriers, particularly on slopes up to 4%, control runoff and soil loss while offsetting potential yield losses through increased biomass production. Over a period of three years, it was found that these barriers have significantly increased the soil depth and significantly contributing to agricultural sustainability.

Sustainable soil management strategies: Sustainable soil management in the hilly NEH is crucial for addressing soil erosion, nutrient depletion, and organic matter decline. Maintenance of soil fertility requires regular applications of manure and fertilizer with an adjusted pH of 5.5 to reduce the aluminium toxicity found in these areas. Practices like multiple cropping, intercropping, and integrating legumes boost productivity while preserving soil health. With 85% of the NEH region having acidic soils, application of lime and use of acid-tolerant crop varieties, along with organic amendments, can significantly improve the yields. Recycling abundant weed biomass (5-20 t/ha) and incorporating biochar into acidic soils further enhance soil quality, increases pH, improve water efficiency, and promote resilience in challenging conditions.

SUMMARY

System diversification offers a viable pathway to ensure sustainable livelihoods in the Eastern Himalayan region of India. By integrating a variety of crops, livestock, agroforestry practices, and non-farm activities, farmers can mitigate the risks associated with climate change, fluctuating markets, and the region's challenging topography. Improvement in the rice and maize fallow areas by the inclusion of short duration legumes and oilseeds besides adopting regenerative techniques like vegetative barriers, integrated farming systems, organic agriculture, and water-efficient methods, farmers can enhance productivity and resilience. Agroforestry, and sustainable soil management play vital roles in improving crop yields and preserving ecological balance. More focus should be oriented towards the indigenous practices for moisture conservation along with that some smart approaches as hydrophobic mulches, no-till farming should be initiated. Empowering farmers through capacity building and market-oriented initiatives will further strengthen livelihoods and promote long-term sustainability in this vulnerable region.

*Corresponding author email: subhiari@gmail.com



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Protect environment.

