Crop Productivity in Hilly Areas of North East India: Constraints and Strategies

Bimal Deb Nath[1] and Sugata Deb Nath[2]*
[1]*Assistant Professor, Department Management, NEHU (Meghalaya), India.*
[2]*Assistant Professor, Donbosco College, Tura (Meghalaya), India.*

(Corresponding author: Bimal Deb Nath)*

ABSTRACT: The North Eastern Region (NER) of India, blessed with potentialities of valuable natural resources compared to the rest of the country, is struggling in the agricultural sector. Agriculture has been a constant source of sustenance for the region. Still, recent trends in this sector indicate that there has been a downturn in regions' agricultural productivity and at the same time contribution to national GDP is low. There are various obstacles to maintaining the standard level of crop productivity. The main challenge is the identification of the major hurdles and examining the possible strategies that may boost crop productivity as a whole. Against this backdrop, the present study gives insights into the various studies undertaken to address the issues of crop productivity in the hilly areas of NER, India. Finally, it outlines the possible strategies based on critical review that may be adopted to boost crop productivity. The findings of the study would help the policymakers to focus on those agricultural practices, that may increase agricultural productivity as a whole.

Keywords : North–Eastern Region (NER), Crop productivity, Hilly Areas, Information and Agriculture.

INTRODUCTION

Agriculture is the backbone of the economic system of developing countries like India and has a vital role in sustainable development and GDP contribution. It is the core basis for livelihood, poverty alleviation and provides employment opportunities to a substantial population (Birthal *et al*., 2006; Kannan *et al*., 2011). However, with the recent trends in the agricultural sector in India especially in the North–Eastern Region, there has been a downturn in agricultural development and the contribution of agricultural production to the region's GDP is relatively low (Roy *et al.,* 2014). Even after being blessed with potentialities of valuable natural resources compared to the rest of the country, the NER, India is struggling in the agricultural sector particularly in maintaining the standard level of crop productivity (Banerjee, 2006). A lot of factors like biological patterns, markets, different seasons, and lack of adequate farming knowledge impact crop production, and subsequently, farmers face a monstrous amount of losses. Recovery can be achieved using an integrated approach to understand soil types, pressure, fair weather, and crop types, and subsequently to achieve optimum crop yields (Rajeswari, 2019). Thus the region needs a radical change like Business process reengineering (BPR) in the agricultural sector to survive in the changing conditions of the economy. Further, in search of the literature, it was observed that there is also a lack of research concerning the strategies or especially the areas for development at ground level

to address these issues in the context of NER, India. These gaps led us to the present study.

The primary objective of the paper is to provide possible strategies that may be adopted to boost crop productivity in hilly areas of North East India. To achieve the objectives, the study considered exploratory approaches in the absence of concrete and relevant literature. Initially, the major challenges of crop production are examined on the basis of critical review of earlier literature and then finally possible solutions are suggested on the areas that need to be developed for enhancing crop productivity.

CHALLENGES IN WORLD AGRICULTURE

Modern agriculture not only helped to achieve a dramatic increase in crop yield, ensuring food security and commercialization of agriculture but also continually facing challenges to sustain. Increased production also led to the gradual decline in the cropping environment and as a result, yield levels started to fall, and soils are becoming degraded in intensively cultivated areas. Some of the major challenges that world agriculture is facing in the 21st century are as follows (Alexandratos and Bruinsma 2012).

Global Food Security: World agriculture is facing a major challenge to produce enough food to feed the growing world population. This population may reach eight billion people by 2025. Nearly, most of this will be in developing countries. So the food production

challenge requires increasing productivity that does not damage natural resources or the environment.

Poverty Reduction: Despite the rapid urbanization, the majority of the poor are still rural dwellers. Most of them draw their income from agricultural activities. Billions of farmers live in poverty or near the poverty line. Therefore the second challenge that global agriculture faces is to develop policies that can unleash agriculture's full potential as an engine of growth.

Sustainable Natural Resource Management: The third challenge to agriculture is to develop a set of technologies and policies that support and guide especially small–scale farmers. This is critical because farmers use natural resources, and appropriate management of natural resources may help in improving the sustainable productivity and profitability of small-scale farmers in the developing world.

Other Challenges of Modern Agriculture: The other challenges are soil degradation, erosion, water pollution, excessive use of chemicals, waste of water, decreasing groundwater tables, destruction of natural habitats for wildlife and insects, and pest resistance against insecticide and pesticides are a few of the concerns expressed by environmentalists, ecologists, agricultural professionals, policymakers, farmers and public (Leeuwis, 2004; Al-Subaiee *et al.,* 2005).

In addition, soil pollution in a locality is caused by improper use of farm machinery, improper use of chemical fertilizers and pesticides, improper irrigation and lack of modern irrigation systems such as trickle and drip irrigation, deforestation, early and excessive gazing of rangelands, and farmland being used for housing and industrialization purposes. Further, there is a lack of laws and regulations at the macro level, which will direct the optimal use of chemicals and pesticides.

Farmers also struggle to cultivate crops due to irregular rainfall, intermittent drought, and land degradation causing low productivity and production due to crop encroachment and population growth. Further, the decisions concerning managing resources and cropping environment are determined at the family level and village or higher levels. Families settle in limited land resources, leading to inadequate management practices, and causing lower farm productivity. This situation is reflected in the marginal land; the increasing pressure on marginal and degraded land that may affect its sustainability and thus the farm-family income (Young, 1998). In addition, lack of knowledge and inadequate information also represent a significant barrier, especially for farmers in rural areas, and little effort has been put forth to provide this information that can help transform farmers' output.

Issues in Agricultural Productivity: In India, agriculture is one of the critical activities and fulfills basic needs such as food, clothing, and shelter (Thirtle *et al.,* 2001). However, several factors pose a significant risk to agricultural productivity, leading to a reduced yield if not correctly monitored and well managed (Metcalfe and Elkins, 1980). A review of the relevant literature indicated that agricultural productivity is highly dependent upon yield-determining factors that include extreme weather phenomena, water availability, air pollution, and temperature. This influences all components of crop production, including crop area and crop intensity (Tandzi and Mutengwa 2019). According to a few researchers (He *et al.,* 2018; Mekureyaw, 2017; Dresselhaus and Hückelhoven 2017) most critical dominating factor influencing the suitability of a crop to a particular region is climate because the yield potential and the variation of crops mainly depend on it. In addition, the knowledge of appropriate planting methods is also essential because uneven climate phenomena influence the selection of planting methods and thus affect yield even though the total planted area remains unchanged (Lizumi and Ramankutty 2014). Another important determining factor is soil fertility. A soil can provide nutrients needed for the optimum growth of a specific crop (Wang, 2014). It supports crop production that is determined by the entire spectrum of its physical, chemical, and biological attributes and includes significant sources of micronutrients (Fe, B, Cl, Mn, Zn, Cu, Mo, Ni) and macronutrients (N, P, K, Ca, S, C, Mg, O, H) that are needed for crop growth (Shang *et al.,* 2014; Heggeenstaller, 2012; Tandzi *et al.,* 2018). On the other side, the lack of soil nutrients in the soil causes deficiencies in plants, and their excess leads to toxicities, which negatively impacts crop yields (Shang *et al.,* 2014).

OVERVIEW OF CROP PRODUCTIVITY IN NORTH EASTERN REGION (NER), INDIA

The northeastern region of India is blessed with tropical, subtropical, and temperate climates where various agro-ecological conditions are observed. Despite a considerable increase in the area under cultivation and yield of staple food grains aided by modern methods, it failed to meet the demands of the growing local population, resulting in heavy dependence on food imports. The improvement in food grain production is also occurring without much dependence on external synthetic input and high-yielding variety seeds, which is essential for maintaining agro-biodiversity. In addition, unsustainable farm practices exist, mainly due to exhaustion of soil nutrients, deforestation through slash and burn cultivation, and reduction of fallow periods, giving rise to the high incidence of rural poverty. Infrastructure constraints have also prevented the region from growing at a pace commensurate with or proportionate to the rest of the country (Roy *et al.,* 2014). Recently, the state and central governments of India have also undertaken several initiatives to stimulate the regional economy and promote agricultural growth. Many studies have also dealt with the issues and opportunities of agricultural development in the NER, India. Some of these that are relevant to the proposed study are highlighted below:

Opportunities: The northeastern states are congenial for producing essential vegetables, and the market value of these products becomes significantly higher when produced during the off-season. Significant vegetables grown with substantial area in the region are Potato, Cabbage, Cauliflower, Tomato, Radish, and Brinjal.

The progress in vegetable production has not gained momentum as has been observed for fruit production. Sikkim, Meghalaya, and Nagaland have recorded a substantial increase in area and production. However, for other states, vegetable production has been either marginally increasing or declining. The primary factor affecting vegetable production is the wide fluctuation in prices in local markets due to supply from neighboring states like West Bengal and also from within the region, Assam. The vegetable production is mainly determined by the demand in major cities within the region where the population is high. Therefore, vegetable production is primarily confined to the capital cities of the various northeastern states only. The opportunity for commercial vegetable production in rural areas is mainly impeded by the poor road transportation facilities, which is essential to shift these perishable commodities in the quickest possible time. However, in some pockets, the use of inorganic inputs and pesticides has been very high, and the productivity is also relatively high, and these farmers are cultivating vegetables in commercial mode. Therefore, there is a distinct dichotomy in vegetable production in the various pockets of the region, and a marked difference is there in terms of productivity (Birthal et al., 2006).

The region is home to some of the high-value niche crops like Assam lemon, Joha rice, medicinal rice, sticky rice (Manipur), pineapple, aromatic rice of Tripura (harinarayana & kalikhasa), Khasi mandarin, ginger, turmeric (Meghalaya), French bean, King chili, bird eye chili (Nagaland) Assam tea, large cardamom, ginger, pineapple and passion fruits which have high market demands. Due to the thin population density compared to the vast natural resources available in the region, less pressure on food demand. Dependence of mid and high-altitude farmers on renewable farm resources; time-tested indigenous farming systems in agriculture are mostly prevailing in the region; agri-export zones (AEZ) have already been established for organic cultivation of pineapple in Tripura and ginger in Sikkim (Das et al., 2008).

Challenges: Despite the abundant natural resources and congenial climate, the NER has failed to reap the benefits of enormous opportunities for societal welfare and the people's livelihood has been affected by several constraints. The agriculture problems in the NER, India are characterized by uneven land, high and variable rainfall patterns, and ethnicity; inter-state disparity in most economic indicators is highly conspicuous; growth of output is at a snail's pace; rice dominates agriculture, but the productivity is low, and production risky (Barah, 2007).

The challenges of agriculture in the NER, India scenario are also low and uncertain agricultural productivity due to vulnerability to floods, soil erosion, and heavy siltation, lack of market opportunities and remoteness and isolation, high production risk as well as income risk; low usage of the growth augmenting inputs such as irrigation, fertilizers, protective measures against biotic/abiotic stress, low-quality seed

replacement contributed to the dismal performance, and the resultant outcome is the vicious cycle of low-input, low productivity, and low income, a precursor to agrarian distress. In addition, one of the major retrograde factors is the lack of an effective market network, which caused erosion to the profitability of agriculture (Dev et al., 2006). Notwithstanding a large stock of high-value crops, the region failed to reap the benefits as the problems of the inefficient market system, transportation, power, infrastructure, finance, and services in rural areas need to be overcome for broader income impact (Banerjee, 2004). This has also perpetuated the sheer wastage of resources and Agri-products (Bhowmick et al., 2005). The major impediments to attracting investment in the food grain sector are the lack of supply of seed and quality planting material, very high transportation cost, lack of market availability for these commodities, lack of information, colossal post-harvest losses, lack of link road, poor market intelligence, high transport cost, etc., are the other constraints that impede agricultural development (Mittal, 2007).

Other significant challenges associated with the North Eastern Region are pest and disease management for the farmers; less awareness creation on organic farming; less knowledge or assistance to farmers in post-harvest handling, processing, value addition, and packaging, identifying certification agencies within the region, and reduction of certification cost, creation of infrastructure and mechanisms for marketing of organic produce; the prevailing policy instruments need to be re-looked, re-defined, and efficiently implemented to take care of the prevailing loopholes in agriculture management practices (Bujarbaruah, 2004).

Factors affecting Crop yield in North Eastern Region, India: A critical review of various relevant literatures confirms that the crop production environment consists of inherent sources of heterogeneity due to numerous parameters. These parameters mainly can be categorized into Environmental; Physical; Economic and Technological. The various major factors underlying these parameters in the context of India in general and North East Region, India in particular are highlighted in Table 1.

It is evident from the review of earlier literature that biological, socio-economic, climate and institutional/policy, poor economic status of farmers, lack of quality inputs, and input/output price support are the leading causes of low productivity at the production level and these factors may vary based on geographical location.

In addition, farmers of India, including NER, have the practice of using different types of crops, but the information that the small, marginal, and medium farmers have access to is less and from fewer sources than large-scale farmers. NER, India, started showing a decline in yield due to various challenges, particularly the absence of adequate information and arrangements to support production.

Table 1: Factors affecting Crop yield.

Domain	Factors
Crop-Agricultural Production	Land area usage, land situations, method of sowing, land preparation, harvesting, varieties, traditional cropping system, seed treatment, method of irrigation, harvesting, varieties, weeding frequency, manure frequency, fertilizer frequency, Weather, and time of sowing (Borthakur, 2002)
Crop-Soil suitability	Quality of soil, soil texture, soil structure, soil density, soil temperature, soil fertility, soil color, soil composition, soil depth, soil stickiness, soil plasticity, moist soil, dry soil, soil pH, major nutrient, minor nutrient, fertilizer usage, manure usage (Bodaghabadi *et al.*, 2019).
Crop-Irrigation and water facilities	Quality of water, type of irrigation size, irrigation canal, irrigation management, irrigation purpose, irrigation sources of water, irrigation conveyance system, surface irrigation system, surface drainage system, drainage ownership and drainage duration (Rai, 1981)
Crop-Pest control	Pest control (PC) natural, PC applied conventional, PC applied modern, PC integrated pest management, protection on chemicals (Pingali, 2010; Prasad, 2009)
Crop-Agricultural Economics Information	Nature of agricultural production, agricultural finance, market seller, market time, market competition, market regulation, market area, market function, the market volume of sale, fluctuation in agricultural price, and farmer's attitude (Barah & Neog 2005).
Crop-sustainability strategy	Types of traditional farming, a system of farming, types of cooperative farming, agricultural labor, elements of sustainability, conservative farming and agricultural sustainability (Birthal *et al.*, 2006).
Crop-Agricultural constraints	Land problems, irrigation problems, indiscriminate use of agrochemicals, vulnerability problems and Environmental problems (Barah and Neog 2005)
Farmer personal information	Gender, Age, Education level, Family type of farmer, Size of Household, Experience in farming, Total land property(ha), The main source of income, Dependent on Farming and Share of Income (Debnath *et al.*, 2016).

Farmers' Attitude towards Agriculture: The Farmers' attitude plays a major role in agricultural productivity. As a profession, it provides opportunities to contribute to the mission of eradicating hunger and enabling food security in India (Shah *et al.*, 2019). In the case of India, including NER, the attitude of farmers is a strong indicator to predict whether they are going to remain in farming occupation or not (Debnath *et al.*, 2016), and the success and failure of farming mainly depend upon the farmers' mindset or attitude (Nataraju *et al.,* 2019). The factors that influence farmers towards farming include personal characteristics such as age (Lahiri, 2016), education level of the farmer (Debnath *et al.,* 2016), experience in farming; irrigation and cropping intensity (Debnath, *et al.,* 2016), business characteristic such as the market orientation of farming, farm size, type of farm enterprise, debt level, ownership of farm geographical characteristics such as distance to market centers, distance to the nearest technological adopter, annual income, innovation proneness, extension service commitment, problems (Debnath, *et al.,*2016); family type and size, material possession, social participation, planning orientation, production orientation, market orientation, risk orientation, economic motivation, farmer's knowledge satisfaction and farmer's literacy, extension contacts (Sadati, *et al.,* 2010; Lahiri, 2016).

Few researchers (Debnath *et al.,* 2016; Zollingrand and Krannich 2002), while exploring the decision to continue farm activity in the future by a farmer, emphasized that the intention of the farmer and family member participation is very crucial. It was noticed that farming families tend to involve more family labor in farming, as they may have a more profound familiarity with the work of the farm. Thus, it influences the decision to continue farm activity (Wieley *et al.,* 2005). Further, farming decisions also depend on other alternative competing sectors of a family and the respective contributions to achieve their agricultural productivity. In NER, India, most of the farmers are small landholders, followed by medium and marginal landholding farmers. The possible reason for this is that the families have been nuclear in size in recent times, and the joint family system is fading away, resulting in fragmentation of land among the family members. In addition, the household structure of marginal family farms and their decisions are such that they influence the farmer's attitude towards agriculture.

DISCUSSION

Agriculture can bring many economic and social changes but a past model of agricultural development of NER, India has failed to result in lackluster growth of the economy. The contribution of agriculture and an allied sector to the national domestic product remained meager. Therefore, revitalizing the economy by promoting growth and rebuilding the models for agricultural development is a great challenge. Because of the coexistence of diverse ethnicity, geophysical, socio-economic, and cultural factors, the issues of developmental deficiencies are more complicated and thus require more in-depth understanding and strategies for a long-term economic solution.

It is imperative from the above studies that it is very crucial to boost the crop productivity, especially in the North Eastern Region, India and it must be probed separately. The North-Eastern Region (NER), with a landmass of 2.6 million sq. km located strategically in the eastern part of the country, comprises eight States and has several unique and unparalleled features; fertile land, abundant water resources, dense evergreen forests, high and dependable rainfall, mega biodiversity, flora and fauna and a mixture of socio-economic, political, ethnic and cultural diversity. The congenial temperate climate is favorable to agriculture, which is the primary occupation of the region's people. Agriculture in the region is traditionally maintained by families and villages where the passing on and sharing of relevant information and knowledge is regarded as very important (Manjunath *et al.,* 2019).

However, rather than converting these strengths optimally into opportunities, the weaknesses threaten the regional economies, adversely affecting livelihood (Barah, 2007). The earlier systems have failed to meet

the demand for crop productivity in the region and many researchers have tried to address the same. Due to wide variations in yield determining factors conditions, there exist bottlenecks and uncertainty for increasing crop production. It has become a challenging task to achieve desired targets in Agri-based crop yield. Researchers have suggested that crop prediction with records on factors that directly impact production and productivity can help farmers reduce the loss as well as achieve the desired targets. Effective management practices along with efficient decision-making are crucial to boosting agricultural yield and limiting environmental externalities across India (ICAR, 2013; Sadati *et al.,* 2010). Farmers in developed countries are already generating and capturing massive agricultural data using information communication technology (ICT) tools which are stored and later retrieved using application software. Developing countries like India need a vast technological boost/up-gradation in the Agricultural sector to survive in the changing conditions of the economy. It will enable the farmers to optimize their crop yield and minimize the input costs and losses due to uncertain rainfall, droughts, etc. With the addition of this technology, farmers will benefit from greater access to farm-related information that can have a massive impact by adequately improving the capability of the farmers for effective cultivation and reduction of farm-related diseases. A data-driven agricultural information system can facilitate an effective knowledge broadcast service to support the

farmers in problem-solving, decision-making, and early warning. Additionally, present economic conditions and government policies of a nation are such that they necessitate the adoption of tools of Information Technology and precision farming.

The innovative strategy for improving is indeed a sine-qua-non for productivity growth and in increasing agricultural production. The NER must unleash a dynamic growth process for the agricultural sector consistent with its natural path of easy-go type. The complete dependence on crop-based agriculture at the production level has failed to generate the desired production level and household income. Even for food production, except for Assam, the entire region is a food deficit, posing a regional food security question. Moreover, the inability to build a strong foundation in the high-potential horticulture, fisheries, poultry, and dairying sector, has worsened the chance of income insecurity (Arjun *et al.,* 2016).

According to a study by Bujarbaruah(2004), agriculture development is a function of six elements (6T's), *viz.,* institutions (including land tenure, R&D, training, marketing, credit, stock exchange in agricultural goods, etc.), infrastructure (including power, irrigation, cold storage, transport, etc.), investment, inputs (seed, fertilizers, etc.), incentives and information (on technology, prices, costs, quality, etc.). Accordingly, considering the challenges and opportunities of NER, India, the author has summarized possible solutions to boost agricultural productivity as shown in Table 2.

Table 2: Solutions to Boost Agricultural Productivity in North Eastern Region (NER), India.

Challenges	Need of Development
Crops that cannot grow in hilly areas	Designing an agro-ecological zone particular to crop-based farming
i) Non-availability of quality seed new varieties, planting material, fertilizers, ii) input costs are increasing.	Production and distribution of seed materials by farmers, testing and introducing good quality yielding varieties, the scope for diversified farming systems, locally adapted varieties to increase yield and seed chain development. Availability of essential fertilizer and lowering input cost
unorganized marketing, no value addition, price fluctuation, lack of proper marketing channel	Developing Value addition, the introduction of suitable varieties, the establishment of processing units and export market, alternative uses of e-marketing.
Lack of suitable storage of crops	Creation storage facilities infrastructure such as cold storage, off-season production can be carried out hills after harvesting in plains
Lack of motivation and negative attitude of farmers to engage in farming activity and commercial production	Capacity building in entrepreneurship and making farming more innovative and profitable.
Competition from other crops,	Searching nearest and readily available market for distribution of crops, supplying seed to other nearby by market or states.
Lack of adequate mechanization for crop cultivation at large scale	Identification of machinery and small tools in large number
Crops depend on season-specific, shortage of crops, and labor shortages during some periods	Introduction of short-duration crops, and group farming through SHGs.
Diseases and Pests	Integrated pest management control, capacity building/awareness about diseases of crops, and crop prediction model.
Landslides, floods, cyclones, wind hail storms	Taking preventive action and crop prediction model
Lack of awareness about technologies	Creating awareness by using advanced technologies such as the crop prediction model and precision farming.
Lack of Information and knowledge of farmers	Development of Crop prediction model, identification of major production factors influencing yield, examination of yield-reducing factors, and provision for capturing and storing high dimensional agricultural data for retrieval to necessary action information and decision making.
Information system	Integrated Intelligent Agricultural system with different farm-level practices to be developed.

Source: Author's compilation

To sum up, the ongoing economic reform process has thrown up several opportunities as well as challenges. However, to capture the advantages of the untapped potential, the northeastern region needs to reorient its development strategy within the overall macroeconomic framework. This is essential to achieve the broader developmental goals because the stronger states make a vital region, and strong regions make a strong nation. Unfortunately, most of the states in the northern region of India lag under the garb of resource constraints and infrastructure hiccups. Therefore, a state-wise conscientious development strategy is essential to synergize the lagging and leading sectors or accelerate the development process, which is the need of the day (Banerjee, 2006).

The study attempts to suggest possible solutions to enhance crop productivity and underlines the importance of integrated solutions for crop productivity as well as agriculture development for the region. The study apprised that to ensure environmental, economic, and social sustainability, farmers must adopt an integrated Intelligent Agricultural system with different farm-level practices such as judicious use of chemicals, integrated pest management, adequate irrigation, and good plant and animal health. These findings would help the policymakers to focus on those agricultural practices that may increase agricultural productivity. The study is an attempt to spotlight an investigation on Crop productivity supposed not to be free from a few limitations. One of the major limitations of the study was the absence of an established agriculture data bank. This has resulted in the present study solely depending on past studies. Further, the study has considered the conditions of crop production irrespective of crops. However, these conditions may vary depending on crop varieties and geographical locations. With this knowledge, it is appropriate that future studies should focus on creating a data bank to record past field-level activities on a crop basis. Future work is also required to address other commercial crops where research is lacking.

REFERENCES

Alexandratos, N. and Bruinsma, J. (2012). World agriculture towards 2030/2050. The 2012 revision, ESA Work Pap, 3.

Al-Subaiee, S. S. F., Yoder, E. P. and Thomson, J. S. (2005). Extension agents perceptions of sustainable agriculture in the Riyadh Region of Saudi Arabia. *Journal of International Agricultural Extension Education, 12*, 5-13.

Arjun, S., Joshi, A., Das, P. H., and Amutha, R. (2016). Big Data Analytics for Agricultural Development in India. *International Journal of Engineering Research & Technology (IJERT), 4*(22), 1-5.

Banerjee, A. (2004). Food Security and Public Distribution System Today: Failures and Successes, Kanisha Publishers, New Delhi.

Banerjee, A. (2006). Economic Growth and Sustainability of North Eastern States, in P.M. Passah (Ed.) (2006), In Defence of Regional Economic Development in India: A Case for the North East, Akansha Publishing House, New Delhi.

Barah, B. C. (2007). Strategies for Agricultural Development in the North-East India: Challenges and Emerging Opportunities. *Indian Journal of Agricultural Economics, 62*(1), 14-31.

Barah, B. C. & Neog, A. K. (2005). Analysis of Resource Endowment and Economic Management: A study of North East India, in Baruah A. (Ed.) (2005), India's North East: Developmental Issues in a Historical Perspectives, Manohar, Publications. New Delhi.

Bhowmick, B. C., Barah, B. C. and Barthakur, N. (2005). Changing Pattern of Rice Production Systems and Technology in Assam: A Spatio-Temporal Analysis of Performance and Prospects, Policy Paper No. 22, National Council of Applied Economics and Policy Research, New Delhi.

Birthal, P. S., Jha, A. K., Joshi, P.K. and Singh, D. K. (2006). Agricultural Diversification in North Eastern Region of India: Implications for Growth and Equity. *Indian Journal of Agricultural Economics, 61*(3), 328-340.

Bodaghabadi, M. B., Faskhodi, A. A., Saleh, M. H., Hosseinifard, S. J., and Heydari, M. (2019). Soil suitability analysis and evaluation of pistachio orchard farming, using canonical multivariate analysis. *Scientific Horticulture Journal, 246,* 528–534.

Borthakur, D. N. (2002). Shifting Cultivation in Northeast India: An Approach Towards Control, in BJ Deb (ed.). Development Priorities in Northeast India, New Delhi: Concept Publishing Company.

Bujarbaruah, K. M. (2004). Organic Farming: Opportunities and Challenges in North Eastern February. 2004. ICAR Research Complex for NEH Region, Umiam, Meghalaya.

Das, A., Patel, D. P., Munda, G. C., Hazarika, U. K. and Bordoloi, J. (2008). Nutrient recycling potential in rice – vegetable cropping sequences under in-situ residue management at mid-altitude subtropical Meghalaya. Nut. Cycl. *Agro-ecosyst, 82* (3), 251-258.

Debnath, A., Saravanan, R., and Datta, J. (2016). Farmers' Satisfaction with the Public Agricultural Extension Services in Tripura State of North-East India. *International Journal of Social Science, 5*(2), 65-80.

Dev, Bimal J. and Ray, B. D. (2006). Changing Agricultural Scenario in North East India, Concept Publishing Company, New Delhi.

Dresselhaus, T., and Hückelhoven, R. (2017). Biotic and abiotic responses in crop plants. *Agronomy, 8*(267), 1-6.

Heggeenstaller, A. (2012). Managing soil pH for crop production. *Crop Insight, 22*(15), 1-4.

He, W., Yang, J. Y., Qian, B., Drury, C. F., Hoogenboom, G., He, P., Lapen, D., and Zhou, W. (2018). Climate change impacts on crop yield, soil water balance and nitrate leaching in the semiarid and humid regions of Canada, 13.

ICAR (2013). Package of practices for organic production of important crops in NEH region. Published by ICAR Research Complex for NEH Region, Umiam – 793 103, Meghalaya.

Kannan, Elumalai, and Sundaram, S. (2011). Analysis of trends in India's agricultural growth, The Institute for Social and Economic Change, Bangalore, India, Working paper 276.

Lahiri, B. (2016). Agricultural information seeking behaviour of GARO tribal framers of Meghalaya, India. *Ecology, Environment and Conservation, 22,* 227-236.

Leeuwis, C. (2004). Communication for Rural Innovation: Rethinking Agricultural Extension. Blackwell, Iowa, USA.

Lizumi, T., and Ramankutty, N. (2014). How do weather and climate influence cropping area and intensity? *Global Food Security, 4,* 46-50.

Manjunath, R., Bindu, S., HariKireeti, B. K., Irfan-Pasha, F. and Kavya, R. (2019). An Effective Big Data Framework

based on Farmer's Agricultural Context. *International Journal of Scientific Research and Review, 07*(05), 570-578.

Mekureyaw, M. F. (2017). Maize lethal necrosis disease: And emerging problem for maize production in eastern Africa. *Journal of Plant Physiology & Pathology, 5*(4).

Mittal, S. (2007). Strengthening Backward and Forward Linkages in Horticulture: Some Sucessful Initiatives. *Agricultural Economics Research Review, 20,* 457-469.

Nataraju, M. S., Lakshminarayan, M. T., Preethi, and Lalitha, K. C. (2019). Attitude of Farmers towards Agriculture. *International Journal of Current Microbiology and Applied Sciences, 8*(1), 2729-2734.

Pingali, P. (2010). Chapter 74 Agriculture renaissance: Making 'agriculture for development' work in the 21st century. In P. Pingali & R. Evenson (Eds.), Handbook of agricultural economics (pp. 3867–3894). Elsevier. Retrieved from http://www.sciencedirect.com/science/article/pii/S157400 7209040742.

Prasad, R. (2009). Efficient fertilizer use: The key to food security and better environment. *Journal of Tropical Agriculture, 47*(1–2), 1–17.

Rai, R. N. (1981). Water management in North Eastern Hill region, ICAR Res Bull NEH *Region, 14* (1981), 79.

Rajeswari, S., Suthendran, K., and Rajakumar, K. (2018). A smart agricultural model by integrating IoT, mobile and cloud-based big data analytics. Proc. 2017 Int. Conf. Intell. *Comput. Control*, *I2C2,* 1–5,

Roy, A., Tripathy, A. K., Mohanty, A. K., Singh, N. U., Dhar, D. S., Baruah, S., Saxena, R., and Ngachan, S. V. (2014). Commodity profile on potato, tomato, ginger, turmeric, and pineapple in Meghalaya. Umiam, Meghalaya: ICAR Research Complex for NEH Region.

Sadati, A. S., ShaabanaliFami, H., Asadi, A., and Abolghasem Sadati, S. (2010). Farmers Attitude on Sustainable Agriculture and its Determinants: A Case Study in Behbahan County of Iran. *Research Journal of Applied Sciences, Engineering and Technology, 2*(5), 422-427.

Shah, R., Singh, A. K., and Rakshit, S. (2019). Development of a scale to measure farmer's attitude towards farming as an occupation. *Journal of Pharmacognosy and Phytochemistry, 8*(2), 411-414.

Shang, Q., Ling, N., Feng, X., Yang, X., Wu, P., and Zou, J. (2014). Soil fertility and its significance to crop productivity and sustainability in typical agro ecosystem: A summary of long-term fertilizer experiments in China. *Plant and Soil, 381*, 13-23.

Tandzi, N. L., and Mutengwa, C. S. (2019). Estimation of maize (*Zea mays* L.) yield per harvest area: Appropriate method. Agronomy MDPI.

Thirtle, C., Irz, X., Lin, L., Mckenzie, H. V., and Wiggins, S. (2001). Relationship between changes in agricultural productivity and the incidence of poverty in developing countries. In: DFID Report No. 7946.

Wang, C. H. (2014). Farming methods effects on the soil fertility and crop production under a rice Vegetables cropping sequences. *Journal of Plant Nutrition, 37,* 1498-1513.

Wieley, A., Bogg, T., and Ringo, H. M. (2005). The influence of parental socialization factors on family farming plans of preadolescent children: An exploratory analysis. *Journal of Research Rural Education,* 11-20.

Young, A. (1998). Land resources: Now and for the future. Cambridge University press. United Kingdom.

Zollingrand, B., and Krannich, R. (2002). Factors Influencing Farmers' Expectations to Sell Agricultural Land for Non-Agricultural Uses. *Rural Sociology, 67*(3), 442-463.

How to cite this article: Bimal Deb Nath and Sugata Deb Nath (2023). Crop Productivity in Hilly Areas of North East India : Constraints and Strategies. *Biological Forum – An International Journal, 15*(3): 892-898.