



## **Land use planning and strategic measures in North Eastern Region of India**

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**Abstract:** Land use planning (LUP) is an iterative process between stakeholders aiming at the negotiation and decision for a sustainable land use as well as initiating and monitoring its implementation. Despite richness in natural endowments, the North Eastern Region (NER) of India is one of the most backward areas of the country, home for a very high proportion of the poor. Agriculture is highly risky and productivity is low. Accelerated agricultural development of the NER states can be achieved by identification and prioritization of the constraints, resolving issues related to crop production and transfer of appropriate agro-technologies. A case study of district level land use planning showed that optimum utilization of available farm level resources with scientific farm mechanization techniques and adequate extension services will certainly elevate the agricultural productivity of the NER many folds.

**Key words:** *Decision support system, Natural resources, Jhum cultivation, District Level land use planning*

### **Introduction**

Land use planning (LUP) is an iterative process based on the dialogue amongst all stakeholders aiming at the negotiation and decision for a sustainable form of land use as well as initiating and monitoring its implementation. The LUP process covers all steps starting from the collection of data and information through its processing, analysis, discussion and evaluation right up to the negotiation for a consensus concerning the form of land use to be practiced (Amler *et al.* 1999). LUP pursues basic steps *viz.* land resource evaluations, interpretation of socio-economic factors, integration of land resource data base with socio-economic appraisals, simulation of various crop models to extract best possible crop-

ping options with economic viability and finally, a Decision Support System (DSS) so that the planners are able to take suitable decisions in relation to the ground realities. The necessity of developing comprehensive land use plans at different levels has been increasingly felt and emphasized in different five years plans.

Conceptually, LUP involves altering the land area allocations over alternative uses through suitable technological and institutional devices like supplies of the various commodities and service which follow from the stipulated land use pattern, broadly conforming to the projected demand for such items. The proposed land uses are sustainable in the sense that the current uses by one group does not jeopardise the uses of another group

or those of the future generation and the bio-mass production, *i.e.* the streams of output which follow from the stipulated land use pattern (and even income and employment following from the streams of output) are maximized (Datta and Chakrabarti 1998).

The NER of India comprise eight states *viz.* Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim covering 25.509 M ha, which is about 8% of country's geographical area. More than 64 % of the total geographical area is covered by thick and mixed deciduous and semi ever green forest. Except the Brahmaputra valley covering about 30 % land of NER, the rest is hilly and mountainous track with steep slopes. Despite the richness in natural endowment, the NER is the most backward area of the country, home for a very high proportion of the poor, and agriculture is highly risky and productivity low. The abundant and rich natural resources are neglected in the past but must be put to efficient use now to catalyse developmental process. In the absence of concerted efforts, the state is unable to provide necessary support system to manage these resources for the benefit of the people.

#### *Conflicts on land use planning in NER*

Large stock of natural resources, abundant water resources, number of perennial river system and the precious human capital is under-utilised. As a result, the region suffers from drought situation on one hand and frequent floods inundating vast plain areas on the other hand. Under the circumstances, if the resources are not properly developed and managed, the food security in the predominantly agrarian economy will be endangered. Therefore, the missing policy link between effective supporting infrastructure, coordination and implementation of the developmental schemes is a major cause of concern requiring urgent attention.

Lethargic growth pattern and low-production agriculture in the region illustrate extremely depressing future, making food insecurity most grievous in the face of harshly growing population. Hit by frequent natural disasters such as floods, erratic rainfall, increasing food deficits, low and unstable productivity in agriculture and

livestock, the region poses a serious development question to the policy makers. Access to institutional and infrastructure support (including effective delivery system and credit institutions), lack of people's participation in the development process and management have been the inhibiting factors for development. The present circumstances require special attention for developing strategic measures against the burning issues of the region with concurrent policies to be developed by the policy makers.

Keeping in view the numerous constraints (elaborated inside), the critical priorities for accelerated agricultural development of the NE states can be identified into four sections. The first section presents a report of the status of economy, particularly the agricultural sector (agriculture, horticulture, plantation crops, livestock and fisheries), identification and prioritization of the constraints, second section takes stock of the technology and future prospects for agricultural economy, third section discusses the emerging institutional reforms and future needs and finally conscientious recommendations are formulated. These are suggested to be pursued vigorously, particularly should receive highest attention in the 12<sup>th</sup> Five-Year Plan for the NER.

#### *Specific researchable issues related to crop planning*

There are ample scopes to pin point specific researchable issues related to crop planning in the NER *viz.*

- Rabi fallow and waste land utilization
- Boro rice cultivation in low lands with suitable fertilizer dosages
- Breeding cold-tolerant rice varieties and rice varieties for high altitude
- Rain-fed upland rice/direct seed/transplanted "ahu" rice
- Wheat in *rabi* with emphasis on developing short duration HYV
- Short-and long-term impact of the shallow tube well (STW) programme
- Crop diversification for efficient utilization of irrigation water through STW

- Rain water (Watershed) management
- Improvement in '*Jhum*' cultivation
- Post-harvest management of horticultural/animal/fishery products.

The extension/ developmental issues include:

- Watershed development
- Micro-irrigation/sprinkler programmes
- Value-addition to '*ahu*' rice for making beaten rice and rice-bran oil
- Commercialization and post-harvest management/value-addition of rice
- Strengthening research-extension-farmer (REF) linkage
- Supply of seeds/planting materials/feeds/animals/vaccine/soil testing
- Agricultural extension/credit/market facilities/market information
- Promotion of allied enterprises (apiculture, sericulture, floriculture, *etc.*) and
- Development of appropriate rural infrastructures by promoting aids to rural crafts

It is therefore necessary to develop effective and strategic land use plans and policy issues in the NER of the country. The policy research issues should include land reforms, market reforms, backward and forward linkages with corporate/plantation agriculture, peoples' institutions on participatory approach mode with traditional knowledge, self-help groups, farm management committee (FMC), shifting cultivation (impact analysis of '*Jhum*' control scheme), medicinal and aromatic plants, *etc.*

#### *Agricultural scenario of NER*

The burning issues in the NER may be depicted in following points:

- Low agricultural productivity leads to hampered food security in the region
- The cultivation practices are age old with poor level of farm management badly affecting the yield of crops
- Severe soil erosion hazards due to inherent soil acidity, unscientific cultivation practices and weak geological formations

- Severe flood hazards in the banks of Brahmaputra and some tributaries
- Over exploitation of forests for livelihood security

By and large, agriculture is traditional. The agricultural productivity is low, irrigation facility almost non-existent in many of the areas and consumption of fertilizer is extremely low in the region. If the present scenario of adoption of agricultural technology continues, it will be difficult to catch up with required rate of productivity to meet the demand of food arising from the growing population.

In the NE states of the country, as whole, agricultural land including fallow is 22.20% (varying between as high as 37.43% in Assam and as low as 4.40% in Arunachal Pradesh) as against 54.47% in India. The fertilizer consumption in the region is low enough *viz.* consumption of NPK (kg ha<sup>-1</sup>) is 130.5 in Manipur, 46.6 in Assam, 29.4 in Tripura and 17.0 in Meghalaya (Patel 2013). NER is endowed with 33% of country's water resources. Due to high rainfall, NER has inherent advantage to exploit rain-water harvesting. However, the rate of harnessing and utilizing irrigation potential has been low since only 11% of net cultivable land is irrigated. Accelerated Irrigation Benefit Program (AIBP) emphasizes exploiting surface irrigation through Minor Irrigation (MI) schemes in NER. Under MI schemes, irrigation potential of 46,500 ha has been created of which 34,300 ha (73.76%) are being utilized. Besides, irrigation potential of 2,93,110 hectares under *Bharat Nirman* is targeted comprising 1,09,140 ha under major and medium irrigation and 1,83,970 ha under MI schemes (Patel 2013). NER has significant amount of unexploited irrigation potential, particularly in the Imphal valley of Manipur and in Tripura. Till recently, about 19% of the total potential of 5.7 lakhs ha is exploited in Assam as against 40% in India. Manipur can attain about 10% of its potential to cover 65,000 ha. Irrigation potential in Tripura can cover 2.81 lakhs ha. Surface irrigation potential in Mizoram, Meghalaya, Nagaland, and Sikkim needs to be exploited since topographical conditions do not favour exploitation of groundwater for irrigation. In

view of high rainfall and fragile top soil, an integrated program for water development and soil management is considered necessary. The program should have appropriate institutional mechanism and should mobilize adequate funds to equitably spread the benefits of irrigation.

The major rice farming systems of NER are (i) direct seeded, rain-fed in upland (on steep slopes), (ii) direct seeded rain-fed on level bench terraces, (iii) transplanted on wet terraces and (iv) transplanted in valley lands. The total rice production of NER is estimated to be around 5.50 Mt with average productivity 1.57 t ha<sup>-1</sup>, which is much below the national average 2.08 t ha<sup>-1</sup> (Pattanayak *et al.* 2006).

As far as the productivity scenario of rice in the NE states is concerned, the in depth report is available with status paper on rice in North East India (Ngachan *et al.* 2009) and in Rice Knowledge Management Portal (RKMP). The rice production scenario of NER showed an increasing trend starting from 35.26 lakh Mt during 1980-81, to 67.18 lakh MT during 2008-09 with area coverage of 30.64 lakh ha to 35.00 lakh ha, respectively. The percentage share of NE India in total rice production of the country stood at alarming low of 6.96 % (2008-09) and average productivity was 1919 kg ha<sup>-1</sup> against the national average of 2 178 kg ha<sup>-1</sup>. Area under rice was maximum in Assam and minimum in Mizoram. Rice production in Mizoram gained momentum as area under the crop increased from 0.15 (2000-01) to 1.47 lakh ha (2008-09). The productivity of rice was highest in Tripura (2586 kg ha<sup>-1</sup>) followed by Manipur (2357 kg ha<sup>-1</sup>) and Nagaland (1994 kg ha<sup>-1</sup>) during 2008-09. Assam registered highest production (41.74 lakh Mt) in 2008-09 sharing 62.18% of the total NE rice production (67.18 lakh Mt) in 2008-09. The share of NE India to total national production of rice was 6.57%, 6.07%, 6.66% and 6.96% in 1980-81, 90-91, 2000-01 and 2008-09 respectively. The state wise growth rates of area, production and yield of rice in NE India revealed that during the period 1997-98 to 2007-08, the area under rice in the region increased marginally while per ha yield increased/decreased significantly. The area expansion as well as yield increases

caused the output to grow at an annual rate of 2.52%. The low productivity growth rate of NE India was due to lack of technological breakthrough in most of the states of the region. Out of the seven states in the NE India, four states showed positive trends and three states negative trends in growth of area under rice. But except Arunachal Pradesh and Nagaland, the growth rates of area in other states of the region were significantly low (less than 1%). It was due to the various restrictions imposed by the respective state Governments to the practice of '*jhum*' cultivation since the late eighties. Rates of growth of production and yield were observed to be positive in all the states except Meghalaya. Mizoram experienced the highest growth rate of rice production and the least being Meghalaya.

The shifting cultivation is one of the common practices followed particularly in the hill areas. Shifting cultivation locally known as '*Jhum*' system has several unique features of the cultivation in hilly areas of north-east India. At present, it covers as much as 14,660 km<sup>2</sup> providing livelihood to 4.44 lakh '*jhumia*' families. The virtues of the system include, a long evolution process over the ages, employs the local knowledge and judgement for efficient management of natural resources. It is a slash and burn method of cultivating an admixture of crops continuously for a couple of years. Use of external inputs is minimal in '*Jhum*' and hence is a model of pure organic farming system. It also uses minimum tillage and less or no inputs besides being an eco-friendly system (Barah 2001). Shifting cultivation is the chief means of livelihood of tribal people in the hilly areas of NE India (Satapathy and Sarma 2002). '*Jhum*', as practiced in the region, is a highly complex farming system with wide variation based on cropping and yield potential. These variants based on ecological and cultural variations in the tribal societies are highly insulated because of topographical barriers.

#### *Land use planning in NER: An overview*

A number of research workers have assessed lands for best possible agricultural planning towards sustainable development in the state of Assam and as well

as other North Eastern states of the country at various scales.

Rice-based cropping system is very much common in the River Island of Majuli, Assam. However, continuous mono-cropping in this area has led to declined productivity. Soil site suitability showed that wheat, potato, cabbage, french bean, tomato, cowpea, pea and rapeseed are highly promising in paddy fallow region because of the favourable soil conditions as well as economic viability (Vadivelu *et al.* 2004) and swamps were suitable for paddy-fish integrated farming (Bhaskar *et al.* 2005). The soils of Jorhat district were suitable for mustard, groundnut, potato, onion, cabbage, peas, french bean, tomato, fodder maize, lucerne, cowpea and banana crops in post *kharif* season (Vadivelu *et al.* 2003; 2005). Soil pH and coarse texture were the major limitations. Whereas, suitability assessment of soils of Brahmaputra valley showed that levee and meandering scar are productive and suitable for growing *ahu* rice and *rabi* crops in post *kharif* season (Walia and Chamuah 1992).

The most profitable cropping pattern in upper Assam is autumn rice (*ahu*) followed by winter rice (*sali*), winter rice-pea, autumn rice-mustard/potato/black gram/vegetables whereas, in lower Assam, autumn rice (*ahu*) followed by winter rice (*sali*), summer rice-wheat, jute-rice-rice (Barthakur *et al.* 1998; Sharma 2002), whereas, Bhowmick *et al.* (1999) studied the farming system in six agro-climatic zones existing in the state *viz.* lower Brahmaputra valley zone, northern bank plain zone, upper Brahmaputra valley zone, Barak valley zone and hill zone. The prevailing farming system in different agro-climatic zones is a mixed type. It is basically a diversified system with dominance of crop activities. Some of the allied activities like sericulture and weaving, apiculture with bee keeping, cane craft, bamboo craft *etc.* under the homestead component will further increase the relative share of net returns and employment.

Being a rain-fed state, 90% of the crops are produced in *kharif* season in Nagaland. Agriculture is one of the significant contributors to the net state domestic product and is the largest employer of the working force in

the state. About 86.14% of the cultivable area in Nagaland is under the traditional *Jhum* and Terrace Rice Cultivation (TRC) system and rest under commercial and other crops (HRD 2004). In *jhum* lands on moderately sloping hills, paddy with short duration varieties like Bhalum-3, 4 and SARS-1, 2 may be grown. In TRC, transplantation of 30-35 days old seedlings of local paddy varieties (*var.* Nagaland special) is recommended. The local varieties of ginger and turmeric may be grown in high hill slopes in ridges/ furrows with mulching. Since, the entire state is hilly; the irrigation in the state is painstaking. To increase production and productivity of crops on hilly terraces, the following improved practices are found economically viable and socially acceptable, *viz.* (i) *jhum* intensification with fallow land management, (ii) Alder based agriculture, (iii) wet terrace rice cultivation (WTRC) with paddy cum fishery and snail culture and (iv) integrated farming system. On hills with variable slope gradients from moderate slope (8-15%) to steep slope (>30%), the fruit crops like banana, papaya, orange and citrus may be grown in bench terraces, half moon terraces and in contour bunds (Sharma *et al.* 2006; NASTEC 2008). Alder based cropping system and *Panikheti* system and *Zabo* farming are quite popular in Nagaland. These indigenous methods are enriched with traditional base of water harvesting and soil fertility management and are sustainable as long as the population pressure is low (Das *et al.* 2012).

In Sikkim, the maize based cropping system rotated with wheat, barley, mustard and intercropped with pulses, finger millet and vegetables or ginger based cropping system, ginger-sweet potato/chilli, ginger-tapioca, ginger-maize/garlic, depicted the best profitable cropping systems in the state (Singh *et al.* 1988). In Meghalaya, land use planning was carried out at various scales *viz.* district, block, watershed and village levels. Different farming systems attempted successfully in the state like developing suitable cropping system in bench terraces, contour bunds and flat lands as agriculture based land use, utilization of watersheds through fodder crop production. Afforestation of grasslands by creating buffer zones around the existing forests, social forestry, fencing

and restriction of coal and sand mining and suitable soil and water conservation measures in gently sloping landscapes of Cherrapunji (Nair *et al.* 2006). Das *et al.* (2014) recommended alternate land use options for Mawryngkneng block of East Khasi Hills district of Meghalaya based on natural resource assessments. Open forest and wastelands with dense scrub are suggested for plantation with multipurpose and fast growing climatically adopted tree species. Intensive cultivation of major crops of the study area is suggested in existing agriculture area with good soil and water conservation practices. Orange and pine apple plantation is suggested in the wastelands with open scrub.

In Tripura drainage, flooding, erosion and water logging are the major soil problems. Coconut, papaya, arecanut, lemon, pepper, ginger, turmeric, banana, pineapples can be grown in well drained, fine loamy soils occurring on gently sloping undulating plains and mounds (Tillas), whereas, betelvine, potato, jute and vegetables can be well grow in poorly drained, clayey soils on very gently sloping floodplains (Bhattacharyya *et al.* 1996).

In Mizoram, Lallianthanga and Sailo (2013) attempted to develop alternate land use plan using remote sensing satellite data (LISS-III and Cartosat-I) for Mamit district. Analysis showed that there is good potential for agricultural/horticultural system. In addition, the available flat lands could provide extensions for taking up other allied agricultural activities such as WRC, pisci-culture and terrace cultivations.

#### *Strategic measures of NER*

The strategic measures for agricultural development may be depicted as follows:

##### (i) *Crop diversification in rice-fallows in Brahmaputra plains*

Introducing micro-irrigation facilities by shallow tube well with pump sets on cooperative basis would be one of the logical solutions towards *rabi* cropping in rice-fallows. Crop rotation with short term pulses (black gram, green gram *etc.*) will append economic benefit to

crop performances reducing the costs of fertilizers and maintaining soil health.

##### (ii) *Rain-fed rice cultivation in hills*

Hill agriculture is always painstaking due to inaccessibility of irrigation water at high altitude and thus is mostly rain-fed. However, high yielding and short duration varieties of rice may be introduced with efficient package of practices by judicious fertilizer recommendations. In case of *ahu-rice*, short term direct seeded breeds may be sown in rain-fed uplands and hills.

##### (iii) *Waste land utilization*

Short term legumes namely, *lucerne*, *glyricidia*, *etc.*, may be grown for maintaining long term soil health of waste lands and at the same time the output may be used as forage crops for feeding the animals.

##### (iv) *Market reforms*

One of the major agriculturally related constraints in NER is the poor accessibility of markets in terms of availability of good quality of agricultural inputs and proper linkages to the farmers. Supply of improved seeds/planting materials/feeds/animals/vaccine/soil testing/agricultural extension/credit/market facilities are of utmost importance. Furthermore, provisions must be held post harvest management of agricultural/horticultural/animal husbandry and fishery products with justified selling prices. There must be the direct linkage of market to the producers for getting higher net profit with rational benefit to cost ratios.

##### (v) *Soil and water conservation measures*

Irrespective of sufficient rainfall and favourable humid climate in the region, it is afraid to state that there is still a gap in the region in efficient water utilization for agriculture, fishery and animal husbandry. Rain water harvesting in earthen dams, small ponds or in structural water harvesting units may be encouraged by the state soil and water conservation departments. Steep slopes in hills are one of the major hurdles towards hampered crop growth. Various terracing practices viz., con-

tour terrace, bench terrace, half moon terrace, *etc.* are efficient measures of soil conservations. Various watershed development programmes may further assist the land managers to implement need based agricultural planning on priority area basis based on soil quality, drainage characteristics, intensity of crop growth and severity of erosion hazards.

(vi) *Promotion of allied enterprises*

The state line department may encourage the farmers by employing themselves in agriculturally allied enterprises, namely, apiculture, rural crafts, sericulture, mushroom production, floriculture, *etc.* as subsidiary sources of income generation.

(vii) *Human resource development*

The stake-holders may be encouraged in participating hands on demonstration/ training programmes, building self-help groups, farm management committee (FMC), *etc.* for dissemination of scientific knowledge and techniques.

(viii) *Livestock development*

Animal husbandry is a sub-sector of agricultural economy and plays a significant role in rural economy by providing gainful employment, particularly to the small and marginal farmers, women and agricultural laborers. Livestock production in Assam is pre-dominantly the endeavor of small holders. Almost 90% of the rural households keep livestock of one species or the other. Livestock farming is practiced traditionally mostly for agricultural operations. Milk production is secondary to agricultural operations. There are hardly any commercial livestock farms in the rural areas although in the periphery of cities and towns a few commercial dairy farms exist. The major constraints hindering the development of animal husbandry in NER are:

1. Acute shortage of feed concentrate and green fodder
2. Absence of quality breeds of animals
3. High animal density is a management deterrent

4. Small land holding size limiting cultivation of fodder
5. Poor perception of the farmers towards livestock production as a viable alternative
6. Recurrence of flood causes high incidence of parasitic disease in ruminants and
7. Lack of stated policy on animal breeding.

The strategic measures may be depicted as follows:

- There is a need to evolve a comprehensive livestock development policy in the state involving the Agricultural University, Department of Agriculture, Department of Industry and the Department of Animal Husbandry and Veterinary.
- Genetic improvement of the indigenous non-descript animals through crossbreeding with superior germplasm.
- Upgrading the indigenous buffaloes through improved breeding of animals of Indian origin.
- Utilization of straws/crop of cereals and food crops with suitable treatment.
- Suitable plan and strategy for cultivation of green fodder in the fallow land.
- Facility for artificial insemination and pregnancy diagnosis at farmers' door needs to be located.
- Timely prophylactic measures and emergency of services for treatment of livestock, and,
- Intensive epidemiological studies of the livestock diseases particularly the infectious diseases should be under taken to plan programme for control and eradication.

The key to better livestock production is the availability of quality animals, quality feed and fodder and effective disease control measures. There should be a comprehensive policy approach to deal with the above key factors. The fallow land needs to be exploited for cultivation of green fodder and the utilization of non-conventional feed resource may augment the feed supply situation.

*NBSS&LUP on land use planning*

The Bureau has developed a mammoth soil resource data base at state levels during soil resource mapping of India. The most recent achievement of the Bureau is to attain district level land use planning (LUP) through development of district wise land management unit by unique combination of soil, land use-land cover and bio-climate using GIS platform followed by incorporation of agricultural production system on it. The decision support system (DSS) has been designed in such a way that alternate land use options as per each management unit appear at sub-divisions, blocks and even at village levels.

In this consequence, there is enough scope to develop state level LUP programme by using the available data sets and maps. State level LUP will have different aspects than district and watershed/village levels. In district level LUP, the incorporation of bio-climate factor may not always be important due to existence of single agro-climatic feature in a district in most of the cases. However, in state level, bio-climate varies from one district to another and hence it is one of the essential factors for land management interventions. Moreover, due attention has to be made in generalization of soil map for a state where the ground truth verification are to be carried out where the observations are lacking to avoid the information gap on soil and site parameters. For state level planning evaluation of productivity potentials for field crops, plantation, pasture and forestry will be more effective. Crop data collected from State Agricultural Research Farms may be used to assess land suitability for crops which may be extrapolated to the similar adjoining areas. This will assist land managers to identify specific zones for crop and horticultural planning, pasture management and conservation of forest covers in the state.

The state level LUP is to be made in consortia mode with state line departments for monitoring LUP activities and their subsequent planning and implementations. The relevant organizations will be:

*State Departments:* The involvement of SLUB is for pro-

viding necessary land use-land cover information at village/block level from land record surveys and as well as constant monitoring of land use planning activities at various phases.

*State Remote Sensing Centre:* The importance of State Remote Sensing Centre is because of supplying necessary remote sensing input on land use-land cover information of the state and for further follow-up actions to be taken in generalization of mapping units for management interventions.

They will act as nodal agencies for supplying information of agricultural production and productivity of the state at districts/blocks/village levels for planning and implementation, as well as in assisting for collection and collation of socio-economic data in relation to identify problems and potentials as and when required and also assisting to identify window areas/ specific zones for improvement in horticulture, agri-silviculture, agro-pastoral, agro-forestry, etc. in the state.

*Methodology for district level land use planning*

The methodology of LUP may be divided into following four phases:

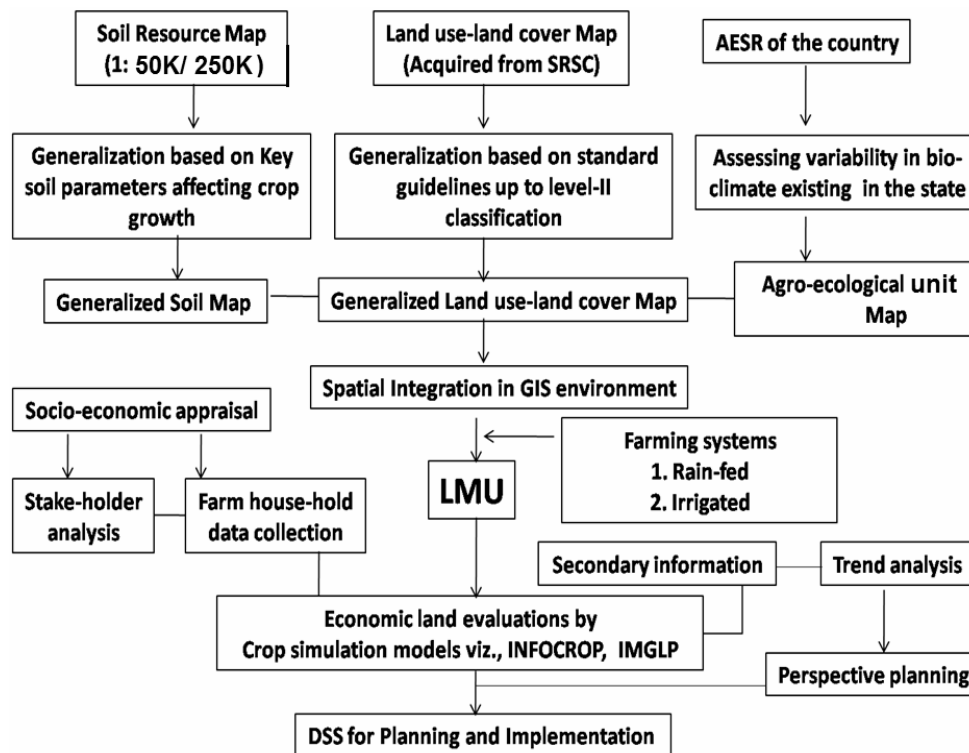
*1<sup>st</sup> Phase:*

- Soil resource data base at district level (1: 50,000 to 1: 250,000 scale) can be used to generalize soil map considering the key features of both dominant and sub-dominant soils on which the crop growth is affected viz. landform, soil depth, surface texture, internal drainage, etc.
- The land use-land cover map of the district can be obtained from the state remote sensing centre. This map has to be further generalized upto level-II land use-land cover classification as per standard guidelines.
- From generalized land use land cover map major land units under agriculture, forest cover, fallow area and land other than agricultural use may be identified which will further help in generating different management units.



- In the district, variability in bio-climate is an essential criterion for interpreting management interventions which may be ascertained by considering various agro-ecological units occurring in the district.

Spatial integration of soil, land use-land cover and agro-ecological unit layers may be performed in GIS platform to obtain land unit map (Fig. 1)



**Fig. 1.** Flow diagram of methodology for district level land use planning

- Secondary agronomic information will be collected from state line departments to identify major farming systems, cropping systems will be the primary components and fishery and animal husbandry will be the subsidiary components.
- The farming system may be broadly categorized to rain-fed and irrigated. In rain-fed farming system, the cropping system may be single or may be integrated with backyard livestock and fishery, whereas, for irrigated farming system may include mixed cropping system, mixed integrated cropping system etc.
- The land management unit map of the district will be obtained after due incorporation of major farming systems existing in the state to the land unit map.
- Each land management unit will represent homogeneous soil and site characteristics occurring under particular land use types and characterized by specific farming systems towards their management interventions.
- Land suitability will be assessed using quantitative methods will be followed *viz.* evaluation of productivity potential. Evaluation of productivity potential of land will help in sectoral identification of specific zones for agriculture, horticulture, pasture and forestry in the district for improvement field crops, plantation and forestry in the district in a spatial mode.

*2<sup>nd</sup> Phase:*

- A comprehensive socio-economic appraisal is required in the state to analyze the current and future land utilization types and identify constraints and potentials towards agricultural productivity of the district.
- Key socio-economic parameters are to be identified on region specific mode for district level land use planning.
- One of the major steps in socio-economic appraisal is stake-holder analysis. In stake-holder analysis, major stake-holders are identified; their interests and level of influence on land use planning activities are measured by conducting meetings, interviewing selected farmers.
- Number and kinds of datasets to be used has to be standardized for state level land use planning. State Agricultural Departments along with KVKs in each district may be identified to take the lead role in carrying out district wise socio-economic appraisal.
- Trend analysis may be an effective tool in assessing the future land use scenario for perspective planning of the state.

*3<sup>rd</sup> Phase:*

- Crop growth models are emerging as new tools for land evaluations to quantify production scenario and to highlight constraints under different land use systems.
- Various crop simulation models may be proposed to be operated for assessing land suitability on static or dynamic resource basis.
- Evaluations of land index by Stories' method or FAO's framework on crop yield estimations are the examples of static methods. In dynamic resource basis, crop simulation models like WOFOST, INFOCROP, DSSAT, *etc.* are used for yield estimation.
- For quantitative economic assessment of lands for evaluation of crop performance, interactive multiple goal linear programming (IMGLP) may be applied.

IMGLP is a part of land use planning and analysis system (LUPAS) in which the objective function are fixed depending up on the policy issues of the concerned area. Sectoral allocation of lands will be possible for various field and plantation crops in the state based on the quantitative economic evaluation of crop performances.

*4<sup>th</sup> Phase:*

- The entire data base may be put to standard softwares, *viz.*, JAVA, MS-ACCESS, *etc.* to build up query form to generate a suitable decision support system for the state for disseminating the suggested action plan for agro technology transfer.
- Stake-holder's interaction meet are to be organized at different phases of work.

*A case study of district level land use planning*

Jorhat district is situated in the upper Brahmaputra plains of Assam covering an area of 2,85,100 ha. Despite richness in natural endowment, the district is among one of backward one in the state. The district suffers from drought situation in summer, severe floods inundating vast plain areas on monsoon as well. Under these circumstances, if resources are not properly developed and managed, the food security in the predominantly agrarian economy will be endangered. The agricultural productivity is low owing to lack of farm mechanization, poor irrigation facility and inadequate consumption of fertilizers. A decreasing trend has been noticed in past five years in the district on acreage, production and productivity in high yielding as well as common varieties of cereals. About 41.9% of the total geographic area of the district is net sown. Paddy is the mainstream cultivation. In parts of Majuli Sub-division and Titabar block paddy is grown thrice a year, *viz. boro* paddy during January to April, *autumn* paddy during Aril to August and *kharif* paddy during August to November. Only 11.3% of the total area is multi-cropped. The demand and supply equation shows that demand for food out strips the production and the gap is increasing over time. It thus, implies the need for policy imperatives for enhancing production by inducting appropriate technol-

ogy and necessary institutional change along with good governance.

The results on district land use planning of Jorhat district showed that the following points may take into consideration:

1. Improvement of irrigation facility through short- and long-term impact of STW (Shallow Tube Well) approach on co-operative basis in rice-fallows for rabi crops.
2. Waste land utilization by short term green manuring.
3. Introduction of improved varieties of *kharif* and *boro* rice with the help of State Agricultural University.
4. Encouraging cultivation of wheat in rabi with emphasis on developing short duration and high yielding variety.
5. Preparation of rain water harvesting structures and identification and management of micro-watershed with the help of Soil and Water Conservation Department.
6. Animal disease forecasting and cross breeding local animals.
7. Cultivation of fodders (napier, alpha-alpha) as livestock feeds.
8. Encouraging producers for integrated paddy-cum-fish particularly in flood prone areas of the district.
9. Post-harvest management of horticultural/animal/fishery products.
10. Micro-irrigation/sprinkler for horticultural crops.
11. Strengthening research-extension-farmer (REF) linkage.
12. Supply of seeds/planting materials/feeds/animals/vaccine/soil testing/agricultural extension/credit/market facilities/market information.
13. Promotion of allied enterprises/activities (bee-keeping, rural crafts, sericulture, mushroom production, floriculture *etc.*).

14. Development of appropriate rural infrastructures and market reforms, and

15. Backward and forward linkages with corporate/plantation agriculture.

### Conclusions

Optimum utilization of available farm level resources with scientific farm mechanization techniques and adequate extension services will certainly elevate the agricultural productivity of the NER quite a many folds. Keeping in view the land-man-animal relationship along with food production *vis-a-vis* consumption scenario, the need of the day is to develop perspective land use strategies as well as monitoring and maintenance of the quality of natural resources.

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