ANALYSIS OF PREVAILING AND POTENTIAL LAND USE SYSTEM AND HUMAN CARRYING CAPACITY OF LAND RESOURCES OF NAKLA UPAZILA FOR SUSTAINABLE DEVELOPMENT

PhD. THESIS

KANIZ AKLIMA SULTANA

DEPARTMENT OF SOIL, WATER AND ENVIRONMENT
UNIVERSITY OF DHAKA
DHAKA-1000, BANGLADESH
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BY

KANIZ AKLIMA SULTANA

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Declaration

I do hereby declare that the submitted thesis entitled "Analysis of Prevailing and Potential Land Use System and Human Carrying Capacity of Land Resources of Nakla Upazila for Sustainable Developemnt" has been composed by me and all the works presented herein are of my own experimental findings. I further declare that this work has not been submitted anywhere for my academic degree, prize or scholarship and not published any where.

(Kaniz Aklima Sultana)

Certificate

Have much pleasure to certify that the research work presented in this dissertation entitled "Analysis of Prevailing and Potential Land Use System and Human Carrying Capacity of Land Resources of Nakla Upazila for Sustainable Developemnt" has been performed by Kaniz Aklima Sultana with land, soil, crop suitability, land use, agroclimate and socio economic data of Nakla Upazila of Sherpur District. She accomplished all sorts of research activities under my supervision and guidance. The part of this dissertation has not been submitted to elsewhere for any degree or diploma. It is further certified that the work presented herewith is original and very suitable for submission for the award of the degree of PhD.

Prof. Dr. S.M. Imamul Huq

Dedicated to
The Freedom Fighters of Our Beloved Country

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Kaniz Aklima Sultana

A thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy

Supervisor : Prof Dr. S. M. Imamul Huq

Previous Degree: Master of Agricultural Systems and Engineering
Asian Institute of Technology
Bangkok, Thailand

Master of Science in Soil Science
University of Dhaka
Dhaka, Bangladesh

Department of Soil, Water and Environment
University of Dhaka
Dhaka-1000, Bangladesh
November 2015

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ABSTRACT

The study was conducted in Nakla Upazila of Sherpur zila, to see the prevailing land use system and potential production capacity of the land resources with an aim to estimate human carrying capacity of the area and to facilitate the formulation of development strategies for the area.

Land and soil properties of the area were extracted from the Land and Soil Resource Utilization Guide of Bangladesh. Crop suitability analyses of the soil groups for socially acceptable crops were conducted using Limiting Condition Principle of FAO. Extents of suitable area for suitable crops were calculated from spatial information of Soil and Landform Map of the area. Income from each crops were calculated using field data and data form Bangladesh Bureau of Statistics. Income, yield, hydrology, crop season and growing period of crops were matched to develop a cropping pattern for highest possible income. Income from livestock, poultry, fishery and labour were calculated using field and BBS data. Standard income and expenditure requirement for the study area were calculated using government estimated income and expenditure data from Bangladesh Bureau of Statistics data and National Nutrition Survey data.

The study indicates that the present population of the area is above the HCC in respect to present income. It has also been found that a remarkable achievement is possible in terms of income through suitable crop selection, recommended fertilizer application and proper crop and soil management resulting an increase in HCC. But if population continues to grow with its present rate it will soon exceed the potential HCC. If population increase with its present rate it will drive the HCC in a venerable stage.To avoid these situation farmers can select high income generating cropping patterns, follow the recommended fertilizer application and crop management practices. Initiative should be taken to develop alternative income generating activities and opportunities such as agrobased industries, small and cottage industries as well as control of population growth. It can be concluded that crop suitability as well as potential income generating capacity of soils can be good indicators of human carrying capacity inany agro-ecosystem.

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LIST OF ACRONYMS

ADB	Asian Development Bank
AEZ	Agroecological Zones
BARC	Bangladesh Agricultural Research Council
BBS	Bangladesh Bureau of Statistics
ºC	Degree Celsius
DAE	Department of Agricultural Extension
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
HCC	Human Carrying Capacity
HIES	Household Income and Expenditure Survey
HYV	High yielding variety
IFAD	International Fund for Agricultural Development
IUCN	International Union for Conservation of Nature and Natural Resources
LGED	Local Govt. and Engineering Depatment
LSRUG	Land and Soil Resource Utilization Guide
MOA	Ministry of Agriculture
MS	Moderately Suitable
NGO	Non Governmental Organization(s)
NPP	Net Primary Productivity
NS	Not suitable
PET	Potential evapotranspiration
S	Suitable
SOFA	The State of Food and Agriculture
SRDI	Soil Resource Development Institute
Tk.	Taka
UNEP	United Nations Environment Program
UNFPA	United Nations Fund for Population Activities
USAID	United States Agency for International Development
WFP	World Food Program

CHAPTER 1
INTRODUCTION

1.1 Background

Bangladesh is located in Southern Asia, between 20°34'and 26°38'latitude North and 88°01' and 92°41'longitude East and covers a total area of 147 570 sq. km. Agriculture is the single most important sector of the economy and is the driving force behind economic growth. It accounts for about 17.22 percent of Gross Domestic Product (GDP) and employs some 45.6% of the labor force (BBS, 2012). As a result, increasing food and agriculture production has always been a major concern of Bangladesh. Since late 1950s, with increasing population, Bangladesh became a perennially food-deficit country. Threats of mass starvation have been felt several times since independence owing to droughts and flooding. Therefore, the overriding objective of agricultural policy and development since independence of Bangladesh has been to achieve self-sufficiency in food-grains particularly in rice. A substantial acceleration in the growth rate of domestic food production has later been observed, yet the majority of the rural population still remains afflicted by malnutrition and semi-starvation. Bangladesh is one of the most densely populated countries of the world. The present population is about 156.6 million. The average density of population is about 1,222 persons per square kilometer (BBS, 2013). The high population density and scanty and stressed resources are the main development constrains of the country.

1.2 Problem Statement:

To meet the needs of the increasing population of the country it is needed to utilize the potential capacity of the resources to get more production and income. Over the past four decades to cope up with the growth of population, pressure on land and soil has tremendously increased in Bangladesh for increasing agricultural/crop production.This hindered expansion of cultivated extent instead intensification was done for increasing crop production using multiple cropping, and application of higher inputs which resulted increase of crop yield per unit of land. Though it is found that there is a trend of remarkable progress in domestic food production, yet the food demand is widened gradually because of faster population growth (Table-1.1, 1.2).

However, meeting the demand with domestic production will be challenging due to declines in availability and quality of natural resources (especially land and water), climate change impacts and soil fertility is declining due to high cropping intensity and imbalanced use of chemical fertilizers. Already land degradation has become a serious problem in Bangladesh. Researchers have identified different kinds of degradation such as erosion, nutrient degradation, salinity, organic matter depletion etc. (Rahman et al., 1999). Of all these causes, ever-increasing population and associated effects have become the major contributing factors for land degradation. As the agro system has its own limitation to supply food, a question that would arise is that Bangladesh could support a population expected to exceed 300 million? Under the circumstances for resource sustainability, management and over all national level planning it would be useful to know how much population can be supported by the land resources. This would require an assessment of carrying capacity as an essential component in the search for sustainable development.

Table 1.1: Foodgrains (rice and wheat) production and availability in Bangladesh

Year	Net domestic production ('000 m.tons)	Private import ('000 m.tons)	Public distribution ('000 m.tons)	Internal procurement ('000 m.tons)	National availability ('000 m.tons)	Import as % of total availability	Per capita Availability (gm/day)
1	2	3	4	5	6=2+3+4-5	7	8
1991-92	16999	0	2345	1016	18328	8.5	444
1995-96	16769	850	1795	422	18992	12.8	430
1998-99	191915	3200	2237	781	23887	23.0	515
1999-00	21918	1234	1900	967	24085	8.7	512
2001-02	22797	1289	1460	1053	24493	7.3	506
2003-04	24151	2480	975	843	26763	10.5	533
2007-08	26201	2916	1329	870	29576	11.7	555
2008-09	28306	2217	2129	1483	31169	9.7	578
2009-10	29239	2899	1961	805	33294	10.4	609
2010-11	30371	3109	2292	462	35310	15.0	641
2011-12	30698	1240	2095	1426	32607	7.0	582
2012-13	30886	1419	2086	1404	32987	5.7	582
2013-14	31377	2137	2220	1439	34295	8.9	598

Note: Net production is estimated after 12% deduction for seed, feed, waste etc.
Source: FPMU: Database on Food Situation, MoFDM, Dhaka.

Table1.2: Production and availability of other food items (1994-2011)

Food Items	Production (millions tons)			Availability (gm/capita/day)		
	1994-95	2004-05	2010-2011	1994-95	2004-05	2010-11*
Potato	1.50	5.95	8.30	32	108	153
Pulses	0.53	0.31	0.72	11	10	13
Oilseed	0.48	0.56	0.84	10	10	15
Vegetables	1.21	6.50	11.19	21	108	207
Fruits	1.41	4.60	3.56	24	68	65
Fish	1.17	2.10	2.89	27	41	53
Meat	0.48	1.06	1.90	11	21	35
Egg (millions)	2400	5623	6078	19**	41**	41

Source: BBS 2011, DAE, DLS, DOF, BARC * Population 148.69 million in 2011, ** per year. (adopted from Kashem and Faroque, 2011)

This requires a model to accurately assess agricultural carrying capacity in specific and to construct sustainable agro-ecosystems. “Future research on agriculture and regional carrying capacities must integrate considerations of the environment and sustainability, rather than relying on more abstract yield growth models” (Harris, 1996).

1.3 Hypothesis

1. A non- selection of best performing crops, use of unsuitable cropping patterns and sub optimal crop and soil management practices have currently lead to low agricultural productivity and low income from land resources and hence low human carrying capacity (HCC).

2. Given consideration on the potential of agro-echo system and selection of suitable crops as per land and its associated resources together with appropriated crop and soil management practices, there would have enormous potential to promote both crop yield, farmers income and hence human carrying capacity.

3. Estimation of human carrying capacity would enable to recognize and develop strategies for improving HCC and to make recommendation to the government of Bangladesh to formulate development strategies and policy intervention to enhance livelihood of the people in Nakla Upazila and in the country.

1.4 Objective

Overall objective of the research is to assess the human carrying (HCC) capacity from the sustainable agricultural production point of view and to construct a model to estimate HCC from the perspective of yield potential of crops and the capacity of land resources as well as income generated from agricultural lands in Nakla Upazila, Bangladesh.

1.5 Specific Objectives

- To study the crop suitability and productivity of the soils.
- To study the potential income generating capacity based on suitable cropping pattern.
- To study the income and demand situation based on potential land use in 2014.
- To study the income and demand situation based on potential land use in 2050.
- To assess the human carrying capacity on the basis of overall potential income of the area for 2014.
- To assess the human carrying capacity on the basis of overall potential income of the area for 2050.
- To develop an agricultural model for carrying capacity analysis.

1.6 Scope and Limitations and Assumption of the Study

The main focus of the analysis was to generate maximum possible income generated from agro-based production of the land and to compute the maximum number of individuals it can support.Hence, income on the basis of local agricultural production in relation to population growth would be evaluated on a perspective focused on ecological limits. In this study, the economy is considered to remain agro based as it is now, and assume there would be no dramatic change in production technology. It is also assumed that the area of the agricultural land will be remaining same. Food requirement in general means the requirement of balanced food with carbohydrate, protein, vitamin and minerals in appropriate proportions of each. Bangladesh government's recommended standard per capita food grain requirement of 502 gram/day for rural, is taken as the standard for HCC calculation. Land productivity, land-use composition and minimum/subsistence income per capita were considered to influence HCC. Available soil and land characteristic data generated by Soil Resource Development Institute (SRDI) were used to calculate suitable area for crops. Soil and land form map at 1:50,000 scale of SRDI was detailed enough for Upazila level crop suitability area calculation. Research findings of Bangladesh Agricultural Research Councilon production capacity of different crop varieties were used to calculate potential production capacity of the crops of different soil group of the research area. Income from suitable crops was calculated usinginput cost and harvest time market pricedata of Bangladesh Bureau of Statistics.

CHAPTER 2
LITERATURE REVIEW

2.1 Carrying Capacity: Concept and Definition

Ehrlich (1994) defined carrying capacity of an ecosystem as the "maximum population size of a species that an area can support without reducing its ability to support the same species in the future". The definition of carrying capacity is controversial. According to Hayden (1975) carrying capacity, is "the maximum ability of an environment to continuously provide subsistence at the level of culture provided by the inhabitants". Hayden's definition refers 'K' as an "ability of the environment" – i.e. a measure of resources. It has also been defined as the maximum population density theoretically supportable by the habitat (Hardesty,1977; Ricklefs,1973). Although the second definition appears to be more commonly used, its acceptance rests on a faith that resource availability is directly limiting the population - K *is* real and this is how one measures it (Moore, 1983).

The carrying capacityconcept attempts to address a fundamental question of what population size cana given environment support? The focus of carrying capacity is mainly on human population, although environments must ultimately support plants and animals on which humans ultimately rely. Therefore, physical characteristics of the environment play amajor role in determining carrying capacity. Precipitation, temperature, length of growing season, elevation, soil quality, slope and other physical factors come into play. If only physical factors were involved, calculating carrying capacity for humans would be relatively easy. However, cultural factors and levels of human knowledge and technology are equally important in determining carrying capacity.

2.2 Food Security – As an Indicator of Carrying Capacity

Food security can be considered as another way of looking at carrying capacity. It has been a topic of considerable attention during 1970s, since then, thirty definitions of it have been identified by Maxwell and Frankenberger (1992). Initially, the tendency was to highlight the issue only from the supply point of view. In 1979 the World Food Programme Report (WFPR) conceptualized food security, equating it with an "assurance of supplies and a balanced supply-demand situation of stable foods in the international market "(Malaku, 1997). One of the most influential definitions of food security is the "access by all people at all times to enough food for an active and healthy life (World Bank,1986)."

However, global food availability does not ensure food security to any particular country because famine-affected people in African countries cannot access what is available in the world market, as the economies of these countries, in general, cannot generate the foreign currency needed to purchase food from the world market, or from another country.
One way to break the vicious circle of poverty and food insecurity is to increase agricultural productivity, particularly where gains can be achieved by small farmers who are often among the poorest. As the world's population and living standards rise, the need for food will grow, and the availability of under-utilized arable land will continue to decrease. Therefore, it is important to intensify production on land with agricultural

potential currently in use, using sustainable methods, rather than to encroach on land that is only marginally suitable for cultivation.

In Bangladesh the national-level food-grain availability problems are lessening in good harvest years, but the country's very low nutrition indicators reflect the acute food insecurity at household and individual level. Using a combination of poverty line and calorie requirement norm of 2,122, around 15.6 per cent and 10.8 per cent households (HIES 2005) are estimated to be in extreme food insecure and moderate food insecure group respectively. The average daily per capita caloric intake in Bangladesh is 2,318.3 kcal, while the average for developing countries is 2,628 and in developed countries is 3,377 (USAID, 2004, HIES 2010).

2.3 Food Grain and Calorie Requirement

Per capita calorie requirement and the food-grain production capacity of an area can be other measures of human carrying capacity of land resources.In Bangladesh, food-grain primarily refers to rice, wheat, maize, oats rye and barley. Assessment of daily per capita food-grain requirement is important for production planning, overall food management, and food budgeting. Since 1985-86 the national planners have used taking 453.6 g as the per capita daily food-grain requirement (Mondal, 2004). Foodgrain requirement is strongly related to per capita calorie requirement, and hence per capita calorie intake can be a measure of poverty level.

Household Income and Expenditure Survey (HIES) of Bangladesh Bureau of Statistics calculated 222.22 g as the average national daily per capita intake of rice and wheat, and daily per capita calorie intake is 2318.3 kcal (Table 2.1. 2.2) (BBS, 2010).

Table 2.1: Trend in Average per capita per day intake of food (gm).

Survey Year	National	Rural	Urban
1	2	3	4
2010	222.22	222.33	219.0
2005	210.62	210.29	211.58
2000	198.47	199.7	193.49

Table 2.2: Daily per capita calorie intake in Bangladesh (kcl)

Survey year	**National**	**Rural**	**Urban**
2010	2318.3	2344.26	2244.5
2005	2238.5	2253.2	2193.8
2000	2240.3	2263.2	2150.0
1995-96	2254.0	2263.1	2208.1

BBS, Report of HIES, 2010

2.4 Carrying Capacity and Technology

Conventional wisdom suggests that because of technology and trade, human carrying capacity is infinitely expandable and therefore virtually irrelevant to demography and development planning (Rees, 1996). In contrast, Harris, (1996) argues that ecological carrying capacity remains the fundamental basis for demographic accounting. A fundamental question for ecological economics is whether remaining stocks of natural capital are adequate to sustain the anticipated load of the human economy into the next century. Even in the best of circumstances, technological innovation does not increase carrying capacity per se but only the efficiency of resource use. In theory, shifting to more energy- and material-efficient technologies should enable a defined environment to support a given population at a higher material standard, or a higher population at the same material standard, thereby seeming to increase carrying capacity. However, in either case, the best we could hope for in an increasingly open global economy would be to maintain total human load constant in the vicinity of carrying capacity—the latter would still ultimately be limiting.

In practice, the steady gains in efficiency throughout the post-world-war period had been accompanied by steadily increasing per capita and aggregate consumption. It seems that efficiency gains may actually work against conservation through the price and income effects of technological savings. As Saunders (1992) noted, this counter intuitive hypothesis has been the focus of considerable controversy. He tested it using neoclassical growth theory and found that energy efficiency gains might well increase aggregate energy consumption by making energy cheaper and by stimulating economic growth, which further "pulls up" energy use. How might this work? If a firm saves money by switching to more energy- and material efficient manufacturing processes, it will be able to raise wages, increase dividends, or lower prices, which can lead to increased net consumption by workers, shareholders, or consumers respectively. These behavioral responses to changes in prices and income are referred to as the "rebound effects" by economists (Jaccard, 1991). Similarly, technology-induced money savings by individuals are usually redirected to alternative forms of consumption, canceling some or all of the initial potential benefit to the environment (Hannon, 1975). To the extent that such mechanisms contribute to increased aggregate material consumption and accelerated stock depletion, they indirectly reduce carrying capacity.

More generally, however, technology can directly reduce carrying capacity while creating the illusion of increasing it! We often use technology to increase the short-term energy and material flux through exploited ecosystems. This seems to enhance systems productivity, while permanently eroding the resource base. For example, the effectiveness of electronic fish-finding devices and high-tech catching technology has overwhelmed the reproductive capacity of fish stocks; energy-subsidized intensive agriculture may be more productive than low-input practices in the short term, but it also increases the rate of soil and water depletion. The net effect is to create unsustainable dependencies on enhanced material flows (the technologies involved are often based on nonrenewable resources) while reducing long term carrying capacity (Rees 1996)

In both the scientific and lay communities the current perspective is that food production must be increased in order to support a growing human population (Postel, 2001; Bongaarts, 1994; Waggoner, 1994; Brundtland, 1993; Baron, 1992; Anifowoshe, 1990; Brown, 1989; Robson, 1981). Young (1999) noted that current UN population projections predict that the population of developing countries will rise to about eight billion by 2025 and nine billion by 2050. He then asserted, “It is widely recognized that massive agricultural development will essentially be needed to feed this added population.”

2.5 Biophysical vs. Social Carrying Capacity

The long-term sustainable carrying capacity for the human species on the Earth varies with resource availability as well as culture and level of economic development (Daily and Ehrlich, 1992). There are two measures of human carrying capacity: the biophysical carrying capacity and the social carrying capacity (Ehrlich, 1994). The biophysical carrying capacity is a measure of the maximum number of population that the planet can support by its resources at a given level of technology. The social carrying capacity is the sustainable biophysical carrying capacity within a given social organization, including patterns of consumption and trade (Ehrlich, 1994). The social carrying capacity therefore must be less than the biophysical as it will account for quality of life and estimate the number of humans that can be sustainably supported at a given standard of living (Gigi, 2002). To estimate a sustainable human population, it is important to select or assume a standard of living or level of consumption by the population. Here is the importance of introducing social issues. For a socially stable situation it is important to meet the basic human needs such as food, water, clothing and shelter. Therefore, a socially sustainable carrying capacity must be based on a level of consumption that meets basic human needs of food, water and space as well as provides opportunity to enjoy socio-political rights, health, education and well-being (Daily and Ehrlich, 1995).

2.6 Dangers of Exceeding the Carrying Capacity

The basic resources of the planet, such as land, water, energy and biota are inherently limited (Pimentel et al, 1999). With the increase in population limited resource of the planet are being exploited increasingly. According to the United Nations Environment Programme (UNEP), in 1990, approximately 850 million hectares had some degree of land degradation, representing more than 28 per cent of the region’s land area. There are 350 million hectares of degraded lands in China, India, and Pakistan, and most of which are grasslands. About 1,320 million people or 39 per cent of the region’s populations, live in areas prone to drought and desertification. According to ADB(2001), the major causes and extent of land degradation in the Asia-Pacific region are: agricultural activities (212 million hectares), vegetation removal (310 million hectares), over-exploitation (46 million hectares), over-grazing (280 million hectares) and industrial activities (1 million hectares).Many regions of the world are facing extreme land constraints. Therefore, majority of all future increases in crop production will have to come from higher output per hectare (Harris, 1996). While yield outputs may be met through high-input agriculture, it may not be considered sustainable from an ecological perspective. As every land and soil has its limits to produce crop, exploiting lands for very high food production beyond its limits may temporarily or irreversibly degrade the soil. There is evidence of salinization of soils from over irrigation which vastly reduced and ultimately destroyed the carrying capacity of much of the land (Rhoades, 1982). Further the problems of soil compaction, loss of organic matter, loss of water and nutrient retention and biological activity in soils, as well as related matters of lake, river and groundwater pollution, and increasing levels of pesticide resistant pest species will create environmental constraint for agriculture. Thus once the carrying capacity of the land is exceeded, disaster results and the quality of the land deteriorates and its ability to support plant, animal and human population declines, unless deterioration can be stopped by effective land reclamation and management practice. Preservation of carrying capacity, which is inherently limited, is fundamental for the present and future well-being of any nation. Over-taxing the carryingcapacitydestroys, sometimes irremediably, the long- term ability of the resource base to sustain those who depend on it. Population growth indubitably increases the pressure on the environment (Abernethy, 2001)

2.7 Estimating Sustainable Carrying Capacity

Many authors (Cohen, 1995; Meyer & Ausubel, 1999) have attempted to develop model of human carrying capacity to accurately estimate the size of the human population that the earth can support. But there is not much agreement regarding appropriate models of human carryingCapacity **(**Cohen, 1995a). Attention has been paid to changes in technology, culture, economics and other factors posited as variables that are part and parcel of the human carrying capacity (Cohen, 1995).New technologies and resources have allowed for increasing crop yields as well as other innovations that have ultimately served to increase human food availability (Cohen, 1995; Meyer & Ausubel, 1999) as well as the human carrying capacity. Besides this selection of one or several of the limited basic resources such as land, water, energy and biota, as a metric for measuring the carrying capacity of the planet is a common method of estimating global human carrying capacity. The use of a single resource or combination of limited resources to estimate carrying capacity includes measuring how much of that resource is available globally. For instance, global wheat harvest can be estimated based on land area and water availability, then used to compute the number of humans that can be supported (Gigi 2002). Technological changes for energy and food production also have impact on resulting carrying capacity estimate. Sir Thomas Malthus, did not account for the technological change in agriculture leading to increased food production, which in turn allowed for greater population growth than estimated. In some carrying capacity estimation/calculation future technological change has taken into account and in other calculations/estimations the level of technological development assumes to remain same. Another way of analyzing carrying capacity of the earth is to calculate its net primary productivity (NPP). This is the total amount of solar energy converted intobiochemical energy through plant photosynthesis, minus the energy needed by those plants for their own life processes. It represents the total food resource on earth (Bryant, 2002).

2.7.1 Estimating carrying capacity from energy inputs

Energy availability is a useful matrix resource that can be used to estimate carrying capacity because it can account for many different resources (Gigi, 2002).Solar energy is the driving force of the Earth's ecosystems (Gigi, 2002). We all the human being, plants, trees, food crops, and animals directly or indirectly require energy from the sun (Pimentel, et al 1994). The balance of energy consumption and production can be used to measure the number of humans that can be supported by the planet in a sustainable manner. The total amount of energy input by the sun to the earth is finite and can be estimated (Pimentel, et al 1994).

When that energy is divided up among the entire earth ecosystem, it is possible to estimate at a given level of consumption, how many humans can be supported on the earth. The resulting estimate is a sustainable number because it does not rely on non-renewable energy sources (Pimentel, et al 1994). Currently, about 50% of all solar energy captured by photosynthesis is used by humans (Pimentel, et al 1994). On its own, solar energy cannot support the present human population without supplementation by non-renewable energy sources, such as fossil fuels (Pimentel, et al 1994).

2.7.2 Estimation of carrying capacity by land area

Land area can be used in different ways to estimate carrying capacity, either as a matrix for other resource uses or as a measure itself (Gigi 2002). The simplest way of using land area to compute carrying capacity is to presume a population density for a given area, and compute the total number of people that the region should support. Another method, the ecological footprint concept, uses land area as a matrix for a combination of other factors. Ecological footprint takes many different resource uses and measures them by the equivalent amount of land area required for their production. The ecological footprint describes how much land is necessary to support a given population in terms of energy, food, and other resources at a certain level of consumption. The result is that developed/rich countries with high levels of resource consumption have much larger footprints than they actually occupy (Rees, 1996).

2.7.3 Estimating carrying capacity from food production

Estimates of carrying capacity using food as a matrix determine the total amount of food that can be produced globally and divided by estimated per capita food consumption. The result is a global population that can be supported at a given level of subsistence assuming that food is equitably distributed around the globe. More complex methods consider changes in crop yield with increased technology, food distribution, varied world diets, and other resource supply, such as fossil fuels (Gigi 2002).

Estimates of carrying capacity vary with method of calculation, conditions assumed, metric used and standard of living. Professor Joel Cohen summarized estimates of human carrying capacity of the Earth beginning with estimates made as early as the 1600’s (Cohen, 1995a). He considered range of population carrying capacities with a low estimate and a high estimate, and the median of the low to high estimates ranged from 7.7 to 12 billion people (Cohen, 1995a). Table 2.3 is the summary of the estimates of Cohen’s book that do consider social sustainability as well as estimates from other sources.

The estimates vary from 0.5 to 14 billion depending on the metric used and the standard of living and technological improvements that are assumed. The medians of the low and high estimates provide a range from 2.1 to 5.0 billion people. With the current Earth population estimated to be 6.1 billion people as UNFPA 2001 population estimate the median range of sustainable carrying capacity estimates suggests that the Earth’s population be reduced in order to be sustainable (Gigi 2002).

Table 2.3 Estimates of socially sustainable carrying capacity

Source	Low estimate (billions)	High estimate (billions)	Basis of Estimation	Assumptions
Palmer 1999	9	9	Ecological footprint	Standard of living lower than US current (1 hectare per person) and improvements in energy efficiency, food production, pollution and preservation of biodiversity.
Rees 1996	4.3	6	Ecological footprint	4.3 billion computed using 13 billion ha of land and 3 ha/person, which is current European standard of living. 6 billion using ecological footprint of current N. American standards.
Pimentel et al. 1994†	1	3	Energy	Based on use of renewable solar energy. 1-2 billion in relative prosperity - based on use of renewable solar energy. 3 billion – Adequate food supply.
Daily et al. 1994	1.5	2	Energy	"Optimum" population estimates with consumption significantly less than current US standard.
Pimentel et al. 1999	2	2	Energy	Optimal human population enjoying a relatively high standard of living.
Smil 1994†	10	11	Food	Eliminate disparity in energy consumption and food production technology between developed and un-developed world. A shift in the Western consumptive mindset toward a sustainable diet and pattern of life would be necessary.
Brown & Kane 1994	2.5	10	Food	Estimate depends on level of consumption. The lower estimate corresponds to US level of consumption and the highest estimate to the level of people in India. Based on an estimated world grain harvest of 2.1 billion tons in 2030.
Hulett 1970†	1	1	Multiple factors	Based on food, wood products and nonrenewable resources. At US standard of living with current (1970) technology and production.
Westing 1981†	2	3.9	Multiple factors	Based on total land area, cultivated land area, forest land area, cereals (grain) and wood assuming technology and politics of 1975 and at affluent (average of world's 27 richest nations) to austere (average of 43 nations of average wealth based on GNP) standards of living.
Heilig 1993†	12	14	NPP*	Based on NPP for biophysical capacity, accounting for increased technology and "with ecological care and in the framework of an economically sound and socially-just development policy"
Whittaker & Likens 1975†	2	7	NPP*	2-3 billion could be supported at a "more frugal European standard" if "steady-state systems of resource use and cycling were established". 5-7 billion with most human beings living as peasants.
Ehrlich 1971†	0.5	1.2	Unknown	Best estimate of what the planet can maintain over long period of time

Source: Cohen (1995)

2.7.3.1 Crop production potential and carrying capacity of land

Crop production potential assessment is an important issue for food security and carrying capacity. It describes the upper limit for the production of crops under given agro-climatic and soil conditions on a specific level of agricultural technology. Various methods have been used to calculate this upper limit. A most detailed and mature methodology under sustainable agricultural practice is agro-ecological zones (AEZ) approach, which was originally developed by FAO (FAO/UNDP 1988). Land productivity and suitability assessment on the basis of land and soil characteristics is also another locally used method for yield prediction.

2.7.3.2 Agro-ecological zoning

Agro-ecological zones (AEZ) are closely related to the suitability of growing crops. Agro-ecological zoning, as applied by FAO, defines zones on the basis of combinations of soil, landform and climatic characteristics. The particular parameters used in the definition focus attention on the climatic and edaphic requirements of crops and on the management systems under which the crops are grown. Each zone has a similar combination of constraints and potential for land use, and serves as a focus for the targeting of recommendations designed to improve the existing land use situation, either through increasing production or by limiting land degradation. The essential elements in defining an agro-ecological zone are the growing period, temperature regime and soil mapping unit.

In Bangladesh, 30 agro-ecological zones have been defined. These zones can however be grouped into 20 major physiographic units. Each of the zones has specific characteristics which are related mainly to topography and soil type (UNDP/FAO, 1988).

2.7.3.3 Land productivity and suitability

FAO (1976) defined land as an area of the earth surface, the characteristics of which embrace all reasonably stable, or predictably cyclic, attributes of the biosphere vertically above and below this area including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal populations, and the results of past and present human activity, to extent that these attributes exert a significant influence on present and future uses of the land. Land characteristics are the attributes of land that can be measured or estimated. These are measurable properties of the physical environment related to land use.

The suitability of a given piece of land is its natural ability to support a specific purpose. According to the FAO methodology (1976), this is strongly related to the “land qualities” such as erosion resistance, water availability, and flood hazard that are not measurable.

Land suitability assessment for agriculture is meant to evaluate the ability of a piece of land to provide optimal ecological requirements of a certain crop variety. In other words, assessing the capability of land in enabling optimum crop development and maximum productivity. This evaluation needs a specification of the respective crop requirements and calibrating them with the terrain and soil parameters. As such suitability can be used as an indicator of potential crop productivity of the soils. Productivity of a land can be converted into potential income generating capacity which again can be used to estimate human carrying capacity of the area.

CHAPTER 3
MATERIALS AND METHODS

Considerable attempts have been made by many researchers to develop model of human carrying capacity for estimating capacity of the earth to support human population. But, because of the conceptual difference and complexity of human nature and requirement there is not much agreement among them regarding appropriate model of HCC **(**Cohen 1995a). Factors like technology, culture and economics have made the calculation difficult. Nevertheless, researchers have attempted to estimate carrying capacity by using one or more of the limited basic resources, such as land, water, energy and biota, of the earth. The use of a single resource or combination of limited resources to estimate carrying capacity includes measuring how much of that resource is available globally. Estimates of carrying capacity vary with method of calculation, conditions assumed, metric used and standard of living.

Affect of technological changes for energy and food production on carrying capacity assessment is a matter of big controversy. Some says it increases the HCC with no bound, some says it only increases the efficiency of resources use and others says through rebound effect (Jaccard, 1991) it indirectly reduce carrying capacity.

Different authors, to estimate HCC, have used energy inputs, land area, ecological footprint, food production etc. as a metrics. But, all these methods have some limitation as such being criticized by others. In energy input estimation of renewable energy, the solar energy, has been used for HCC calculation. Where as the present population cannot live without supplementation by non-renewable energy sources. In this study, a new approach of estimating human carrying capacity through developing potential income generating capacity of the land using income as an index were examined (Figure 3.1).

3.1 Selection of Research Area

Agrobased economy was the main basis to select the area. The accessibility, a variety of land use with different soil and crop husbandry practices, availability of soil, land use, agroclimate and socioeconomic data were also considered for the selection.

3.2 Secondary Data Collection

Soil, land, land use, agro-climatic and socioeconomic data and maps were collected from different government and non-governmental organizations such as Soil Resource Development Institute, Bangladesh Agricultural Research Council, Department of Agricultural Extension, Meteorological Department and Bangladesh Bureau of Statistics.

<u>Soil Resources Development Institute:</u> This institute has developed a nationwide database on land and soil resources of the country. 'Land and soil resource utilization guide' (LSRUG) is an Upazila wise report/database of this institute, which contains soil and land use information and a soil and landform map at 1:50,000 scales. The report contains physical and chemical properties of the identified soils of the Upazila. It also has a guideline to assess crop suitability of the soils. The report and map data of the study area

were collected from this institute to study crop suitability of different soils and to estimate maximum possible production and income generating capacity of the soils of the area.

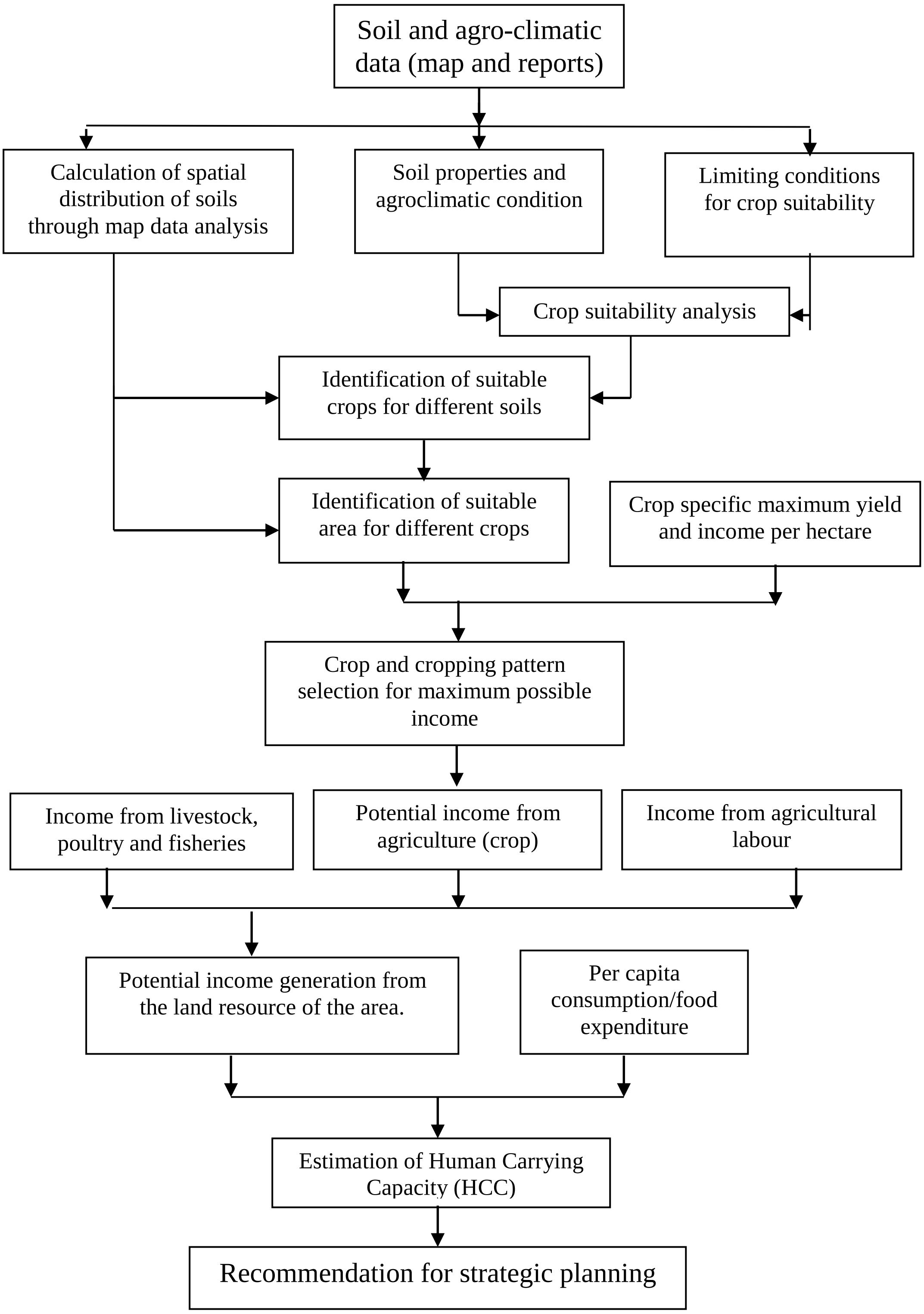


Figure 3.1 Research framework (Part 1)

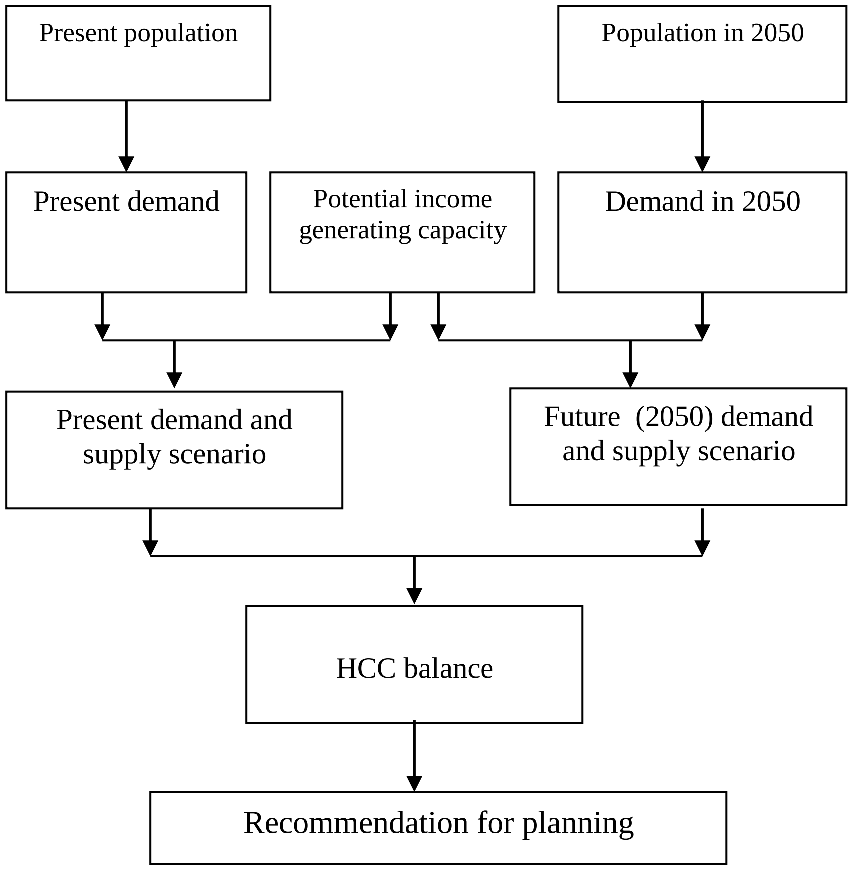


Figure 3.1Researchframework (Part 2)

Bangladesh Agricultural Research Council (BARC): This is a national institute which coordinates the research activities of all agricultural research institutes of the country. "Fertilizer Recommendation Guide" prepared by this institute contains recommendations of fertilizer for the highest possible yield of selected crops. The recommendations were made based on long-term research work of different agricultural research Institutes of the country.

Meteorological department: Agroclimatic data of the area were collected from both BARC and Meteorological department.

Bangladesh Bureau of Statistics: Labour, fisheries, livestock and poultry, and other socioeconomic data of the research area were collected from the department of Bureau of Statistics and department of Agricultural Extension.

3.3 Field Survey

A field survey was carried out to study the present land use of the area. The primary data of infrastructure, markets, bank, socially acceptable crops, time of planting and harvesting of crops, farm gate price at harvest, and production costs of some crops, homestead garden were collected during the field survey. Livestock and poultry data were collected from the local agricultural extension office.

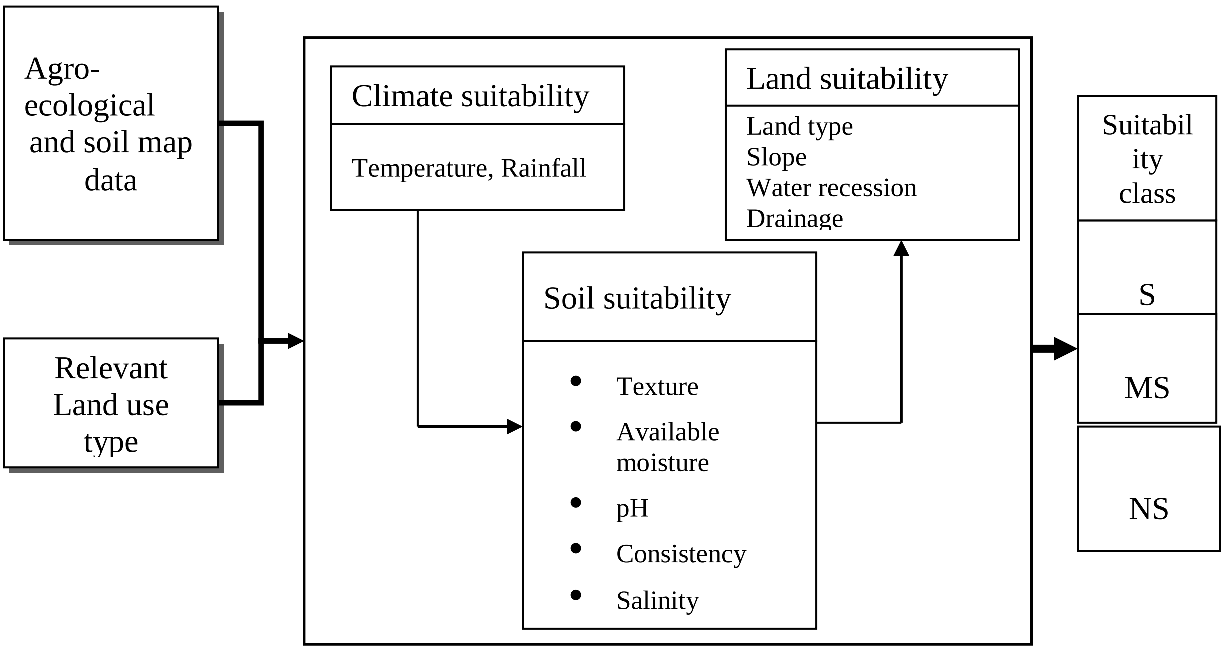
Soils samples were collected from 93 locations of from where samples were collected during 2001 by Soil Resource Development Institute for Upazila Nirdeshika. The samples were analyzed in the laboratory to study the changes in soil pH, organic matter status and nutrient status of the area from 2001 to 2014.

3.4 Soil Identification and Area Calculation

Soil groups of the area were identified from the soil data of LSRUG of SRDI. The spatial distribution of soil groups and land types were calculated from the Soil and Landform map at 1:50,000 scales. Soil properties required for crop suitability analysis were studied, identified and extracted for each soil groups from the LSRUG report. Only the topsoilproperties, 0-15 cm, were considered for this study.

3.5 Assessment of Crop Suitability

Based on limiting condition principals, recommended by FAO, SRDI has developed a crop suitability assessment methodology under Bangladesh conditions (Figure 3.2). Crop suitability assessment was conducted using SRDI model (Appendix B-1). For each land utilization type following nine land and soil qualities were considered by SRDI: Land type, relief, drainage, water recession conditions, texture, consistence, water supplying capacity, soil reaction and salinity. As the soils of the area were non-saline and the land use type was considered under irrigated condition, salinity and water supplying capacity were not included in suitability analysis of the study.



Note: S= Suitable, MS= Moderately suitable and NS= Not suitable

Figure 3.2 Crop suitability assessment

On the basis of relevant parameters, crops have been classified as suitable, moderately suitable and not suitable for a particular soil (Appendix B-2). Agroclimatic suitability of the crops was assessed using AEZ report and agroclimatic data of the area.

3.6 Calculation of Income

Income of the area was calculated for both present and potential land use. Total potential income includes potential income from agriculture (crop), income from livestock, poultry, fisheries and agricultural labour. Total present income includes income from present land use, income from livestock, poultry, fisheries and agricultural labour (Figure 3.3).

Calculation of total potential income (TIpo)

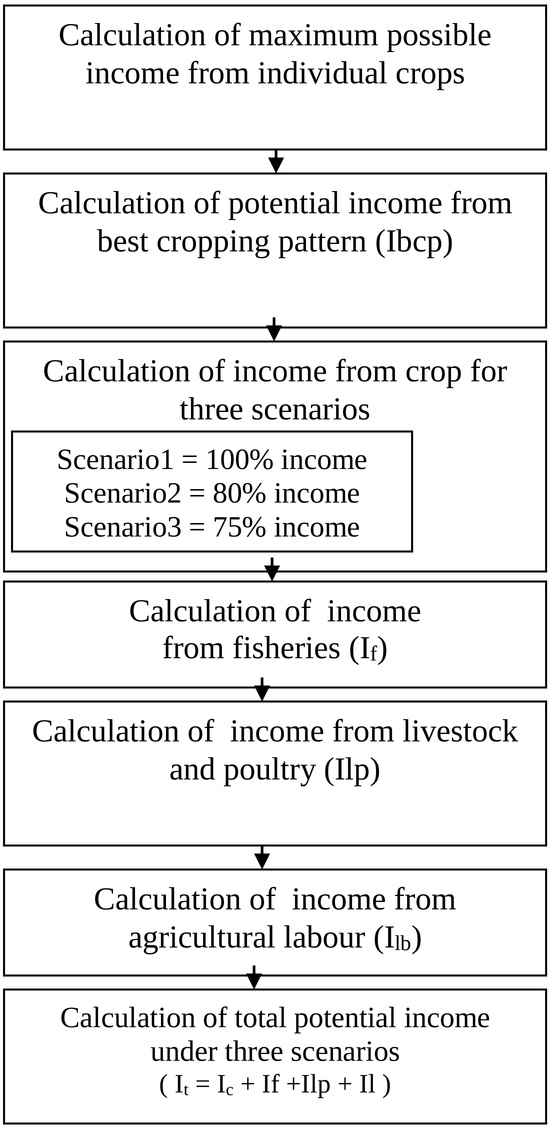


Figure 3.3 Flow diagram for calculation of total potential

3.6.1 Calculation of total potential income

The total potential income was calculated by adding income from all possible sources, i.e. land resources, livestock and poultry, and fisheries. The total potential income was calculated using the following formulae (Eq. 1).

Total potential income (TIpo) = Ibcp + If + Ilp + Il ……………………………..(Eq 1)

Ibcp = Income from best cropping pattern
If = Income from fisheries
Ilp = Income from livestock and poultry
Il = Income from labour sources

3.6.1.1 Income from potential land use

Crop suitability of soils indicated the productivity and crop yield capacity of soil resources. Maximum possible income generated from the soils by utilizing the soil resources in full capacity without degradation, was considered as potential income.

After suitability analysis maximum possible production of each crop from each soil groups were calculated. Total production of a particular crop in a particular soil was then converted into total income. Here yield level mentioned in the BARC Fertilizer Recommendation Guide was taken as the standard for yield calculation. The identified suitable crops have different growing length and growing seasons. Therefore, to calculate the best possible income from a soil for a year needs to develop best possible cropping pattern.

3.6.1.1.1Calculation of maximum possible income from individual crop

Income per hectare for a specific crop was calculated using maximum possible yield per hectare, production cost and market price at harvest time. Production cost and market price per ton of crops were calculated using field and BBS (2003) data (Table 3.1). Yield for high resource base mentioned in the BARC Fertilizer Recommendation Guide was taken as the standard maximum yield for each crop. Total income for a specific crop for each soil group was then calculated using the following formulae (Eq. 2).

Crop specific total Income = profit x production/ha x area of the soil group---------(eq-2)
(Tk*.) (Tk./t) (t/ha) (ha)

Table 3.1 Maximum possible income from individual crops in Nakla Upazila

Rabi vegetable	**Yield** t/ha	**Price** Tk t^{-1}	**Production cost** Tk t^{-1}	**Profit** Tk t^{-1}	**Income (10^6)** Tk/ ha
Cauliflower	40.0	9000	3024	5976	0.239
Cabbage	100.0	7500	2535	4965	0.4965
Carrot	20.0	18000	8100	9900	0.198
Tomato	80.0	10500	4431	6069	0.48552
Bottle Gourd (Lau)	23.0	5000	835	4165	0.95795
Lady's Finger	9.0	7960	2801.92	5158.08	0.04642272
Red Amaranth (Lal Shak)	30.0	6000	660	3540	0.1602
Spinach (Palong Shak)	35.0	4750	570	4180	0.1463
Snake Gourd (Chichinga)	10.0	7637	1160.824	6476.176	0.06476176
Stripe Gourd (Jhinga)	12.0	9828	1493.856	8334.144	0.100009728
Bitter Gourd (Karala)	16.0	30500	4880	25620	0.40992
Brinjal	65.0	11500	1805.5	9694.5	0.6301425
Rabi crop					
Wheat	4.5	10280	3752.2	6527.8	0.0293751
Potato	32.0	15500	4479.5	11020.5	0.352656
Chilli (dry)	2.0	68639	26837.849	41801.151	0.083602302
Mustard	1.8	18090	4612.95	13477.05	0.02425869
Maize	6.5	10000	3030	6970	0.045305
Groundnut	3.2	23590	8846.25	14743.75	0.047180
Boro HYV	6.0	10025	3829.55	6195.45	0.0371727
Boro local	3.5	8880	4013.76	4866.24	0.01703184
Kharif 1 vegetables					
Stripe Gourd (Jhinga)	20.0	9828	1493.856	8334.144	0.16668288
Snake Gourd (Chichinga)	10.0	7637	1160.824	6476.176	0.06476176
Teasle Gourd(kakrol)	18.0	7637	1244.831	6392.169	0.115059042
Bitter Gourd (Karala)	16.0	12320	1971.2	10348.8	0.1655808
Cucumber	16.0	10000	1450	8550	0.136800
Red Amaranth (Lal shak)	30.0	6000	660	5340	0.1602
Stem Amaranth (data)	30.0	15000	1650	13350	400500
Kharif 2 Vegetables					
Red Amaranth (Lal shak)	30.0	6000	660	5340	0.1602
Radish	80.0	3750	761.25	2988.75	0.2391
Bean	1.3	11000	3916	7084	0.0092092
Kharif 1 and 2 crop					
T* Aman HYV (Paddy)	4.5	10410	5090.49	5319.51	0.023937795
T* Aman LIV (Paddy)	3.5	11005	5997.725	5007.275	0.0175254625
B* Aman (Paddy)	2.5	30000	13050	16950	0.042375
T* Aus HYV (Paddy)	4.5	9890	4598.85	5291.15	0.023810175
B* Aus local (Paddy)	2.5	8880	4164.72	4715.28	0.0117882
Jute, Tossa	4.5	21570	4206.15	17363.85	0.078137325
Jute, local	3.5	20500	4202.5	16297.5	57041.25

Note *- T= Transplant, B=Broadcast

3.6.1.1.2Cropping pattern development and selection of best cropping pattern for maximum income

After selection of suitable crops for all the soil groups, crops were grouped based on three growing seasons, namely rabi, kharif 1 and kharif 2. On the basis of crop length and growing season possible combination of suitable crops, the cropping pattern, were developed (Figure 3.4). Total income from these cropping pattern were calculated by adding calculated income from individual crops and subsequently cropping pattern with highest income were selected for the study. Marketing facility, social acceptability, farmers choice and capability were also taken into consideration to develop alternative cropping pattern.Moderately suitable crops were also incorporated in the cropping pattern where there were no suitable crops for a particular soil. In such case, production level was considered as 30 percent less than the suitable production level.

Potential income from land was calculated under three scenarios. In scenario 1, hundred percent income from the land resources were taken into consideration. But in practice 100 percent management efficiency is not possible at the field level cultivation. Therefore, a second scenario was developed with 20 percent less income in terms of management efficiency. A third scenario was developed with 50 percent income loss for a 10 year cycle of natural calamities due to EL Nino effect, i.e. 5 percent annual income loss in addition to scenario2 resulting an overall annual income loss of 25 percent.

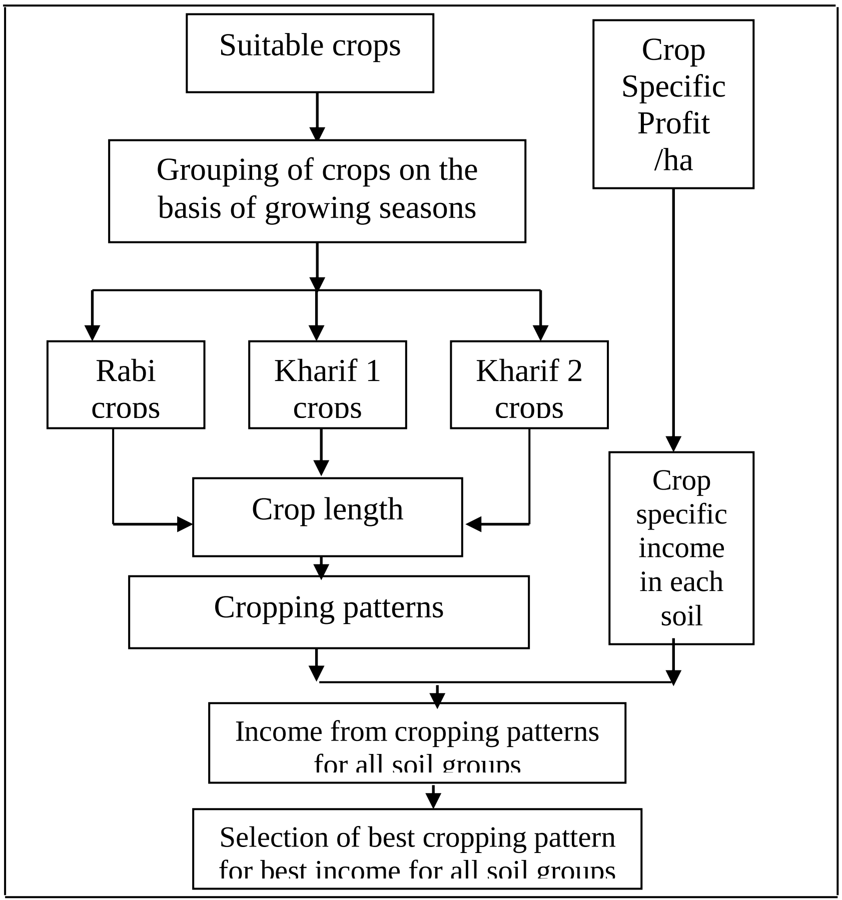


Figure 3.4 Cropping pattern selection

3.6.1.2 Income generation from other agricultural sectors

As income from the land resources was taken as the index of HCC in this study, income generated directly or indirectly from the land resources such as livestock, poultry, fishery and agricultural labour were also taken into account to calculate the total income from the land resources. Calculated present income from these sectors were added to both present and potential income from crop production, which were used as a base for calculation of present and potential HCC of the area.

3.6.1.2.1Calculation of income from fisheries

Area of Nakla Upazila is 12.82% of the Sherpur Zila. As the data on fisheries sector of the research area was not available 12.82% of the total income of Sherpur Zila on this sector was considered as the income from fisheries-sector of the study area. The total catch of the Zila was multiplied by average fish price as gathered from field data.

3.6.1.2.2Calculation of income from livestock and poultry

Production, price and cost of production of livestock and poultry were gathered from the local agricultural extension office during field survey. As per field data, the production cost was 50 percent of the gross income. Estimated income of hides and skin was 50 percent and bones, hoofs and horns was 10.98 percent of the total income from livestock (Census of Agriculture, 2008, Sherpur). No cost of production for bones, hoofs and horns was calculated. These field data were used to calculate the total income from livestock and poultry of the study area.

3.6.1.2.3Calculation of income from agricultural labour household

To get the monthly total income from the agricultural labour sector of the study area, total number of agricultural household, number of earner per household, daily wage rate and monthly available working days were taken into account. These all data were collected from field and Bangladesh Bureau of Statistics. The following equation (Eq. 3) was used to calculate the income from labour sector of the area.

$$Li = Nhh \times Ne \times Wr \times Ad \qquad \text{(Eq. 3)}$$

Here, Li = Total monthly income from agricultural labour
Nhh = number of household
Ne = number of earner
Wr= Daily wage rate
Ad= Number of available working days per month.

3.7 Calculation of Expenditure

3.7.1 Estimated consumption expenditure (basic need expenditure)

To calculate the carrying capacity government estimated consumption expenditure was taken into account. Estimated consumption expenditure was shared between the items of basic needs, (a) food and beverage, (b) cloth and footwear, (c) housing and house rent, (d) fuel and lighting, (e) household effects and (f) miscellaneous (Table 3.2, 3.3).

Table 3.2 Share of components on total consumption expenditure

Residence	**Per capita consumption expenditure Tk/month**	Share of Components of Consumption Expenditure					
		Food & beverage	**Cloth & footwear**	**Housing & h-rent**	**Fuel/lighting**	**Household effects**	**Misc.**
2010							
National	2491	54.81	4.95	9.95	5.63	1.68	22.98
Rural	2122	58.74	5.12	7.29	6.06	1.85	20.94
Urban	3526	48.19	4.67	14.41	4.89	1.40	26.43

Residence	**Per capita consumption expenditure Tk/month**	**Food & beverage**	**Cloth & footwear**	**Housing & h-rent**	**Fuel/lighting**	**Household effects**	**Misc.**
2005							
National	1325	53.81	5.51	12.25	5.98	2.05	20.37
Rural	1281	58.54	5.54	9.77	6.10	1.80	18.22
Urban	1848	45.17	5.48	16.78	5.76	2.49	24.29

Residence	**Per capita consumption expenditure Tk/month**	**Food & beverage**	**Cloth & footwear**	**Housing & h-rent**	**Fuel/lighting**	**Household effects**	**Misc.**
2000							
National	1008	54.60	6.28	9.00	6.81	1.41	20.32
Rural	862	59.29	6.53	5.70	7.19	1.22	18.23
Urban	1583	44.55	5.73	16.05	6.00	1.81	24.80

(BBS, HIES 2010)

3.3Per Capita Percentage Share of Food Expenditure for Major Food Items

Food item	National			Rural			Urban		
	2010	**2005**	**2000**	**2010**	**2005**	**2000**	**2010**	**2005**	**2000**
01	02	03	04	05	06	07	08	09	10
Total food expen.	1340	713	559	1232	672	511	1636	835	706
% of total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Cereals	35.95	39.00	38.02	39.62	42.25	41.23	28.41	31.30	28.87
Pulses	2.35	2.65	2.92	2.32	2.39	2.79	3.00	3.28	3.29
Fish	13.71	12.24	12.48	12.74	11.46	12.06	15.71	14.11	13.66
Meat &eggs	10.31	8.51	8.02	8.61	7.64	6.97	13.80	10.56	11.01
Vegeatables	7.79	8.38	9.21	7.98	8.34	9.44	7.40	8.48	8.57
Milk & milk product	3.02	3.74	3.95	2.74	3.46	3.62	3.58	4.41	4.89
Edible oil	4.35	4.25	3.71	4.26	4.07	3.62	4.53	4.67	3.97
Condim/Spices	9.99	7.52	7.13	10.54	7.18	7.22	8.85	8.31	6.87
Fruits	4.08	3.23	2.97	23.49	2.97	2.57	5.29	3.83	4.10
Sugar/Gur	1.06	1.56	1,34	1.04	1.54	1.29	1.12	1.62	1.49
Beverage	0.73	0.68	1.97	0.51	0.45	1.57	1.18	1.21	3.10
Miscellaneous	5.67	8.25	8.29	6.15	8.25	7.62	6.38	8.23	10.18

BBS, HIES 2010

3.8 Calculation of Human Carrying Capacity

Carrying capacity is defined as the capacity of an ecosystem, which could maintain its components and their availability, productivity, adaptability, and capacity of renewal (IUCN/UNEP/WWF, 1991). There are many ways to calculate carrying capacity of an ecosystem. In this study income of land resources was considered as the main determinant of carrying capacity, termed as human carrying capacity (HCC).

Human carrying capacity was calculated by dividing the total income of the area by estimated per capita expenditure. Potential income from the crop production was considered as the main source of income. On the other hand, present income from livestock, labour and fisheries was taken into account in the computation of total income. As the aim of the study was to compute the human carrying capacity for providing the basic needs, only consumption expenditure was taken into consideration. The following equation was therefore used to calculate the HCC.

$$HCC = \frac{\text{Total income}}{\text{Per capita expenditure}} \qquad \text{(Eq. 5)}$$

3.9 Characteristics of the Study Area

3.9.1 General Descriptions

The physiography of Bangladesh is characterized by two distinctive features: a broad deltaic plain subject to frequent flooding, and a small hilly region crossed by swiftly flowing rivers. Roughly, 80 percent of the landmass is made up of fertile alluvial lowlands called the Bangladesh Plain.

The study area is the Nakla Upazilla, which is located at the central northern part of the country comprising Sherpur district (Figure 3.5). About 80% of the area is covered by the Brahmaputra and Jamuna floodplains. Most of these areas are routinely flooded during the monsoon season. The area lies between approximately 24˚ 53□ and 25º 02□ North latitude and 90º 07□ and 90˚ 16□ East longitude covering an area of 174 sq. km. This Upazilla is bordered by Nalitabari Upazila in the north, Phulpur and Haluaghat Upazila of Mymensingh district in the east, Mymensingh Sadar and Jamalpur sadar district in the south and Sherpur upazilla Sadar in the west.

Figure 3.5: Map of the research area

3.9.2 Population

According to the census of 2011 the total population of Nakla Upazila is 1,97,373. Itwas 162,065 according to 1991 census. In 1974 and 1981 the population was 112,737 and 135,065 respectively (BBS, 1993), which represents a 2.17 percent increase of population from 1991 to 2011, 2.8 percent increase from 1974 to 1981 and 2.1 percent from 1981 to 1991.

3.9.3 Communications

Communications system of this Upazilla is moderately developed. An all-weather metalled road links the Upazilla (Sadar) Headquarter (HQ) with Sherpur district (Sadar) Headquarter. All the Unions under the Upazila are connected with Upazila HQ (Sadar) by fair-weather unmetalled road. There are 230 km of metalled road, 110 km partially (partly surfaced border road) metalled road and 225 km of unmetalled road in this Upazilla. There is no railway communications in this Upazila. The old Brahmaputra river in the south of the Upazila flows from west to east in which boats can provide transportation in the monsoon.

3.9.4 Climate

Nakla Upazilla has a pronounced tropical monsoon climate. Out of six seasons of Bangladesh three seasons are dominant in the area. The south-west monsoon season lasts from May to August. About 92% of the annual rainfall occurs during May - October. The cool dry winter season lasts from November to February. In the winter season the average rainfall is 59 mm which is much lower than the evaporation. FromNovember to April, the rate of rainfall is lower than 75 mm (Figure. 3.6). Occasional rain occurs during the transitional period, preceding and following the monsoon period. March and April are summer or pre-monsoon period. During this period, the humidity is very low and temperature is very high (Table 3.4).

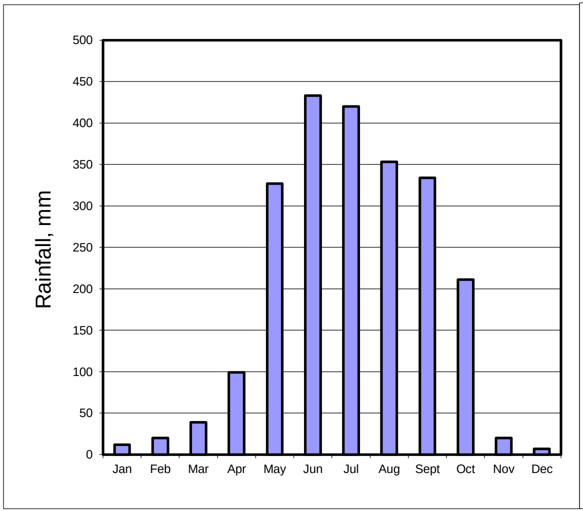


Figure 3.6: Monthly rainfall

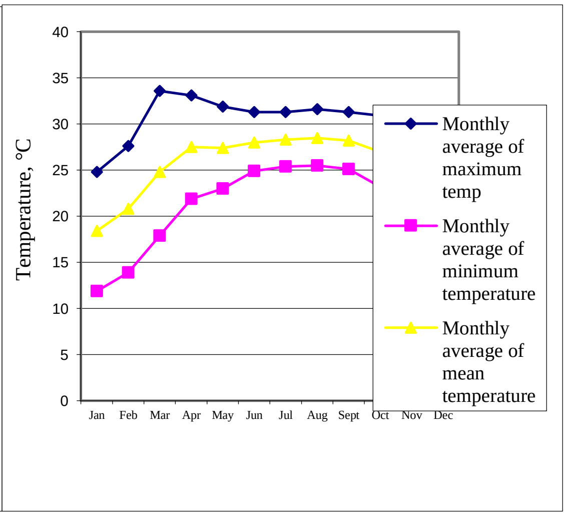


Figure 3.7: Monthly mean, minimum and maximum temperature

The monthly average minimum temperature in December and January is around 12.-13ºC (Figure 4.3, Appendix A-2). The maximum temperatures are experienced in the month of April and May. The maximum temperature rises to 42.2ºC in this period. During January or February, extreme min. temperature of around 4.4ºC is experienced.

Table 3.4: Average seasonal rainfall

Seasons	Average cumulative rainfall in mm
Rabi (November-February)	59
Pre-Kharif (March-May)	465
Kharif (June-October)	1,751

(Source: SRDI, 2003)

3.9.5 Agroecological Region

In Bangladesh, regulatory factors of climate such as, length of growing season, number of dry days, excess moisture in the kharif humid period, occurrence days of maximum temperature, occurrence days of minimum temperature and potential evapotranspiration (PET) are considered when defining different agroclimatic zones. In order to ensure high yield of a crop, planners must consider the constraints in different agroecological regions.

The agroclimatic zones are identified in Bangladesh on the basis of four regulatory factors associated with rainfall and temperature.

a. average length of pre-kharif period when rainfed soil moisture supply is intermittent and uncertain.

b. Average length of the rainfed kharif and rabi growing periods.

c. Average number of days in a year with minimum temperature below 15ºC and certain other temperature limits important for major rabi crops.

d. Average number of days in a year with maximum summer temperature higher than 40ºC, *i.e.* when evapotranspiration reaches high level and crop may be damaged by drought.

Entire area of Nakla upazila belongs to Agroclimatic Code K6 p4 where pre-kharif transition period exists from 24th March to 8th May with a standard deviation on the beginning date of 5-25 days. Average transition period (pre-kharif dry) is 40-50 days out of which 24-30 are dry days (Table 4.3, 4.4). Kharif growing period is from 3rd May to 14th December, and standard deviation on the beginning date of 10-20 days. Average kharif growing period is 220-230 days. Kharif humid period lasts from 17th May to 21st October, with an average length is 140 to 170 days. Excess moisture (moisture above potential evapotranspiration) in kharif humid period is 800-2000 mm. Rabi growing season begins on 21st October and ends on 2nd March with a standard deviation of the beginning date of 15-30 days and average length of 120- 145 days. Territory of this Upazila belongs to two thermal zones: T4 e1 and T4 e2; Lines demarcating these two thermal zones are drawn on the Soil and Land Type Map. Areas covered by T4 thermal zone: In rabi growing period, minimum temperature of below 15ºC occurs from 29 to 17 February (average 70-90 days) and minimum temperature below 17.5ºC occurs from 15 November to 9 March (Average 105 – 120 days). Number of days below 10ºC prevails for about 15-25 days. In extreme temperature zone (e1) the maximum temperature of more than 40ºC in pre-kharif growing period occurs not more than 1-2 days in a year.In extreme temperature zone (e2) maximum temperature of more than 40°C in pre-kharif growing period occurs not more than 1-2 days in a year.Table 3.5 and 3.6 Show kharif growing periods and thermal zones. Crop suitability rating on the basis of agroecoclimates, land and soil characteristics are given in the Appendix B.

Table-3.5: Growing periods based on moisture condition

Zone Sym-bol	**Transition periods**				**Kharif growing periods**			**Kharif humid periods**			**Rabi growing periods**		
	Pre-Kha-rif days	**Trans-ition period**	**SD (days range)**	**Period (P) dry days**	**Days**	**Peri-Od**	**SD (days range)**	**Days**	**Peri-od**	**Excess mois-ture**	**Days**	**Peri-od**	**SD (days range)**
K6/p4	40-50	24 March -8 May	2-25	24-32	220-230	3 May-14 Dec	10-30	140 - 170	17 May-21 Oct	800-2000	120-145	21 oct-2 Mar	15-30

Note: SD for standard deviation

Table-3.6: Thermal zones characteristics of the area

Zone Symbols	**Cool period-Winter/Rabi growing period (Nov/Dec- Feb/Mar)**									**Hot period-summer/pre-kharif transition period**
	MINIMUM TEMPERATURE				**MEAN TEMPERATURE**				**Occurrence (days) of min. temp less than 10C**	**Occurrence (days) of max. temp less than 40°C**
	Less than 15°C		**Less than 17.5°C**		**Less than 20°C**		**Less than 22.5°C**			
	Days	**Period**	**Days**	**Period**	**Days**	**Period**	**Days**	**Period**		
T4 e1	70-90	29 Nov - 17 Feb	105-120 15Nov-9Mar	40-70	9Dec-3Feb	90-110	19Nov-27Feb	15-25	15-25	0.0-0.5 (Av. not more than 1-2 days in a year)
T4 e2	70-90	29 Nov - 17 Feb	105-12015Nov-9Mar	40-70	9Dec-3Feb	90-110	19Nov-27Feb	15-25	15-25	0.5- 0.5 (Av. not more than 1-2 days in a year)

(FAO/UNDP, 1988)

3.9.6 Physiography

Three physiographic units were recognized in the Nakla Upazila namely: (1) Piedmont plain (2) Old Brahmaputra Floodplain and (3) Active Brahmaputra Floodplain. They occupy around 1.7%, 79.8%, 6.5%, and 3.5% of the Upazila respectively. However, 8.5 percent area occupy homesteads, water bodies and other infrastructure.

1. Piedmont plain: This physiographic unit extends over 298 ha which is 1.7% of the Upazila. The landscape is nearly level to gently undulating ridges and basins. Highland ridges are above the normal flood level occurring during the rainy season. In the rainy season, lowland ridges are generally shallowly to moderately deeply flooded, whereas basins are moderately deeply to deeply flooded.

2. Old Brahmaputra Floodplain: This unit extends over 13,854 ha which is about 79.8% of the Upazila. The landscape includes nearly level to gently undulating ridges and basins. Highland ridges are above the normal flood level occurring during the rainy season. In the rainy season, ridges are generally shallowly to moderately deeply flooded, whereas basins are moderately deeply to deeply flooded.

3. Active Brahmaputra Piedmont Plain: This physiographic unit occupies a gently undulating ridges and newly formed charlandarea, lower silted up river and canals. In the rainy season, ridges are generally shallowly to moderately deeply flooded, whereas charlands (sandy island) are moderately deeply to deeply flooded.

3.9.7 Water Resources

Rivers, ditches, canals, lakes and ponds are main sources of surface water in the Nakla Upazila. Old Brahmaputra and Doshani river flow from west to east of the upazila. In the dry season the flow of water in the rivers are very low which affects the country boat to ply but the small-scale irrigation is possible to the nearby fields. The Bhugai river flows near the northern margin of the Upazila. It almost dries in the dry season. This Upazila is endowed with many beels (basin) and ponds. Rushnakushi, Pekua, Kursha, Dublakuri, Madidanga and Bardubi beels are some prominent beels in the area. Some dead canals are also scattered in the area out of them Sutanuti is mentionable. These beels and canals can be reconstructed to conserve irrigation water and for fish cultivations. There are 240 ponds in the area within households or market place which are generally used for traditional fish cultivation and household purpose. Ground water is another source, which can be tapped carefully for irrigation purposes.

3.9.8 Irrigation

Utilizing all available devices, area under irrigation in Nakla Upazila has reached 8,105 ha (BBS, 2003) Boro is the main irrigated crop. There are a lot of scopes to bring more lands into cultivation under irrigation. The irrigated area can also be extended by using surface water along with ground water. The dead canals, swamp and basins are needed to be reconstructed and connected by constructing new canals from river to extend an irrigated area considerably.

3.9.9 Present Landuse of Nakla Upazila

About 88% of the total area is cultivated lands. Out of net cultivated area of 13,564 ha, temporary crops occupy an area around 13,267 ha, and area 267 ha is under permanent crops. Around 66.87% area is under irrigated crops.Rice and jute are grown on seasonally flooded and wet lands in the kahrif growing period. Aus and transplant Aman rice are the main crops. Dryland crops like wheat and pulses are grown on lands that have fast drainage quickly enough and have soils with good moisture retaining capacity during dry winter season. However, where low-lying areas and lands remains flooded throughout the year or where soils are impermeable and there is irrigation, Boro rice is grown in the dry season. In the pre-monsoon and early monsoon or kharif-I period Aus varieties rice crops dominate along with jute and broadcast (deepwater) Aman.

3.9.10 Socio-Economic Conditions

The economy of Nakla Upazila is mainly agrobased. Out of 48,776households of the Upazila 46,379 are male headed and 2,397 are female headed (BBS, 2008) (Appendix A-1). The literacy rate is 38.44% (7yr+) (BBS, 2012).Of the total land area, 84.98% percent is the net cropped area that produces variety of crops of local and HYV rice, wheat, jute, mustard, potato, pulses, different kinds of vegetables and others. Various fruits like banana, mango, blackberry, coconut, betelnut, jackfruit, palm, pomello, papaya, jujube (boroi), star apple, ataphol etc. are grown in the homestead gardens. These homestead gardens are mainly operated by women.

Besides crops, livestock and fishery are also some sources of household income. Varieties of fish are caught from rivers, tributary channels and basins. The popular fresh water fishes comprise of Rui, Catla, Marigel, Kalabaus, Chital, Boal, Aiir, Pangas,Gazar, Saul, Pabda, Koi, Shing, Phali, Tengra,, Bele etc. Besides, newly introduced exotic varieties of fishes are Tilapia, Nilotica, Silver carp. Grass Carp etc.

There is no forest area in Nakla Upazila. The total area comprises 18,909 agricultural labour households that included households with no operated area (Table 3.7).

Table 3.7 Agricultural labour holdings classified by size

Items	**All holdings**	**Non farm household**			**F a r m h o l d I n g s**					
					Small				**Medium**	**Large**
		With no operated Area	With no cultivated area	With .01-.04 acre cultivated area	.05-.49 Acre	0.5-0.99 acre	1.0-1.49 acre	1.5-2.49 acre	2.5-7.49 Acre	7.5+ acre
Number of total holding of the area	48776	30	16083	1791	7477	6078	5360	5570	4136	253
No. of agricultural labour house holds	18909	18	9490	929	3764	2730	1053	649	263	13

(BBS, 2008)

Landholder less than 0.01acreare treated as landless and 0.01-0.04acreare treated as marginal respectively. A farm holding having an operated area of 0.05-0.49 acre of land, with a minimum of .05 acre as cultivated land is considered as small farm holding (Table 4.5). In the Upazila, non-agricultural activities are at a negligible state. The Small holder Agricultural Improvement Project is working there to develop locally feasible income generating activities with the inter linkage and partnership among Department of Agricultural Extension (DAE), Local Govt. and Engineering Department (LGED), Sonali Bank and selected NGO (BEES) with the assistance of IFAD (DAE, 2004).

CHAPTER 4
RESULT AND DISCUSSION

4.1 Land Resources and Crop Suitability

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4.1.1 Soil properties

Considering soil from its land use point of view, similarities in parent material, having similar physical, physico-chemical, chemical properties and land use potential, total 21 soil groups were identified in the area among which 13 were basic soil groups and 8 were land type phases of the soil groups (Table 5.2). These soil groups were extended up to 15,431 ha of the area.

4.1.1.1 Land type

Level and duration of inundation of land is the primary determinant for land use planning. Crop selection, cropping pattern and cropping intensity of a given location are largely dependent on this factor. The study area comprises mainly highland, medium highland, medium lowland and low land (Table 4.1, 4.2, Figure 4.1). About 36 percent of the agricultural lands were high land which was suitable for all crops under irrigated conditions subject to suitability of other soil and land conditions. In medium highland, all kinds of paddy, jute and rabi dryland crops and in medium lowlands and low lands only boro and deep water aman paddy were found to be suitable if other conditions were suitable.

Table 4.1 Area and percentage distribution of different land type.

Land type	Flood Level	Flooding Duration	Area ha	Percentage
Highland	Above Flood Level	-	5499	36
Medium Highland	Up to 90 cm	>2 weeks	5007	32
Medium Lowland	90-180 cm	Flood season	4110	27
Lowland	180-275 cm	Flood season	815	5
Total: (Excluding homestead and water bodies)			15431	100

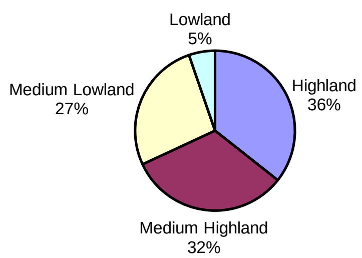

Figure 4.1: Land type distribution in Nakla Upazila

Table 4.2 Land type, soil groups and their soil properties in Nakla Upazila.

soil group	Area ha	Land type	Relief	Water recession after rainy season	Drainage	Soil texture	Soil consistence	Plant available moisture	Soil reaction
Ramnagar	30	HL	NL	VE	ID	Lo	Fr	M	SAc to MAc
Pritimpasha	89	MHL	NL	E	PD	Lo/CL	Fr	M	MAc
Nalitabari	179	MLL	NL	Ne	PD	CL/Cl	Fi	L	SAc
Nakla	964	HL	NL	VE	MWD	SL	Fr	L	SAc
Sherpur	2506	HL	NL	VE	MWD	Lo	Fr	M	MAc
Sonatola HL	1999	HL	NL	VE	ID/ PD	Lo	Fr	H	MAc
Sonatola MHL	2221	MHL	NL	E	ID/PD	Lo	Fr	H	MAc
Silmondi MHL	1151	MHL	NL	E	PD	Lo/CL	Fr	M	MAc
Silmondi MLL	284	MLL	NL	Ne	PD	Lo/CL	Fr	M	MAc
Ghatail MHL	984	MHL	NL	E	PD	CL/Cl	Fi	L	MAc
Ghatail MLL	2069	MLL	NL	Ne	PD	CL/Cl	Fi	L	MAc
Balina MLL	709	MLL	NL	VL	VPD	Cl	Fi	-	N
Balina LL	508	LL	NL	VL	VPD	Cl	Fi	-	N
Melandoho	483	MHL	NL	E	PD	SL/L	Fr	H	MAc
Dhamrai	270	MLL	NL	Nel	PD	L/CL	Fr	M	MAl
Brahmaputra silty alluvium MHL	34	MHL	NL	E	PD	Lo	Fr	M	MAl
Brahmaputra silty alluvium MLL	400	MLL	NL	E	PD	Lo	Fr	M	MAl
Brahmaputra silty alluvium LL	123	LL	NL	L	PD	Lo	Fr	M	MAl
Brahmaputra sandy alluvium MHL	45	MHL	NL	E	PD	S	Ls	L	MAl
Brahmaputra sandy alluvium MLL	199	MLL	NL	E	PD	S	Ls	L	MAl
Brahmaputra sandy alluviumLL	184	LL	NL	L	PD	S	Ls	L	MAl

Note: HL= High land, MHL = Medium high land, MLL = Medium low land, LL = Low land, NL = Nearly level, S = Sandy, SL = Sandy loam, Lo = Loam, CL = Clay loam and Cl = Clay, ID= Imperfectly drained, PD= Poorly drained, MWD= Moderately well drained, VPD= Very poorly drained, SAc=Severely acid, MAc=Mildly acid, N=Neutral, MAl=Mildly alkaline, VE=Very early, E=Early, Ne=Neutral, L=Late, VL=Very late, M= Medium, H=High, L=Low, Fr= Friable, Fi= Firm, Ls=Loose

4.1.1.2 Water recession

Depending on time and period of recession of freestanding water, after rainy season, lands are classified into five classes namely, very early, early, normal, late and very late. Time of land preparation and sowing of rabi crops mainly depend on the condition of water recession after rains or floods. The studied area comprises 35.64 percent very early, 36.33 percent early and 18.15 percent neutral water recession (Figure 4.2). Out of the selected suitable crops 90 percent was found to be suitable in areas with very early water recession condition and some of which were suitable for both very early and early recession conditions, 81 percent of the total crops was found to be suitable in early water recession condition. For neutral condition, 33 percent of the crops were suitable and 48 percent were found to be moderately suitable. Twenty four percent of the crops were found to be suitable and 19 percent moderately suitable in land with late water recession condition. For very late condition the only suitable crop was found to be boro paddy.

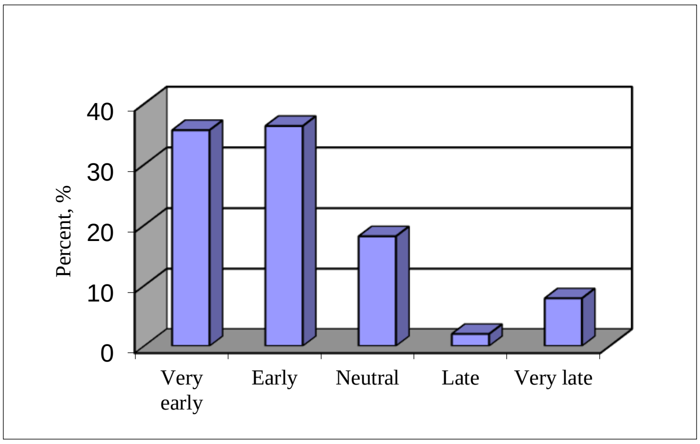

Figure 4.2 Percent extent of water recession condition in Nakla Upazila.

4.1.1.3 Texture

Texture is one of the most important characteristics of the soils which influence other soil properties of great significance for land use and management such as organic matter content, native fertility, moisture content nutrient capacity, cation exchange and buffer capacity and permeability. Generally, soils having loamy texture are better suited for a wider variety of crops and produce higher yield more economically than other soils (SRDI 2003).

About 55 percent of the study area has loamy soil (Figure 4.3), which was favorable for 91 percent of the selected crops. Almost all the selected crops were suitable for the area with clay loam soils and 62 percent of the crops were found to be moderately suitable to clay soils.

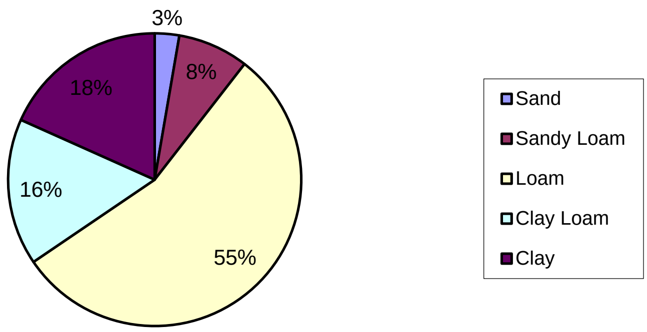

Figure 4.3 Percent texture distribution in the lands of the study area.

4.1.1.4 Consistence

Consistency reflects soil's resistance to breaking under varying moisture conditions. Three types of soils based on consistence were found in the study area namely friable, firm and loose, of which a large area was found to be of friable consistence. The area consist 68.4 percent friable, 28.83 percent firm and 2.77 percent loose consistency. Except paddy, 85.7 percent of the selected crops were suitable in friable soils (Figure 4.4), where as 23.8 percent and 42.85 percent crops were found to be suitable and moderately suitable in firm soils, respectively. Paddy is suitable in firm soils and moderately suitable in friable soils. Consistence of Brahmaputra sandy alluvium soils were found to be loose which were not suitable for any crop.

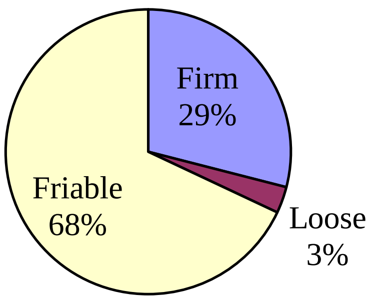

Figure 4.4 Percentage consistence distribution of the soils in Nakla Upazila

4.1.1.5 Drainage

The area showed an expedient drainage condition for the crops (Table 4.3). About 70 percent of the area consisted both imperfect and poorly-drained soils where most of the paddy were found suitable. About 92 percent of the area covered with moderately well-drained to poorly-drained soils where rabi crops and rabi vegetables were found suitable. Very poorly drained soils covered about 8 percent of the area, which was only suitable for boro paddy.

Table 4.3 Area and percentage distribution of lands with different drainage condition in Nakla Upazila

Types of Drainage	Area in ha	Percentage
Moderately well	3470	22.5
Imperfect	4250	27.54
Poor	6494	42.08
Very Poor	1217	7.88

(SRDI, 2003)

4.1.1.6 Soil reaction

Soil pH affects the availability of soil constituents to plants and soil microorganisms. For most of the plants, the ideal soil pH range is pH 6 - 7.5. However, many plants tolerate pH 5.5 - 8.5. In the study area out of 93 collected samples 27 were found below 4.5 pH, 60 samples were 4.6 to 5.5 and the remaining 6 samples were 5.5 to 6.0 pH.

4.1.2 Map analysis and study on changes in soil properties

Old Brahmaputra Flood Plain is the major AEZ of the Upazila. Around 15% in the south of the Upazila has Young Brahmaputra Flood Plain and a very small portion of the Upazila has Northern & Eastern Piedmont Plain in the northern part of the Upazila (Figure 4.5).

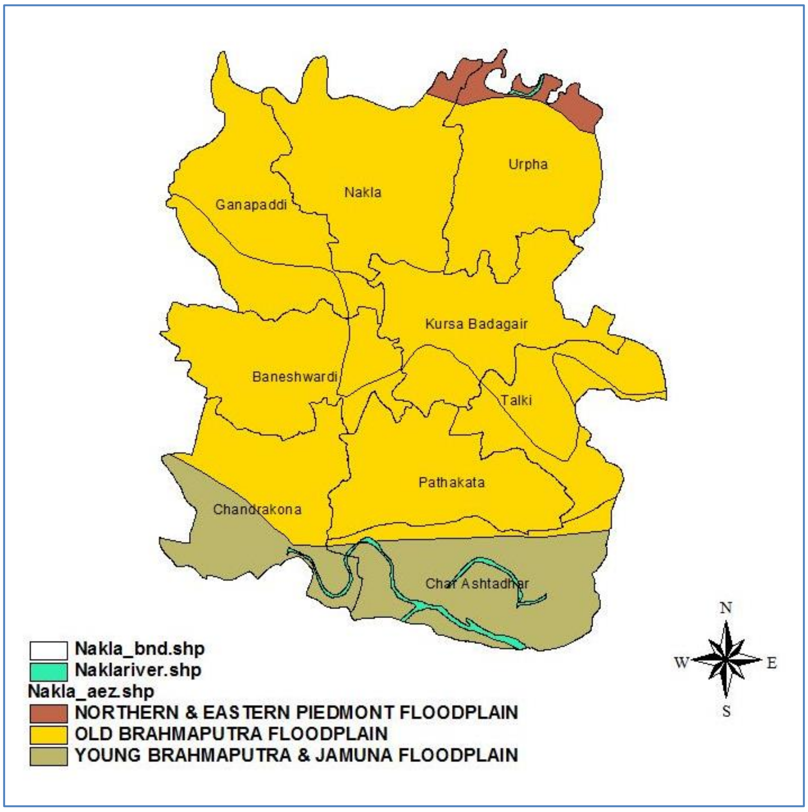

Figure 4.5: Agroecological Regions of Nakla Upazila

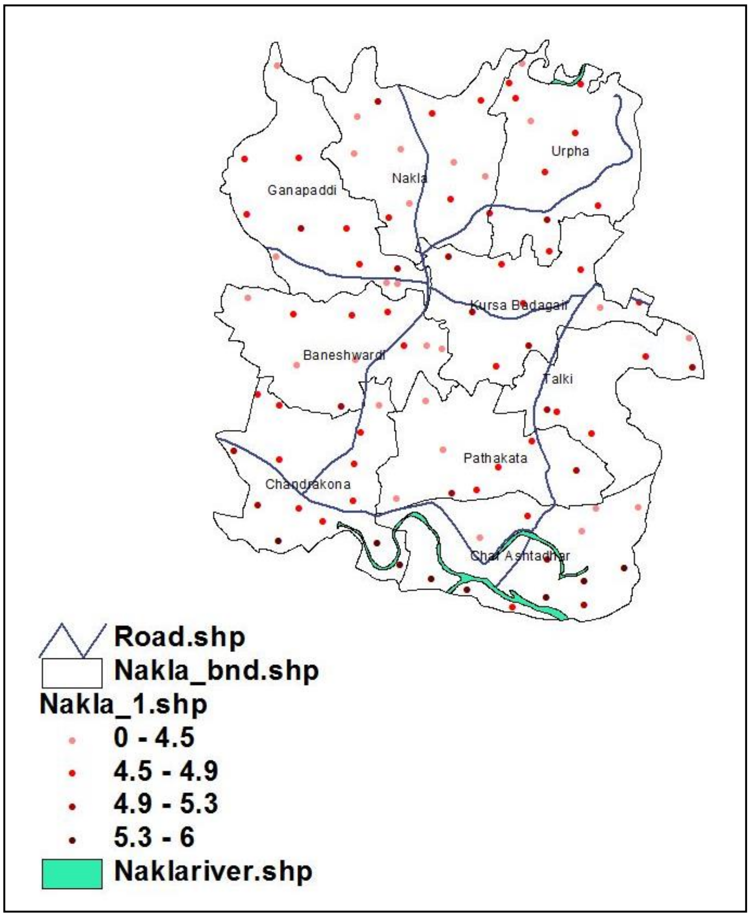

Figure 4.6: Soil sample location map

Soil samples were collected from 93 sites with GPS reading. A point map of the sample site was generated suing ArcGIS 10.2 software (Figure 4.6). Collected soil sample maps were analyzed in the laboratory and the analytical data were entered into the point map database. From the point attribute pH grid surface were created for 2001 and 2014 using spatial analyst tools of ArcGIS software. The resulted maps shows a significant increase in strongly acid and acidic area during last 13 years. In 2001 35% of the area was acidic in reaction which increased to 63% in 2014 (Figure 4.7, 4.8). On the other hand 60% area was neutral in reaction in 2001 which has reduced to 36% in 2014 (Figure 4.9, 4.10).

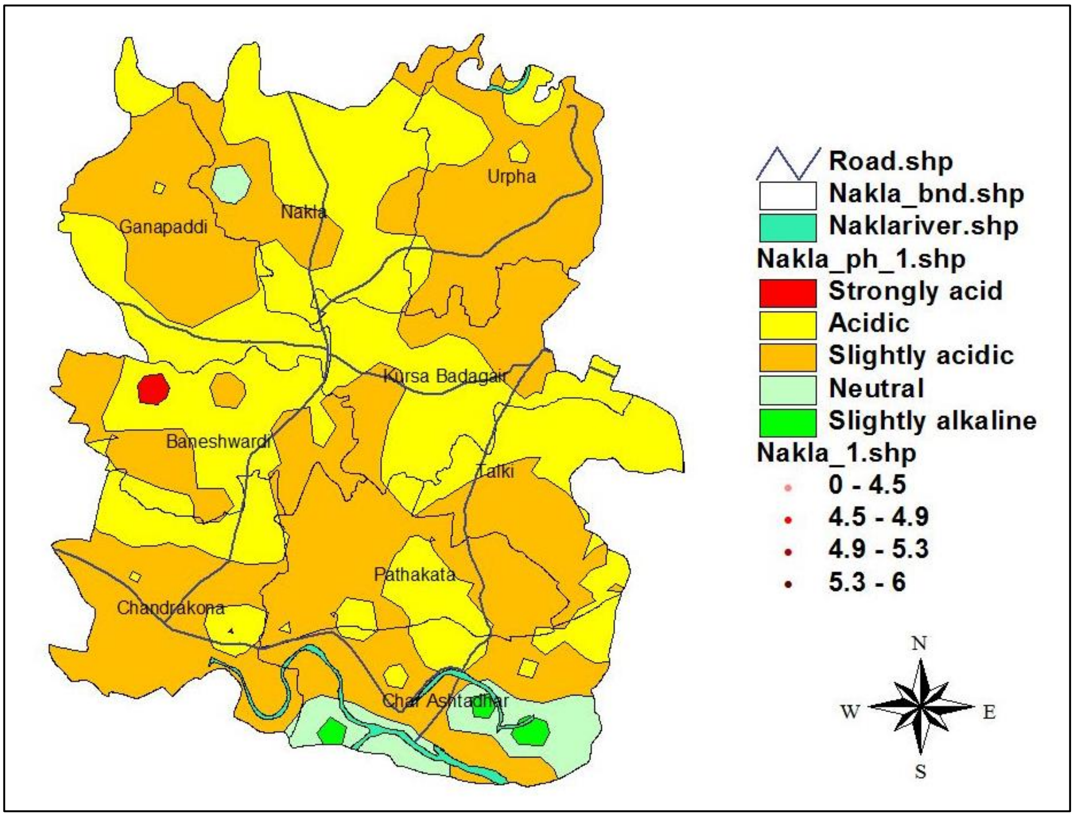

Figure 4.7: Soil pH surface map of 2001

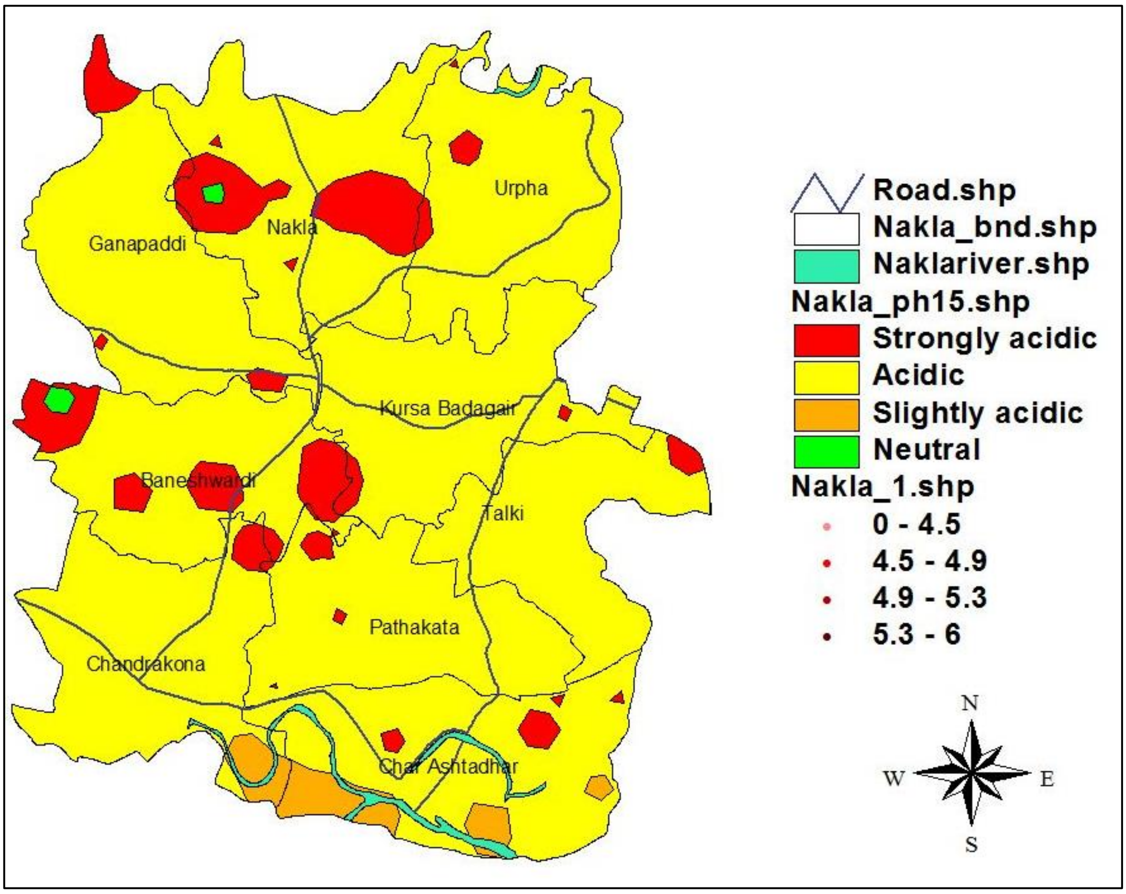

Figure 4.8: Soil pH surface map of 2014

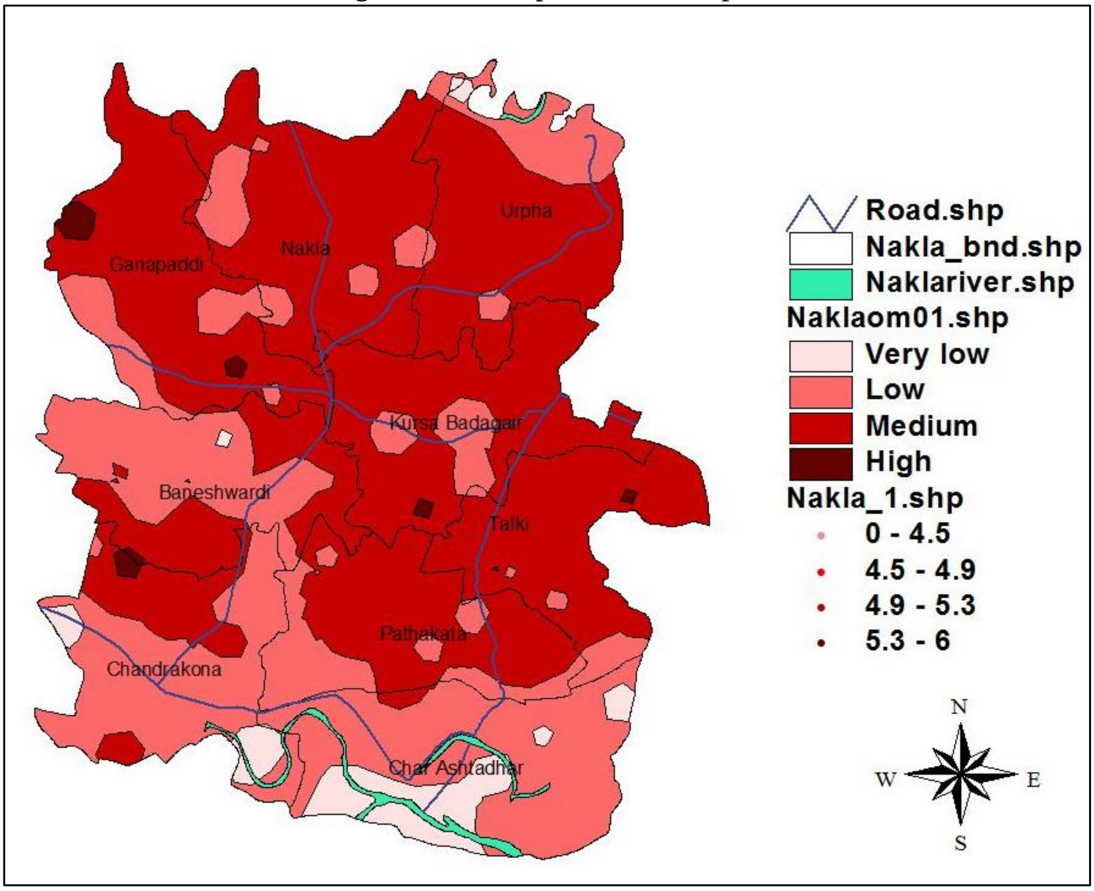

Figure 4.9: Soil organic matter status during 2001

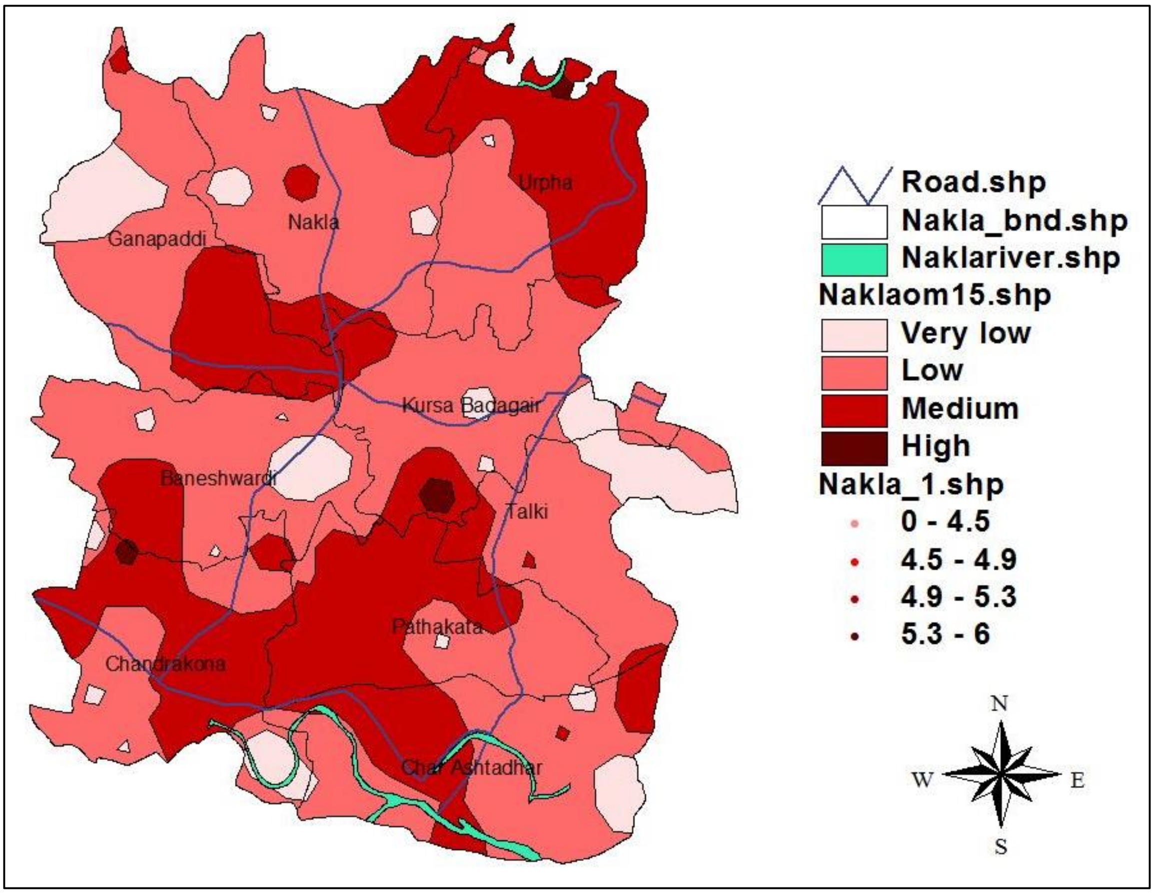

Figure 4.10: Soil organic matter during 2014

Similarly changes in soil organic matter status has also observed in the organic matter status map created from organic matter data using GIS spatial analyst. In 2001 only 1% area was very low and 35% was low in organic matter while in 2014 it has increased to 4% and 63% respectively.

4.2 Soil Groups and Crop suitability

From crop suitability ratings, it has been found that around fifty percent of the soils of the study area were not suitable for all variety of aus and aman paddy. Only a trace amount of area was suitable and rest of the area was moderately suitable for aus and aman. Boro paddy was found to be suitable in low land soils, which comprises 22 percent area as suitable and 42 percent area as moderately suitable. Wheat, maize, potato, rabi vegetable and chilli were found suitable for most of the area (Appendix B-2, B-3).

Pritimpasha, Sherpur, Sonatala, Silmondi MHL and Brahmaputra silty alluvium MHL soils were found to be suitable for rabi crop, rabi vegetable, kharif 1 and kharif 2 crops, vegetables, boro paddy and jute. But, texture, consistency and drainage of these soils lead to moderately constrain for aus and aman paddy. Soils of Ramnagar and Nakla were found to be suitable for a few rabi vegetables and moderately suitable for rabi crops, kharif 1 vegetables and B aus paddy.

Silmondi MLL, Dhamrai and Brahmaputra MLL soils were found suitable for rabi crops, local jute, boro and broadcast aman paddy whereas Ghatail and Balina medium lowland soils were suitable only for boro HYV and Melandaha was suitable for potato. The sandy soils of Brahmaputra sandy alluvium were found not suitable for any crop. The procedure of crop suitability rating used in the exercise was given in the Appendix B-1 and B-2. Only the major and locally acceptable crops were included in this procedure.

4.3 Potential Income

4.3.1 Income from developed cropping pattern

About 81.3 percent potential income of the area was derived from agricultural lands**.** Out of 21 soil groups 16 groups were found favorable for crop cultivation of which 22 percent soil groups were suitable for triple cropping, 70 percent for double cropping and 8 percent for single cropping. Profitable crops were fitted in the cropping patterns according to the suitability of crops, hydrology of the area and growing period (Appendix B-4). The study showed, vegetables, potato, chilli, and rabi crops generates more income than traditional rabi crops-paddy/jute combination. About 52 percent of the area showed rabi and kharif vegetable combination having potential for earning approximately 50 percent more income than other crop combinations (Table 4.4, Appendix C).

Compared to other crops rabi vegetable and potato combination with other suitable crops generated a high income. The cropping patterns developed in the study have more options to be adjusted with different choices and financial conditions. Social acceptability of crops and farmers' resource availability (high, medium and low) have given more emphasis to develop alternative cropping patterns. Paddy and mustard crops generate less income compared to other crops, but these were locally accepted crops, which fulfill the household grain demand of the area.

In addition, the low and medium resource farmers always have keen interest on stable agricultural crops to avoid risk of price fluctuations, inadequate storage and marketing facilities. The study showed that the farmers with higher resources are able to generate more income by growing vegetables, potato and other cash crops and can make use of unused labour forces for vegetable production.

Taking consideration of the high income based cropping pattern, the area could generate income approximately of Tk.347.87 million under scenario1 based on 100 percent income, Tk.278.30 million under scenario 2 based on 80 percent income and Tk.260.90 under scenario 3 based on 75 percent income (Table 4.5).

Table 4.4 Income generated from potential cropping pattern

Soil group	Area, ha	Cropping pattern	Income (all income in Taka)		
			from individual pattern /year	from best pattern /year	from best pattern /month
Ramnagar	30	1. Rabi vegetable-Kharif vegetable	12140424	12140424	1011702
		2. Maize	1359150		
		3. Wheat- B Aus	1234899		
Pritimpasha	89	1. Wheat- B Aus- T Aman HYV	5793997.455	5793997.455	482833
		2. T Aus HYV- T Aman HYV	1.84249569.3 3		
		3. Mustard- BoroHYV- T Aman	5438834		
Naltabari	179	1. BoroHYV- T Aman Local	9790971.088	9790971.088	815915
Nakla	964	1. Rabi vegetable-Kharif vegetable	309665720	309665720	25805876
		2. Potato - Kharif vegetable	129870142		
Sherpur	2506	1. Rabi vegetable-Kharif vegetable	1631658605	1631658605	135971550
		2. Potato -Kharif vegetable	1298701421		
		3. Chilli (R. Crop)- Tossa Jute / B Aus	405319505		
Sonatala HL	1999	1. Rabi vegetable-Kharif vegetable	1063353497	1063353497	88612791
		2. Potato(R.Crop)-Tossa Jute / B Aus	861155857		
		3. Potato (R.Crop)-B Aus-T Aman HYV	776375608		
Sonatala MHL	2221	1. Rabi vegetable- Jute Local /B Aus	127174136	265028148	22085679
		2. Chilli (R Crop)-B Aus- T Aman HYV	265028148		
Melandaha	483	1. Potato-Jute Local	197883772	197883772	197883772
Silmondi MHL	1151	1. Wheat-T Aus HYV-T Aman HYV	88768654	88768654	7397387
		2. Mustard-BoroHYV- T Aman HYV	70338180		
Ghatail	984	1. Boro HYV- T Aman HYV	60132727	60132727	5011060
		2. T Aus HYV- T Aman HYV	46984002		
Brahmaputra silty alluvium MHL	34	1. Potato (R.Crop)- Jute Local / B Aus- T Aman	813885	163878900	13656575
		2. Chilli (R.crop)- Jute Local / B Aus	163878900		
Silmondi MLL	284	1. Boro HYV- B Aman Local	22591546	22591546	1882628
		2. Mustard- Boro HYV	10557046		
Dhamrai	270	1. Boro HYV- B Aman Local	21477879	21477879	1789823
		2. Mustard- Boro HYV	4226310		
Ghatail MLL	2069	1. Boro HYV- T Aman Local	113170498	113170498	9430874.8
Balina MLL	709	1. Boro- Fallow	26355444	26355444	2196287
Balina LL	508	1. Boro- Fallow	18883731	18883731	1573644
Brahmaputra silty alluvium MLL	400	1. Potato (R.Crop)- Jute Local	163878900	163878900	13656575
Total:	14880			4174453415	347871118

Table 4.5 Income from potential land use under three scenarios

Item	Percentage of income	Total income Tk. /month
Scenario 1	100	347871118
Scenario 2 (20 % less income due to lack of management.)	80	278296894
Scenario 3 (25 % less income due to El Nino effect)	75	260903338

4.3.2 Income generated from other agricultural sectors

As income form the land resources was taken as the index of HCC in this study, income generated directly or indirectly from the land resources such as livestock, poultry, fishery and agricultural labour were taken into account to calculate the total income from the land resources. Estimated/calculated present incomes from these sectors was added to both present and potential income from crop production, which has been used as a base for calculation of present and potential HCC of the area.

4.3.2.1 Income from fisheries

Approximately 17.87 million Taka was calculated as the income from fisheries sector. This sector comprised only 2.8 percent of the income to the total potential income from fisheries. About 40 percent of the annual total catch of inland water added from floodland, 51 percent from ponds and only a negligible quantity was added from river(BBS, 2012) (Table 4.6**)**.

Table 4.6 Income from fisheries from annual total catch of inland water during 2010-2011

Item	**Quantity in t**	**Income Tk /month**
1.River	84.35	562371
2. Beel	198.71	1324733
3.Floodland	1411.74	7058692
4.Pond	1769.16	8845800
5.Semiclosed culture	15.77	78843
Total	3479.73	17870439

4.3.2.2 Income from livestock and poultry

Twenty small-scale dairy farms, 12 broiler farms and other household production systems contributed around 24.84 million Taka which was about 4 percent income to the total potential income of the area. The dairy farms mainly produce milk. Meat production mainly meet the at festival demand. The poultry farms were found to supply eggs as well as meat on regular basis. The study showed that meat from cattle and fowls provide a maximum share in the total income in this sector (Table 4.7). The field survey added that goats and sheep were the source of livelihood of some landless households (<0.49 acres).

Table 4.7 Income from livestock and poultry

Item	Total Production kg	Net Income x 10^6	
		Tk /year	Tk /month
Meat from Cattle	1750320	215.29	17.94
Meat from buffalo	35595	4.27	0.36
Meat from Goats	183936	33.10	2.76
Meat from Sheep	4175	0.42	0.03
Meat from Fowls	351624	28.13	2.34
Meat from Ducks	120552	11.57	0.96
Egg	138972.5 doz	4.86	0.41
Milk	30000 L	0.45	0.04
Total Income:	-	298.10	24.84

4.3.2.3 Income from agricultural labour household

Around 235 million Taka was generated the income fromthe labour household which was 37 percent of the total potential income. Total agricultural household of the area was found to be 36,329, number of earner per house was 1.43, average daily wage rate was Tk.300. The field survey findings concluded that average work availability was only 15 days per month.(Table 4.8). About 34 percent of the total households of the study area provided agricultural labour, whose major source of annual income was received by working as agricultural labour in lands operated by other holders. The area comprises 33.7 percent landless (land area<0.49 acre), 17.3 percent marginal land holder (0.5-1.49 acre) and 29.2 percent small farm holder (1.5-2.49 acre), all together 80.2 percent (Agricultural report, 2004).

Table 4.8 Income generated from labour households.

Item	All holdings	Average wage rate	Earner/HH	Income of Single HH	Total Income of labour household (HH) x 10^6	
	no.	Tk/day	no.	Tk/day	Tk/day	Tk/month
No.of Agricutural Labour Household	36,329	300	1.43	366	7.84	235

(Considering 15 working days per month)

4.4 Total Potential Income Generated

The total potential income was generated from income from potential land use and income from other agricultural sectors. Total potential income under scenario1 was calculated approximately Tk.625.83 million, under scenario 2 was Tk.500.67 million and under scenario 3 was Tk.469.37 million (Table 4.9).

Table 4.9 Total potential income

Activity	**Total potential income x 10^6 Tk/ month**		
	scenario 1	**scenario 2**	**scenario 3**
Agriculture-land use	347.87	278.30	260.9
Fisheries	17.87	14.30	13.40
Livestock and poultry	24.84	19.87	18.63
Labour	235.25	188.2	173.44
Total	625.83	500.67	469.37

4.5 Comparative Study of Present and Potential Landuse and crop yield

Though it has been found from the suitability analysis that most of the soils were not suitable for paddy cultivation but presently around 98 percent area produce rice crop. (Table 4.10). Currently,only 0.44 percent of the land was found to be used for vegetable cultivation though the soil was found substantially suitable for vegetable cultivation. On the other hand, the cropping patterns developed in this study included 52 percent of the total lands for vegetable production that can support a high-income target. Along with the profitable crops about 70 percent of the area has the potential for double cropping, against the present use of only 39.16 percent of the area. Fitting suitable crops into cropping patterns primarily ensures the optimum yield under proper management. A significant yield difference of the crops was observed under present and potential land use (Table 4.10)

Table 4.10 Present and potential yield (t/ha) of major crops

Crop	**Present yield t/ha**	**Potential yield t/ha**
T Aman HYV	2.48	4.50
T Aman LIV	1.14	3.50
T Aus HYV	2.00	4.50
B Aman	1.48	2.50
Boro HYV	3.24	6.00
Boro local	1.80	3.50
Jute local	1.60	3.50
Wheat	2.02	4.50
Potato	13.00	32.00
Chilli (dry)	0.80	2.00
Mustard	0.75	1.80
Rabi vegetable	19.00	31.00
Khairf vegetable	12.00	20.00

Source: SRDI, 2003, BARC 2012

4.6 Human carrying capacity of the area

4.6.1 Present Scenario

According to 2011 population census, the population of Nakla Upazila was 193,892 which was calculated to be 317,774 in 2050 with current 0.55 percent growth rate (BBS, 2012). The income demand for these population was calculated to be Tk.679.21 million based on consumption expenditure (Table 4.11).

Table 4.11 Govt. estimated per capita monthly income and expenditure

Rural	Per Capita income Tk/month	Per capita expenditure Tk/month		
		Average	Consumption	Non-consumption
All Group	2,694	3,503	3440	63

Consumption expenditure = expenditure for basic needs.
(,2012)

According to BBS (2003) food expenditure in ruralareas was estimated to be Tk.2,122, which meets the need of 898 g of per capita food grains or 2,263 Kcal intake.

4.6.2 Potential scenarios

The calculated income from potential land use and other agricultural sectors generated the total potential income. Income under scenario 1 was calculated as 100 percent of the potential land use based on the best cropping pattern generated in this study. Scenario 1 showed that the total potential income was calculated to be Tk.625.83 million which was Tk53.38 million less than the present demand (Table 4.12). Scenario 2 was calculated assuming 20 percent less income of potential land use due to production loss because of inefficient management and other unavoidable environmental situation. In Scenario 2, the total income generated was found to be Tk.500.67 million which was 178.54 million below the present demand. Income in scenario 3 was calculated as 75 percent of total potential income assuming 25 percent income loss due to El Nino effect. The total income generated in this scenario was calculated as Tk.469.38 million. The study showed that the income even under scenario 3 was also found to be below the present demand by Tk.209.84 million.

Table 4.12 Demand and balance of income under potential income generating situation.

Situation	Income x 10^6 Tk/month		
	Total	Demand by present population	Balance x10^6
Scenario 1	625.83	679.21	-53.38
Scenario 2	500.67		-178.54
Scenario 3	469.38		-209.84

Income under all the potential scenarios (1, 2 and 3) was found to be below the demand of present population. The income require to meet the basic needs of the present population was calculated to be Tk.679.21 million which was even more than the income of scenario 1 (Table 4.13).

Table 4.13 Human Carrying Capacity (HCC) of Nakla Upazila based on potential income.

Item	Total potential income (Tk/month)	potential income based HCC based	Present Population	Population balance (HCC-Ppln)
Scenario 1	62,58,34,396	1,78,657	1,93,892	-15,235
Scenario 2	50,06,67,517	1,42,925		-50,967
Scenario 3	46,93,75,797	1,33,993		-59,899

In this study carrying capacity were calculated based on total expenditure, i.e. per capita consumption expenditure (basic needs expenditure) plus per capita food and beverage expenditure. Under potential land use condition and per capita consumption expenditure the HCC under scenario 1, 2, 3 and 4 were found to be 1,78,657, 142,925 and 133,993 respectively (Table 5.13, Figure 5.11). The balances of HCC from present scenario to the potential three scenarios were calculated to be -15,235, -50,967 and 59,899 respectively.

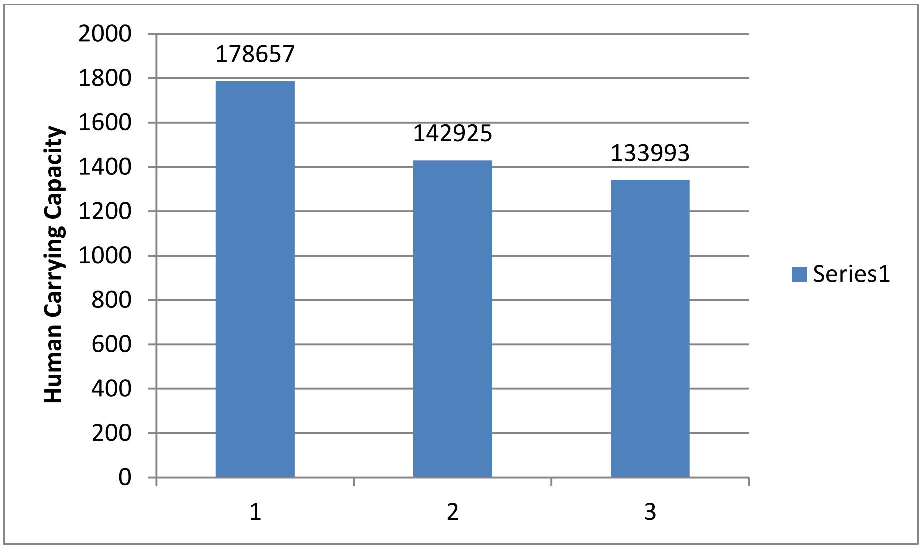

Figure 4.11 Present Potential Human carrying capacity (HCC) for scenario 1, scenario 2 and scenario 3 based on income demand

4.6.3 Scenario in 2050

With the present growth rate, the population in 2050 was estimated to be 3,17,774 which was above the present population by 123,882. To meet the demand for consumption expenditure this population will require Tk.186 million which was found to be Tk.128.7 million more than the present income (Table 4.14, Figure 4.12). Analysis of this research showed that the land resource of the area has a potential to increase income. Thus the potential income generated in this analysis by the improvement of land use and management can contribute to enhance the carrying capacity to some extent above the prevailing situation. Though the potential income and HCC will increase in 2050 the population will exceed the HCC by 190,266 even under scenario 1.

Table 4.14: Human Carrying Capacity and population balance during 2050

Scenario	Potential Income	HCC in 2050	Population in 2050	Population over HCC
1	207,80,83,112	1,27,508	3,17,774	-1,90,266
2	166,24,66,490	1,02,006		-215,768
3	155,85,62,334	95,631		-2,22,143

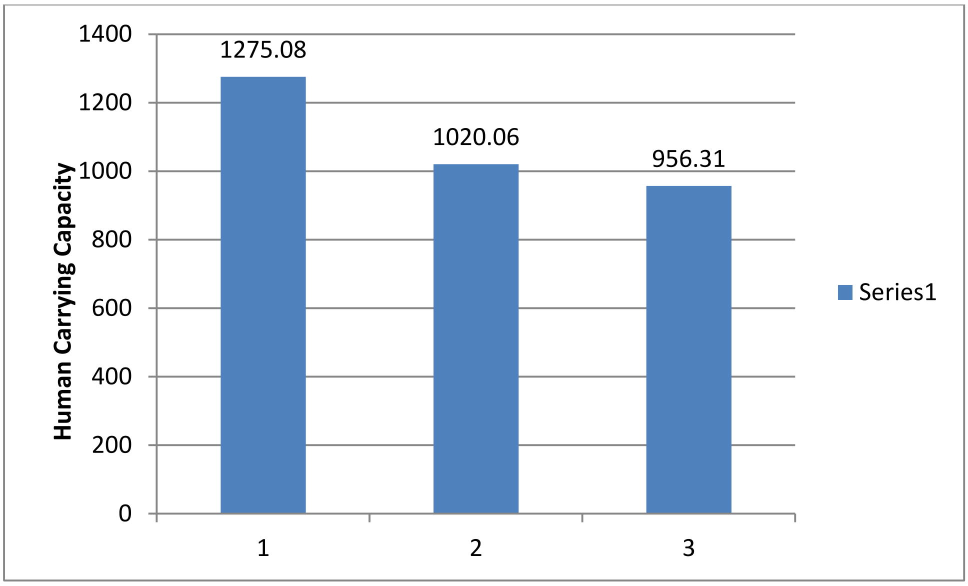

Figure 4.12 Potential Human carrying capacity (HCC)in 2050 for scenario 1, scenario 2 and scenario 3 based on income demand

CHAPTER 5
SUMMARY AND CONCLUSION

Bangladesh is blessed with its fertile soil. But the country is heavily populated with limited land and natural resources.

To meet the increasing demand of food for increasing population of the country is a big challenge. As the land resources and its productivity are not infinite, all effort should be made to boost production with existing technology in order to feed the increasing population. Therefore, for long-term planning and development perspective, it is important to know what the maximum capacity of the land resources is to produce food and how many people it can support at best. Current research has been carried out with realization of the gravity of this problem.

Because of the conceptual difference and complexity of human nature and requirement no unique/ appropriate model has yet been developed to estimate human carrying capacity (HCC). Different authors have used different index to estimate HCC. In this study total potential income from land resources and the income requirement to fulfill basic needs were used to estimate HCC of the area.

The main objective of agricultural policy and development of Bangladesh is to achieve self-sufficiency in food-grains particularly in rice. The government has been giving considerable effort and assistance to increase crop production to feed the ever-increasing population of the country. A substantial increase in agricultural production has already been observed. Yet, the rural population of the country is afflicted by malnutrition and semi-starvation.

Most of the land resources of the country are already being used for agriculture. There is very little scope to increase the extent of cultivation. The only way to increase agricultural production is through intensification of land with multiple cropping and increasing land productivity in terms of yield per unit of land through efficient crop management and with the use of inputs. Yet limited land resource limits the crop production. Over exploitation of the resources is unavoidable at this stage of resources which may damage it irreversibly. Therefore, the capacity of a land to feed people is also limited which is popularly known as human carrying capacity.

The economy of the studied area is mainly agro-based. As such living of the people largely depends on their earning from the land resources of the area. Taking income as an index, it is found that with the potentialincome the carrying capacity of the area is 178,657 which is less than the existing population. This suggests that the population has already exceeded its sustainable carrying capacity. To meet the basic needs including government estimated calorie requirement it needs Tk.3503 per capita per month in 2014. However, the present potential income of the area is calculated Tk. 3227.75 per capita per month which is lower than the income demand by Tk 275.25.

The study also indicates that the soil resources of the area are underutilized. A remarkable achievement is possible in terms of income through suitable crop selection, recommended fertilizer application and proper crop and soil management. Calculated income with high income based suitable cropping patterns indicate that the

HCC is little higher than the existing population, which means that it can support some more people, if the resources are properly utilized. But the population increases will soon exceed the potential HCC of the area.

The main reasons for yield and income difference are differences in cropping patterns which affects cropping intensity, difference in potential and present yields of individual crops, low resource base farming, and lack of marketing, storage facility and lack of technical knowledge. As the present land use is not suitable for the land farmers are getting less production. With expectation of high yield they are using chemical fertilizer irrespective of suitability, productivity and nutrient status of the soil which is not a sustainable land use practice. This practice in the long run may cause permanent damage to the soil resources.

To improve the present situation farmers can select high income based suitable cropping patterns and follow the recommended fertilizer application and crop management practices. But the small and marginal farmers are more inclined to subsistence agriculture. Low resource base is also another constrain to select high income cropping patterns and to follow scientific management practices. Nearly 52 percent of the land is suitable for vegetable production, whereas only around 0.5 percent is being used at present. This is because of lack of storage and marketing facility and to avoid risk of price fluctuation. Therefore, to increase carrying capacity of the area through optimum utilization of land and its resources, it is necessary to ensure market, post harvest processing and storage facilities. For small and marginal farmers there should have enough credit facility to access. As the country is regularly exporting vegetable, the government can give emphasis to this area as the area is very much suitable for vegetable to grow. The infrastructure development is the main factor especially for the crops like vegetable and rabi crop like wheat, maize, chilli and potato, which have high demand in the other part of the country. The study showed that the rice is not suitable in the area and the yield is definitely less even though the farmers like to grow rice crop, indicating that rice is the main food of the area.

It is observed that with the potential income the present population has already exceeded the carrying capacity of the area. To avoid the situation initiative should be taken to develop alternative income generating activities and opportunities coupled with agro-based industries, small and cottage industries as well as control of population growth.

REFERENCES

Abernethy, V.D., 2001. Carrying capacity: the tradition and policy implications of limits. Ethics in science and environmental politics (ESEP),Virginia, USA, pp. 9-18,

Anifowoshe, T.O., 1990. 'Food production: problems and prospects', GeoJournal 20 (3), pp. 243-247.

Baron, L. 1992. 'Beyond the green revolution: singin' the population blues', ZPG Reporter 24 (4), 1 and endash;4.

BBS, 2008.Census of Agriculture – 1996, Zila Sherpur.Bangladesh Bureau of Statistics. Dhaka.

BBS, 2011, Bangladesh Bureau of Statistics.Dhaka.

BBS, 2012. Report of the Household Income and Expenditure Survey. 2010,

Bangladesh Bureau of Statistics.Dhaka.

BBS, 2013, Bangladesh Bureau of Statistics.Dhaka.

Bongaarts, J. 1994. 'Can the growing human population feed itself ?', Scientific American Mar. 270 (3), 36-42.

Brown, L.R. 1989. 'Feeding six billion', World Watch 2(5), 32-40.

Brundtland, G.H. 1993. 'Population, Environment and Development. Rafael M. Salas Memorial Lecture 1993, New York, 28 September 1993', New York, New York United Nations Population Fund (UNFPA), 16p.

Bryant, J.P. 2002. Biodiversity and Conservation: A Hypertext Book School of Biological Sciences, University of California, Irvine, Irvine, CA 92697, USA.

Cohen, J. E. 1995a. How many people can the earth support? W.W. Norton & Co.: NY.

Cohen, J. E. 1995. Population Growth and the Earth's Human Carrying Capacity. Science 269, 341–346

DAE, 2004. Progress Report 2003-2004, Department of Agricultural Extension, Nakla, Sherpur, Bangladesh.

Daily, G. C. and P. R. Ehrlich, 1992. Population, sustainability, and Earth's carrying capacity: a framework for estimating population size and lifestyles that could be sustained without undermining future generations. BioScience 42:761-71.

Daily, G.C. and P.R. Ehrlich, 1996. Socioeconomic equity, sustainability, and Earth's carrying capacity. Ecological Applications. 6(4):991-1001.

Ehrlich, P. R. 1994. Ecological Economics and the Carrying Capacity of the Earth. In: Jansson, A. M. Investing in natural capital: the ecological economics approach to sustainability. Island Press, pp. 38-56.

FAO, 1976. A framework for land evaluation. Soils Bulletin n.32. FAO, Roma

FAO/UNDP 1988. Land Resources Appraisal of Bangladesh for Agricultural Development. Report 2. FAO, Roam.

INFS, 1998.Bangladesh National Nutrition Survey. Institute of Nutrition and Food Science, University of Dhaka.

FAO/UNDP, 1988. Land Resources Appraisal Of Bangladesh For agricultural Development: Report 2, Agroecological Regions Of Bangladesh; Report 5, Land resources, Vol.II-Report6, Land Resources Map And Legend, FAO, Roam.

Gigi, R. 2002. Human Carrying Capacity of Earth. Institute for Lifecycle Environmental Assessment. Seattle, Washington98122.

Hannon, B. 1975. Energy conservation and the consumer. Science 189, 95-102

Malaku Ayalew, 1997. What is food security, famine and hunger? Internet Journal of African Studies. Issue No. 2, March 1997.

Hardesty, D. L. 1977. Ecological Anthropology. New York: Wiley.

Harris, J. M. 1996. "World agricultural futures: regional sustainability and ecological limits." Ecological Economics 17(1996): 95-115.

Hayden, B. 1975. The carrying capacity dilemma: an alternative approach. In (A. C. Swedlund, Ed.) Population Studies in Archaeology and Biological Anthropology: A Symposium. Am. Antiq. 40: pt. 2 memoir 30. pp. 11-21.

IUCN/UNEP/WWF, 1991. Caring for the Earth: A strategy for sustainable living, Gland, Switzerland.

Jaccard, M. 1991. Does the rebound effect offset the electricity savings of powersmart? Discussion Paper for BC Hydro. Vancouver: BC Hydro.

Maxwell, S. and T. Frankenberger, 1992. Household food security concepts, indicators, and measurements. New York, NY, USA: UNICEF.

Meyer, P. S. & J.H. Ausubel, 1999. Carrying capacity: A model with logistically varying limits. Technological Forecasting and Social Change 61 (3), 209–214

Mitchel, 1997. http://www.overpopulation.com/faq/natural_resources/carrying_capacity.html. web site visited on 19.07.2004

MOA, 1997. Annual Report, Ministry of Agriculture, Dhaka, Bangladesh.

Mondal M. Abdul latif 2004. Determining our foodgrain requirement The daily star. Vol 5, No 19, June,15, 2004

Moore, J. 1983. Carrying capacity, cycles and culture. J. Hum. Evol. **12**: 505-514.

Pimentel, D., O. Bailey, P. Kim, E. Mullaney, J. Calabrese, L. Walman, F. Nelson, and X. Yao,1999. Will the limit of the Earth's resources control human numbers. Environment, Development and Sustainability 1:19-39.

Pimentel, D., R. Harman, M. Pacenza, J. Pecarsky,and M. Pimentel, 1994. Natural resources and an optimum human population. Population and Environment 15:347-369.

Postel, S. 2001. 'Growing more food with less water', Scientific American Feb. 284(2), 46-50.

Rahman, M. M., G. Mostafa, S. razia and J. U. Shoaib, 1999. Land Degradation Situation in Bangladesh. Paper presented at the Seminar of Soil Science Association, May 22- 24, Bangladesh Agriculture Research Council, Dhaka.

Rees, W.E. 1996. Revisiting Carrying Capacity: Area-Based Indicators of Sustainability. Population and Environment: A Journal of Interdisciplinary Studies Volume 17, Number 3, Human Sciences Press, Inc.

Ricklefs, R. E. 1973. Ecology. Portland: Chiron Press.

Robson, J. (ed.): 1981, Famine: Its Causes, Effects and Management, New York, Gordon and Breach.

Saunders, H.D. 1992. The Khazzoom-Brookes postulate and neoclassical growth. The Energy Journal 13, 4, 131 -148.

SRDI, 2003. Land and Soil resource Utilization Guide, Nakla Upazila, Sherpur District. Ministry of Agriculture. Dhaka, Bangladesh.

USDAID, 2004. Current Conditions: Food Security. United States Agency for International Development, Bangladesh, Madani Avenue, DhakaBangladesh. http://www.usaid.gov/bd/food_sec.html]

Waggoner, P.E. 1994. How MuchLand Can Ten Billion People Spare for Nature? Report 121, Council for Agricultural Science and Technology (CAST), AmesIowa.

World Bank, 1986. Poverty and Hunger: Issues and Options for Food Security in Developing Countries. Washington, DC, USA: World Bank.

Young, A. 1999. 'Is there really spare land? A critique of estimates of available cultivable land in developing countries', Environment, Development and Sustainability 1(1), 3-18.

APPENDIX A -1

Table 1.1: Basic characteristics of holdings of Nakla Upazila classified by size of holdings

Items	**All Holdings**	**Non Farm House hold**			**Farm HoldIngs**						
General		**With no operated Area**	**With no cultivated area**	**With .01-.04 cultivated area**	**0.02 ha**	**0.2-0.4 ha**	**0.404 ha**	**0.6-0.99 ha**	**0.99-3.03 ha**	**3.03+ ha**	**Total Farm Holdings**
No. of holding	48776	30	16083	1791	7477	8076	5360	5570	26483	4389	30872
Percentage	100	0.06	32.97	3.67	15.33	16.56	10.99	11.42	54.30	8.99	63.29
Male headed	36379	24	14708	1661	7062	7847	5240	5496	25645	4341	29986
Female headed	2397	8	1375	130	415	229	120	74	838	48	886
Operated area	42664		1098	159	2157	5495	6150	10282	24084	17323	41406
Owned area	38100	3	1644	360	1977	3313	3764	6793	15536	4709	36093
% of operated area	101.3		265.4	266.8	124.6	94	92.6	91.7	98.4	105.1	97.9
Homestead area	2086		414	64	274	286	232	308	436	73	1608
Net cultivated area	33516			36	1183	3018	3617	6768	14708	4186	33480
% of operated area	89.1			26.6	74.6	85.7	88.9	91.4	93.2	93.4	90.8
Area under Permanent crop	560			27	100	78	67	89	163	35	533
Net temporary cropped area	32782			5	1067	2921	3537	6645	14481	4127	32777
% of net cultivated area	97.8			14.7	90.1	96.8	97.8	98.2	98.5	98.6	97.9
Holding reporting irrigation	17676			98	3803	4072	2835	3195	3336	337	17578
Net irrigated area	22391			3	762	2115	2515	4583	9660	2753	22388
% of cultivated area	66.8			7.3	64.4	70.1	69.6	67.7	65.7	65.8	66.9
Hold.report.use of fertilizer	20781			100	4595	4714	3309	3731	3932	400	20681
Net fertilized area	28598			3	918	2525	3151	5880	12613	3508	28595
% of cultivated area	85.3			7.9	77.6	83.6	87.1	86.9	85.8	83.8	85.4

APPENDIX A -2

Table 2.1: Long term weather data of Mymensingh

Temperature	Jan	Feb	Mar	Apr	May	June	July	Aug	Spt	Oct	Nov	Dec	An-nual
Extreme max. temp.	29.4	33.3	38.9	42.2	41.7	37.2	36.1	36.7	36.7	36.7	33.3	30.6	
Monthly average of max. temp.	24.8	27.6	33.6	33.1	31.9	31.3	31.3	31.6	31.3	30.9	29.0	26.1	
Extreme min. temp.	4.4	4.4	8.3	15.0	16.7	20.0	22.2	22.2	21.1	16.1	11.1	7.2	
Monthly average of min. temp.	11.9	13.9	17.9	21.9	23.0	24.9	25.4	25.5	25.1	23.2	18.3	13.5	
Monthly average of mean temp.	18.4	20.8	24.8	27.5	27.4	28.0	28.3	28.5	28.2	27.0	23.6	19.8	25.1
Rainfall (mm)	12	20	39	99	327	433	420	353	334	211	20	7	2,275

(Source: SRDI, 2003)

APPENDIX B -1

Table 1.1: Methods of crop suitability ratings based on land and soil characteristics

1- Suitable
2- Moderately suitable
3- Unsuitable

Land characteristics and Soil characteristics		Aus									T. Aman									B. Aman			Boro HYV Irrigated		
		T. Aus HYV rainfed			T. Aus HYV Irrigated			B. Aus Local			HYV irrigated			HYV rainfed			Local								
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1. Land type:	a) highland	x			x			x			x			x			x			x			x		
	b) medium highland	x			x			x			x			x			x			x			x		
	c) medium lowland			x			x		x				x			x		x		x			x		
	d) lowland			x			x			x			x			x			x		x			x	
	e) very lowland			x			x			x			x			x			x			x			x
2. Drainage:	a) well			x			x			x			x			x			x			x			x
	b) moderately well			x			x		x				x			x			x			x			x
	c) imperfect	x			x			x			x			x			x					x	x		
	d) poor	x			x			x			x			x			x			x			x		
	e) very poor	x			x					x	x			x				x				x	x		
3. Water recession after rainy season	a) very early	x			x			x			x			x			x				x		x		
	b) early	x			x			x			x			x			x				x		x		
	c) neutral	x			x			x			x			x			x			x			x		
	d) late	x			x			x				x			x		x			x			x		
	e) very late			x			x			x			x			x			x		x		x		
4. Soil texture	a) sandy			x			x			x			x			x			x			x			x
	b) sandy loam			x			x		x				x			x			x			x			x
	c) loam	x			x			x				x			x			x		x				x	
	d) clay loam	x			x			x			x			x			x			x			x		
	e) clay	x			x				x		x				x		x				x		x		
5. Soil consistence (moist):	a) loose			x			x			x			x			x			x			x			x
	b) friable		x			x		x				x			x			x		x				x	
	c) firm	x			x				x		x			x			x			x			x		
6. Plant available moisture	a) low																								
	b) medium																								
	c) high																								
	d) very high																								
7. Relief:	a) level	x			x			x			x			x			x			x			x		
	b) undulating			x			x		x				x			x		x			x				x
	c) sloping			x			x			x			x			x			x			x			x
8. Soil reaction	a) extremely acid			x			x			x			x			x			x			x			x
	b) severely acid		x			x			x			x			x			x			x			x	
	c) mildly acid	x			x			x			x			x			x			x			x		
	d) neutral	x			x			x			x			x			x			x			x		
	e) slightly alkaline	x			x			x			x			x			x			x			x		
	f) strongly alka.		x			x			x			x			x			x			x			x	
	g) very stro. alka			x			x			x			x			x			x			x			x
9. Salinity (soil)	a) non-saline	x			x			x			x			x			x			x			x		
	b) very sligh. sal.		x			x			x			x			x			x			x			x	
	c) slightly saline			x			x			x			x			x		x					x			x
	d) moderately sal.			x			x			x			x			x			x			x			x
	e) strongly saline			x			x			x			x			x			x			x			x
	f) very stro. sal.			x			x			x			x			x			x			x			x

* Highland was not considered for B.Aman cultivation.

N.B. : Plant available soil moisture storage in soil was not considered when rating kharif crops and irrigated crops suitability.

APPENDIX B-1

Table 1.2: Methods of crop suitability ratings based on land and soil characteristics

1- Suitable
2- Moderately suitable
3- Not suitable

Land characterstics and Soil characteristics		Wheat Irrigated			Wheat Unirrigated			Barley Unirrigated			Maize Rabi Irrigated			Maize Kharif Unirrigated			Gram Unirrigated			Lentil Unirrigated		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1. Land type:	a) highland	×			×			×			×			×			×			×		
	b) medium highland	×			×			×			×					×	×			×		
	c) medium lowland	×			×			×			×					×	×				×	
	d) lowland		×			×			×			×				×		×				×
	e) very lowland			×			×			×			×			×			×			×
2. Drainage:	: a) well	×			×			×			×			×			×			×		
	b) moderately well	×			×			×			×			×			×			×		
	c) imperfect	×			×			×			×			×			×			×		
	d) poor	×			×			×			×					×	×			×		
	e) very poor			×			×			×			×			×			×			×
3. Water recession after rainy season	: a) very early	×			×			×			×			×			×			×		
	b) early	×			×			×			×					×	×			×		
	c) neutral		×			×		×			×					×		×				×
	d) late			×			×			×		×				×			×			×
	e) very late			×			×			×			×			×			×			×
4. Soil texture	: a) sandy			×			×			×			×			×			×			×
	b) sandy loam		×			×			×			×			×			×			×	
	c) loam	×			×			×			×			×			×			×		
	d) clay loam	×			×			×			×			×			×			×		
	e) clay	×				×			×			×			×		×					×
5. Soil consistence (moist):	: a) loose			×			×			×			×			×			×			×
	b) friable	×			×			×			×			×			×			×		
	c) firm	×				×			×			×			×		×					×
6. Plant available moisture	: a) low						×			×									×			×
	b) medium					×			×									×			×	
	c) high				×			×									×			×		
	d) very high				×			×									×			×		
7. Relief:	: a) level	×			×			×			×			×			×			×		
	b) undulating			×		×			×				×	×				×			×	
	c) sloping			×			×			×			×		×				×			×
8. Soil reaction	: a) extremely acid			×			×			×			×			×			×			×
	b) severely acid		×			×			×			×			×				×			×
	c) mildly acid	×			×			×			×			×				×			×	
	d) neutral	×			×			×			×			×			×			×		
	e) slightly alkaline	×			×			×			×			×			×			×		
	f) strongly alka.		×			×			×			×			×			×			×	
	g) very stro. alka			×			×			×			×			×			×			×
9. Salinity (soil)	: a) non-saline	×			×			×			×			×			×			×		
	b) very sligh. sal.		×			×		×				×			×			×				×
	c) slightly saline			×			×		×				×			×			×			×
	d) moderately sal.			×			×			×			×			×			×			×
	e) strongly saline			×			×			×			×			×			×			×
	f) very stro. sal.			×			×			×			×			×			×			×

APPENDIX B-1

Table 1.3: Methods of crop suitability ratings based on land and soil characteristics

1- Suitable
2- Moderaetly suitable
3- Not suitable

Land Characterstics and Soil Characteristics		Mung bean Rabi Unirri-gated			Black gram Rabi Unirri-gated			Mustard HYV irrigation			Mustard Local Unirri-gated			Sun flower Rabi Unirri-gated			Groundnut Rabi Unirri-gated			Groundnut Kharif Unirri-gated		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1. Lana type:	a) highland	×			×			×			×			×			×			×		
	b) medium highland	×			×			×			×			×			×					×
	c) medium lowland		×		×			×			×				×		×					×
	d) lowland			×	×				×			×				×			×			×
	e) very lowland			×			×			×			×			×			×			×
2. Drainage:	: a) well	×			×			×			×			×			×			×		
	b) moderately well	×			×			×			×			×			×			×		
	c) imperfect	×			×			×			×			×			×				×	
	d) poor	×			×				×			×			×		×					×
	e) very poor			×			×			×			×			×			×			×
3. Water recession after rainy season	: a) very early	×			×			×			×			×			×			×		
	b) earlyl	×			×			×			×			×			×					×
	c) Neutral			×		›			×			×			×			×				×
	d) late			×			×			×			×			×			×			×
	e) very late			×			×			×			×			×			×			×
4. Soil texture	: a) sandy			×			×			×			×			×			×			×
	b) sandy loam		×			×			×			×			×		×			×		
	c) loam	×			×			×			×			×			×			×		
	d) clay loam	×			×			×			×			×			×			×		
	e) clay		×			×				×		×			×				×			×
5. Soil consistence (nois):	a) loose			×			×			×			×			×		×			×	
	b) friable	×			×			×			×			×			×			×		
	c) firm			×			×			×			×		×				×			×
6. Plant available moisture	: s) low			..		×							×			×			×			
	b) medium		×		×							×			×			×				
	c) high	×			×						×			×			×					
	d) very high	×			×						×			×			×					
7. Relief:	: a) level	×			×			×			×			×			×			×		
	b) undulating	×			×					×		×		×				×			×	
	c) sloping			×			×			×			×			×			×			×
8. Soil reaction	: a) extremely acid			×			×			×			×			×			×			×
	b) severely acid		×			×			×			×			×			×			×	
	c) mildly acid	×			×			×			×			×			×			×		
	d) neutral	×			×			×			×			×			×			×		
	e) slightly alkaline	×			×			×			×			×			×			×		
	f) strongly alka.		×			×			×			×			×			×			×	
	g) very stro. alka			×			×			×			×			×			×			×
9. Salinity (soil)	: a) non-saline	×			×			×			×			×			×			×		
	b) very sligh. sal.		×				×			×			×	×				×			×	
	c) slightly saline		×				×			×			×		×				×			×
	d) moderately sal.			×			×			×			×			×			×			×
	e) strongly saline			×			×			×			×			×			×			×
	f) very stro. sal.			×			×			×			×			×			×			×

APPENDIX B1

Table 1.4: Methods of crop suitability ratings based on land and soil characteristics

1- Suitable
2- Modratly suitable
3- Not suitable

Land characteristics and Soil characteristics		Jute Tosha			Jute Deshi			Irrigated Cotton (rabi)			Potato irrigated			Cauli-flower Cabbage irrigated			Tomato (rabi) irrigated			Rabi Brinjal Okra (rabi) irrigated		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1. Land type:	: a) highland	×			×			×			×			×			×			×		
	: b) medium highland		×		×					×	×			×			×			×		
	c) medium lowland			×	×					×	×				×			×				×
	d) lowland			×			×			×		×				×			×			×
	e) very lowland			×			×			×			×			×			×			×
2. Drainage:	: a) well	×					×	×			×			×			×			×		
	b) moderately well	×					×	×			×			×			×			×		
	c) imperfect	×			×			×			×			×			×			×		
	d) poor		×		×					×	×			×			×			×		
	e) very poor			×			×			×			×			×			×			×
3. Water recession after rainy season	: a) very early	×			×			×			×			×			×			×		
	b) early		×		×					×	×			×			×				×	
	c) neutral		×		×					×		×			×			×				×
	d) late			×		×				×			×			×			×			×
	e) very late			×			×			×			×			×			×			×
4. Soil texture	: a) sandy			×			×			×			×			×			×			×
	b) sandy loam		×			×			×		×				×			×			×	
	c) loam	×			×			×			×			×			×			×		
	d) clay loam	×			×			×			×			×			×			×		
	e) clay		×			×			×			×			×				×		×	
5. Soil consistence (moist):	: a) loose			×			×			×			×			×			×			×
	b) friable	×			×			×			×			×			×			×		
	c) firm		×			×			×			×			×			×			×	
6. Plant available moisture	: s) low																					
	b) medium																					
	c) high																					
	d) very high																					
7. Relief:	: a) level	×			×			×			×			×			×			×		
	b) undulating		×			×			×				×		×			×			×	
	c) sloping			×			×			×			×			×			×			×
8. Soil reaction	: a) extremely acid			×			×			×			×			×			×			×
	b) severely acid		×			×			×			×			×			×			×	
	c) mildly acid	×			×			×			×			×			×			×		
	d) neutral	×			×			×			×			×			×			×		
	e) slightly alkaline	×			×			×			×			×			×			×		
	f) strongly alka.		×			×			×			×			×			×			×	
	g. very stro. alka			×			×			×			×			×			×			×
9. Salinity (soil)	: a) non-saline	×			×			×			×			×			×			×		
	b) very sligh. sal.			×			×	×					×		×		×				×	
	c) slightly saline			×			×		×				×			×		×				×
	d) moderately sal.			×			×			×			×			×			×			×
	e) strongly saline			×			×			×			×			×			×			×
	f) very stro. sal.			×			×			×			×			×			×			×

APPENDIX B1

Table 1.5: Methods of crop suitability ratings based on land and soil characteristics

1- Suitable
2- Moderately suitable
3- Not suitable

Land characterstics and Soil characteristics		Spinach, Lal Sak, (rabi) irrigation			Irrigated Chilli (rabi)			Patal, Okra (kharif)			Radish, Turnip, Carrot irrigated			Pritter gourd, Snake gourd ribbed kamker			Onion, Garlic unirrigated			Ginger, Turmaic			Betel irrigated		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1. Land type:	a) highland	×			×			×			×			×			×			×			×		
	b) medium highland	×			×				×			×				×	×					×			×
	c) medium lowland		×			×				×		×				×		×				×			×
	d) lowland			×			×			×			×			×			×			×			×
	e) very lowland			×			×			×			×			×			×			×			×
2. Drainage:	a) well	×			×			×			×			×			×			×			×		
	b) moderately well	×			×			×			×			×			×			×			×		
	c) imperfect	×			×			×			×				×		×				×				×
	d) poor	×			×				×			×				×	×					×			×
	e) very poor			×			×			×			×			×			×			×			×
3. Water recession after rainy season	a) very early	×			×			×			×			×			×			×			×		
	b) early	×			×			×			×					×	×					×			×
	c) neutral		×			×			×			×				×		×				×			×
	d) late			×			×			×			×			×			×			×			×
	e) very late			×			×			×			×			×			×			×			×
4. Soil texture	a) sandy			×			×			×			×			×			×			×			×
	b) sandy loam		×			×		×			×				×			×			×			×	
	c) loam	×			×			×			×			×			×			×			×		
	d) clay loam	×			×			×			×			×			×			×			×		
	e) clay			×		×				×			×		×				×			×	×		
5. Soil consistence (moist):	a) loose			×			×			×		×				×			×		×			×	
	b) friable	×			×			×			×			×			×			×			×		
	c) firm			×		×				×			×		×				×			×			×
6. Plant available moisture	a) low																		×		×				
	b) medium																	×			×				
	c) high																×			×					
	d) very high																×			×					
7. Relief:	a) level	×			×			×			×			×			×			×			×		
	b) undulating		×			×			×			×		×				×		×				×	
	c) sloping			×			×			×			×		×				×		×				×
8. Soil reaction	a) extremely acid			×			×			×			×			×			×			×			×
	b) severely acid		×			×			×		×			×				×			×		×		
	c) mildly acid	×			×			×			×			×			×			×			×		
	d) neutral	×			×			×			×			×			×			×			×		
	e) slightly alkaline	×			×			×			×			×			×			×			×		
	f) strongly alka.			×		×			×				×		×				×			×			×
	g) very stro. alka			×			×			×			×			×			×			×			×
9. Salinity (soil)	a) non-saline	×			×			×			×			×			×			×			×		
	b) very sligh. sal.		×			×			×			×				×		×				×		×	
	c) slightly saline			×			×			×			×			×			×			×			×
	d) moderately sal.			×			×			×			×			×			×			×			×
	e) strongly saline			×			×			×			×			×			×			×			×
	f) very stro. sal.			×			×			×			×			×			×			×			×

APPENDIX B1

Table 1.6: Methods of crop suitability ratings based on land and soil characteristics

1- Suitable
2- Moderately suitable
3- Unsuitable

Land characteristics and Soil characteristics		Sugar-cane irrigated			Banana un-irri-gated			Papaya un-irri-gated			Pine-apple un-irri-gated			Mango			Jack-fruit			Coconut Betelnut			Guava Sapota Lemon		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1. Land type.	: a) highland	×			×			×			×			×			×			×			×		
	: b) medium highland		×				×			×			×			×			×			×			×
	c) medium lowland			×			×			×			×			×			×			×			×
	d) lowland			×			×			×			×			×			×			×			×
	e) very lowland			×			×			×			×			×			×			×			×
2. Drainage:	: a) well	×			×			×			×			×			×			×			×		
	b) moderately well	×			×			×			×			×			×			×			×		
	c) imperfect	×			×				×			×			×				×	×				×	
	d) poor		×				×			×			×			×			×			×			×
	e) very poor			×			×			×			×			×			×			×			×
3. Water recession after rainy season	: a) very early	×			×			×			×			×			×			×			×		
	b) early	×					×			×			×	×		×			×			×			×
	c) neutral			×			×			×			×			×			×			×			×
	d) late			×			×			×			×			×			×			×			×
	e) very late			×			×			×			×			×			×			×			×
4. Soil texture	: a) sandy			×			×			×			×			×			×			×			×
	b) sandy loam		×			×			×			×			×			×			×			×	
	c) loam	×			×			×			×			×			×			×			×		
	d) clay loam	×			×			×			×			×			×			×			×		
	e) clay		×				×			×		×			×			×			×			×	
5. Soil consistence (moist):	: a) loose			×			×			×			×			×			×			×			×
	b) friable	×			×			×			×			×			×			×			×		
	c) firm		×				×			×		×			×			×			×			×	
6. Plant available moisture	: s) low						×			×		×			×			×			×			×	
	b) medium					×			×			×		×			×			×			×		
	c) high				×			×			×			×			×			×			×		
	d) very high				×			×			×			×			×			×			×		
7. Relief:	: a) level	×			×			×			×			×			×			×			×		
	b) undulating		×		×			×			×			×			×			×			×		
	c) sloping			×		×		×				×		×			×				×		×		
8. Soil reaction	: a) extremely acid			×			×			×			×			×			×			×			×
	b) severely acid		×			×		×			×			×			×				×		×		
	c) mildly acid	×			×			×			×			×			×			×			×		
	d) neutral	×			×			×			×			×			×			×			×		
	e) slightly alkaline	×			×			×				×		×			×			×			×		
	f) strongly alka.		×			×			×				×		×			×			×				×
	g) very stro. alka			×			×			×			×			×			×			×			×
9. Salinity (soil)	: a) non-saline	×			×			×			×			×			×			×			×		
	b) very sligh. sal.		×			×				×		×			×				×	×				×	
	c) slightly saline			×			×			×			×			×			×		×				×
	d) moderately sal.			×			×			×			×			×			×			×			×
	e) strongly saline			×			×			×			×			×			×			×			×
	f) very stro. sal.			×			×			×			×			×			×			×			×

APPENDIX B-2

Table 2.1 Land suitability for the crop of **Aman (Broadcast)** under specific limiting factors in Nakla upazila, Bangladesh.

	Suitability			**Limiting factors**							
Soil group	**S**	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar			O			2	3				2
Pritimpasha		x				2					
Nalitabari		x						2			2
Nakla			O			2	3	3			2
Sherpur			O			2	3				
Sonatola HL			O	3		2	3				
Sonatola MHL		x				2					
Silmondi MHL		x				2					
Silmondi MLL	√										
Ghatail MHL		x				2		2			
Ghatail MLL		x						2			
Balina MLL			O			2	3	2			
Balina LL			O	2		2	3	2			
Melandoho			O			2	3				
Dhamrai	√										
Brahmaputra silty alluvium MHL		x				2					
Brahmaputra silty alluvium MLL		x				2					
Brahmaputra silty alluvium LL		x			x						
Brahmaputra sandy alluvium MHL			O			2	3	3			
Brahmaputra sandy alluvium MLL			O			2	3	3			
Brahmaputra sandy alluvium LL			O				3	3			

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief,
WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency,
PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.2 Land suitability for the crop of **Aman (Transplant), Local** under specific limiting factors in Nakla upazila, Bangladesh.

	Suitability			Limiting factors							
Soil group	**S**	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramanagar		x				2		2	2		2
Pritimpasha		x						2	2		
Nalitabari		x									2
Nakla			o			2	3	2	2		2
Sherpur			o				3		2	2	2
Sonatola HL		x				2	2	2	2		
Sonatola MHL		x						2	2		
Silmondi MHL		x						2	2		
Silmondi MLL		x		2							
Ghatail MHL	√										
Ghatail MLL		x		2							
Balina MLL			o	2		3	2				
Balina LL			o	3		3	2				
Melandoho			o					3	2		
Dhamrai		x		2				2	2		
Brahmaputra silty alluvium MHL		x						2	2		
Brahmaputra silty alluvium MLL		x						2	2		
Brahmaputra silty alluvium LL			o	3				2	2		
Brahmaputra sandy alluvium MHL			o					3	3		
Brahmaputra sandy alluvium MLL			o	2				3	3		
Brahmaputra sandy alluvium LL			o	3		2		3	3		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief, WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency, PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.3 Land suitability for the crop of **Aman (Transplant), HYV** under specific limiting factors in Nakla upazila, Bangladesh.

Soil group	Suitability			Limiting factors							
	S	MS	NS	LT	RE	WR	DR	Tex	Con	PAM	pH
Ramnagar		x						2	2		2
Pritimpasha		x						2	2		
Nalitabari		x									x
Nakla			o				3	3	2		x
Sherpur			o				3	2	2		
Sonatola HL		x						2	2		
Sonatola MHL		x						2	2		
Silmondi MHL		x						2	2		
Silmondi MLL			o	3				2	2		
Ghatail MHL	√										
Ghatail MLL			o	3							
Balina MLL			o	3		3					
Balina LL			o	3		3					
Melandoho			o					3	2		
Dhamrai			o	3				2	2		
Brahmaputra silty alluvium MHL		x						2	2		
Brahmaputra silty alluvium MLL			o	3				2	2		
Brahmaputra silty alluvium LL			o	3		2		2	2		
Brahmaputra sandy alluvium MHL			o					3	3		
Brahmaputra sandy alluvium MLL			o	3				3	3		
Brahmaputra sandy alluvium LL			o	3		2		3	3		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief, WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency, PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.4 Land suitability for the crop of **Aus (Broadcast), Local** under specific limiting factors in Nakla upazila, Bangladesh.

	Suitability			Limiting factors							
Soil group	**S**	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar		**x**									2
Pritimpasha	√										
Nalitabari		x						2	2		2
Nakla		x					2	2			2
Sherpur		x					2				
Sonatola HL	√										
Sonatola MHL	√										
Silmondi MHL	√	x		2							
Silmondi MLL		x						2	2		
Ghatail MHL		x		2				2	2		
Ghatail MLL		x		2				2	2		
Balina MLL			o	3		3	3	2	2		
Balina LL			o	3		3	3	2	2		
Melandoho			o					3			
Dhamrai		x		2							
Brahmaputra silty alluvium MHL	√										
Brahmaputra silty alluvium MLL			o	3							
Brahmaputra silty alluvium LL			o	3							
Brahmaputra sandy alluvium MHL			o					3	3		
Brahmaputra sandy alluvium MLL			o	3				3	3		
Brahmaputra sandy alluvium LL			o	3							

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief,
WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency,
PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.5 Land suitability for the crop of **Aus (Transplant), HYV** under specific limiting factors in Nakla upazila, Bangladesh.

	Suitability			Limiting factors							
Soil group	**S**	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar		x							2		2
Pritimpasha		x							2		
Nalitabari		x									2
Nakla			o				3	3	2		2
Sherpur			o				3				
Sonatola HL		x							2		
Sonatola MHL		x							2		
Silmondi MHL		x							2		
Silmondi MLL			o	3					2		
Ghatail MHL	√										
Ghatail MLL			o	3							
Balina MLL			o	3		3					
Balina LL			o	3		3					
Melandoho			o					3	2		
Dhamrai			o	3					2		
Brahmaputra silty alluvium MHL		x							2		
Brahmaputra silty alluvium MLL			o	3					2		
Brahmaputra silty alluvium LL			o	3					2		
Brahmaputra sandy alluvium MHL			o					3	3		
Brahmaputra sandy alluvium MLL			o	3				3	3		
Brahmaputra sandy alluvium LL			o	3				3	3		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief, WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency, PAM – Plant available moisture, pH – Soil reaction

APPENDIX B-2

Table 2.6 Land suitability for the crop of **Boro, HYV** under specific limiting factors in Nakla upazila, Bangladesh.

	Suitability			Limiting factors							
Soil group	**S**	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar		x						2	2		2
Pritimpasha		x						2	2		2
Nalitabari		x									2
Nakla			o				3	3	2		2
Sherpur			o				3	2	2		
Sonatola HL		x						2	2		
Sonatola MHL		x						2	2		
Silmondi MHL		x						2	2		
Silmondi MLL		x						2	2		
Ghatail MHL	√										
Ghatail MLL	√										
Balina MLL	√										
Balina LL		x		2				3	2		
Melandoho			o					3	2		
Dhamrai		x						2	2		
Brahmaputra silty alluvium MHL		x		2				2	2		
Brahmaputra silty alluvium MLL		x						2	2		
Brahmaputra silty alluvium LL		x		2				2	2		
Brahmaputra sandy alluvium MHL			o					3	3		
Brahmaputra sandy alluvium MLL			o					3	3		
Brahmaputra sandy alluvium LL			o	2				3	3		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief, WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency, PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.7 Land suitability for the crop of **Bitter gourd** under specific limiting factors in Nakla upazila, Bangladesh.

	Suitability			Limiting factors							
Soil group	**S**	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar		x					2				
Pritimpasha			o	3		3	3				
Nalitabari			o	3		3	3	2	2		
Nakla		x						2			
Sherpur	√										
Sonatola HL			o				3				
Sonatola MHL			o	3		3	3				
Silmondi MHL			o	3		3	3				
Silmondi MLL			o	3		3	3				
Ghatail MHL			o	3		3	3		2		
Ghatail MLL			o	3		3	3	2	2		
Balina MLL			o	3		3	3	2	2		
Balina LL			o	3		3	3	2			
Melandoho			o	o		3	3	2	2		
Dhamrai			o	o		3	3				
Brahmaputra silty alluvium MHL			o	o		3	3				
Brahmaputra silty alluvium MLL			o	o		3	3				
Brahmaputra silty alluvium LL			o	o		3	3				
Brahmaputra sandy alluvium MHL			o	o		3	3	3	3		
Brahmaputra sandy alluvium MLL			o	o		3	3	2	3		
Brahmaputra sandy alluvium LL			o	o		3	3	3	3		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief,
WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency,
PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.8Land suitability for the crop of **Brinjal** under specific limiting factors in Nakla upazila, Bangladesh

Soil group	Suitability			Limiting factors							
	S	MS	NS	LT	RE	WR	DR	Tex	Con	PAM	pH
Ramnagar		x									2
Pritimpasha		x				2					
Nalitabari			o			3		2	2		2
Nakla		x						2	2		
Sherpur	√										
Sonatola HL	√										
Sonatola MHL		x				2					
Silmondi MHL		x				2					
Silmondi MLL			o	3		3					
Ghatail MHL		x				2		2	2		
Ghatail MLL			o	3		3		2	2		
Balina MLL			o	3		3	3	2	2		
Balina LL			o	3		3	3	2	2		
Melandoho			o	3		3					
Dhamrai		x				2		2			
Brahmaputra silty alluvium MHL		x				2					
Brahmaputra silty alluvium MLL			o	3		2					
Brahmaputra silty alluvium LL			o	3		3					
Brahmaputra sandy alluvium MHL			o	3		3					
Brahmaputra sandy alluvium MLL			o			2		3	3		
Brahmaputra sandy alluvium LL			o	3		2		3	3		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief,
WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency,
PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.9 Land suitability for the crop of **Cabbage** under specific limiting factors in Nakla upazila, Bangladesh.

Soil group	Suitability			Limiting factors							
	S	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar		x									2
Pritimpasha	√										
Nalitabari		x				2		2	2		2
Nakla		x						2			2
Sherpur	√										
Sonatola HL	√										
Sonatola MHL	√										
Silmondi MHL	√										
Silmondi MLL		x		2		2					
Ghatail MHL		x						2	2		
Ghatail MLL		x		2		2		2	2		
Balina MLL			o	2		3	3	2	2		
Balina LL			o	3		3	3	2	2		
Melandoho		x						2			
Dhamrai		x		2		2					
Brahmaputra silty alluvium MHL	√										
Brahmaputra silty alluvium MLL		x		2		2					
Brahmaputra silty alluvium LL			o	3		3					
Brahmaputra sandy alluvium MHL			o					3	3		
Brahmaputra sandy alluvium MLL			o	2		2		3	3		
Brahmaputra sandy alluvium LL			o	3	3			3	3		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief, WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency, PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.10 Land suitability for the crop of **Carrot** under specific limiting factors in Nakla upazila, Bangladesh.

Soil group	Suitability			Limiting factors							
	S	MS	NS	LT	RE	WR	DR	Tex	Con	PAM	pH
Ramnagar	√										
Pritimpasha		x		2			2				
Nalitabari			o	2		2		3	3		
Nakla	√										
Sherpur	√										
Sonatola HL		x					2				
Sonatola MHL		x		2			2				
Silmondi MHL		x		2			2				
Silmondi MLL		x		2		2	2				
Ghatail MHL			o	2			2	3	3		
Ghatail MLL			o	2		2	2	3	3		
Balina MLL			o	2		3	3	3	3		
Balina LL			o	3		3	3	3	3		
Melandoho		x		2			2				
Dhamrai		x		2		2	2				
Brahmaputra silty alluvium MHL		x		2			2				
Brahmaputra silty alluvium MLL		x		2		2	2				
Brahmaputra silty alluvium LL			o	3		3	2				
Brahmaputra sandy alluvium MHL			o	2			2	3	2		
Brahmaputra sandy alluvium MLL			o	2		2	2	3	2		
Brahmaputra sandy alluvium LL			o	3		2	2	3	2		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief, WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency, PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.11 Land suitability for the crop of **Cauliflower** under specific limiting factors in Nakla upazila, Bangladesh.

Soil group	Suitability			Limiting factors							
	S	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar		x									2
Pritimpasha	√										
Nalitabari		x				2		2	2		2
Nakla		x						2			2
Sherpur	√										
Sonatola HL	√										
Sonatola MHL	√										
Silmondi MHL	√										
Silmondi MLL		x		2		2					
Ghatail MHL		x						2	2		
Ghatail MLL		x		2		2		2	2		
Balina MLL			o	2		3	3	2	2		
Balina LL			o	3		3	3	2	2		
Melandoho		x						2			
Dhamrai		x		2		2					
Brahmaputra silty alluvium MHL	√										
Brahmaputra silty alluvium MLL		x		2		2					
Brahmaputra silty alluvium LL			o	3		3					
Brahmaputra sandy alluvium MHL			o					3	3		
Brahmaputra sandy alluvium MLL			o	2		2		3	3		
Brahmaputra sandy alluvium LL			o	3	3			3	3		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief,
WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency,
PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.12 Land suitability for the crop of **Chilli** under specific limiting factors in Nakla upazila, Bangladesh.

Soil group	**Suitability**			**Limiting factors**							
	S	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar		x									2
Pritimpasha	√										
Nalitabari			o			2		2	3		2
Nakla		x						2			2
Sherpur	√										
Sonatola HL	√										
Sonatola MHL	√										
Silmondi MHL	√										
Silmondi MLL		x		2		2					
Ghatail MHL			o					2	3		
Ghatail MLL			o	2		2		2	3		
Balina MLL			o	2		3	3	2	3		
Balina LL			o	3		3	3	2	3		
Melandoho		x						2			
Dhamrai		x		2		2					
Brahmaputra silty alluvium MHL	√										
Brahmaputra silty alluvium MLL		x		2		2					
Brahmaputra silty alluvium LL			o	3			3				

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief,
WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency,
PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.13 Land suitability for the crop of **Jute (Local)** under specific limiting factors in Nakla upazila, Bangladesh.

Soil group	Suitability			Limiting factors							
	S	MS	NS	LT	RE	WR	DR	Tex	Con	PAM	pH
Ramnagar		x									2
Pritimpasha	√										
Nalitabari		x						2	2		2
Nakla			o				3	2			2
Sherpur			o				3				
Sonatola HL	√										
Sonatola MHL	√										
Silmondi MHL	√										
Silmondi MLL	√										
Ghatail MHL		x						2	2		
Ghatail MLL		x						2	2		
Balina MLL			o			3	3	2	2		
Balina LL			o	o		3	3	2	2		
Melandoho		x						2			
Dhamrai	√										
Brahmaputra silty alluvium MHL	√										
Brahmaputra silty alluvium MLL	√										
Brahmaputra silty alluvium LL			o	o		2					
Brahmaputra sandy alluvium MHL			o					3	3		
Brahmaputra sandy alluvium MLL			o					3	3		
Brahmaputra sandy alluvium LL			o			2		3	3		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief, WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency, PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.14 Land suitability for the crop of **Jute (Tossa)** under specific limiting factors in Nakla upazila, Bangladesh.

	Suitability			Limiting factors							
Soil group	**S**	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar		x									2
Pritimpasha		x		2		2	2				
Nalitabari		x		2		2	2		2		2
Nakla		x						3			3
Sherpur	√										
Sonatola HL		x					2				
Sonatola MHL		x		2		2	2				
Silmondi MHL		x		2		2	2				
Silmondi MLL			o	3		2	2				
Ghatail MHL		x		2		2	2		2		
Ghatail MLL			o	3		2	2		2		
Balina MLL			o	3		3	3	2	2		
Balina LL			o	3		3	3	2	2		
Melandoho		x		2		2	2	2			
Dhamrai			o	3		2	2				
Brahmaputra silty alluvium MHL		x		2		2	2				
Brahmaputra silty alluvium MLL			o	3		2	2				
Brahmaputra silty alluvium LL			o	3		3	2				
Brahmaputra sandy alluvium MHL			o	2		2	2	3	3		
Brahmaputra sandy alluvium MLL			o	3		2	2	3	3		
Brahmaputra sandy alluvium LL			o	3		3	2	3	3		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief,
WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency,
PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.15 Land suitability for the crop of **Lady's finger (Kharif 1)** under specific limiting factors in Nakla upazila, Bangladesh.

	Suitability			Limiting factors							
Soil group	**S**	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar		x									2
Pritimpasha		x		2			2				
Nalitabari			o	2		2	2	3	3		2
Nakla		x									2
Sherpur	√										
Sonatola HL	√										
Sonatola MHL		x	x								
Silmondi MHL		x	x				2				
Silmondi MLL			o	3		2	2				
Ghatail MHL			o	2			2	3	3		
Ghatail MLL			o	3		2	2	3	3		
Balina MLL			o	3			3	3	3		
Balina LL			o	3		3	3	3	3		
Melandoho		x		2			2				
Dhamrai			o	3		2	2				
Brahmaputra silty alluvium MHL		x		2			2				
Brahmaputra silty alluvium MLL			o	3		2	2				
Brahmaputra silty alluvium LL			o	3		3	2				
Brahmaputra sandy alluvium MHL			o	2			2	3	3		
Brahmaputra sandy alluvium MLL			o	3				3	3		
Brahmaputra sandy alluvium LL						2	2				

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief, WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency, PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.16 Land suitability for the crop of **Lady's finger (Rabi))** under specific limiting factors in Nakla upazila, Bangladesh.

Soil group	Suitability			Limiting factors							
	S	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar		x									2
Pritimpasha		x				2					
Nalitabari			o			3		2	2		2
Nakla		x						2	2		
Sherpur	√										
Sonatola HL	√										
Sonatola MHL		x				2					
Silmondi MHL		x				2					
Silmondi MLL			o	3		3					
Ghatail MHL		x				2		2	2		
Ghatail MLL			o	3		3		2	2		
Balina MLL			o	3		3	3	2	2		
Balina LL			o	3		3	3	2	2		
Melandoho			o	3		3					
Dhamrai		x				2		2			
Brahmaputra silty alluvium MHL		x				2					
Brahmaputra silty alluvium MLL			o	3		2					
Brahmaputra silty alluvium LL			o	3		3					
Brahmaputra sandy alluvium MHL			o	3		3					
Brahmaputra sandy alluvium MLL			o			2		3	3		
Brahmaputra sandy alluvium LL			o	3		2		3	3		

**** In the suitability**

√ Suitable

x Moderately suitable

o Not suitable

***** In the limiting factor**

1 (Blank boxes) Non limiting

2 Moderately limiting

3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief,
WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency,
PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.17 Land suitability for the crop of **Maize** under specific limiting factors in Nakla upazila, Bangladesh.

	Suitability			Limiting factors							
Soil group	**S**	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar		x									2
Pritimpasha	√										
Nalitabari		x						2	2		2
Nakla		x						2			2
Sherpur	√										
Sonatola HL	√										
Sonatola MHL	√										
Silmondi MHL	√										
Silmondi MLL	√										
Ghatail MHL		x						2	2		
Ghatail MLL		x						2	2		
Balina MLL			o			3	3	2	2		
Balina LL			o			3	3	2	2		
Melandoho		x						2			
Dhamrai	√										
Brahmaputra silty alluvium MHL	√										
Brahmaputra silty alluvium MLL	√										
Brahmaputra silty alluvium LL		x		2		2					
Brahmaputra sandy alluvium MHL			o					3	3		
Brahmaputra sandy alluvium MLL			o					3	3		
Brahmaputra sandy alluvium LL			o	3		3		3	3		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief,
WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency,
PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.18 Land suitability for the crop of **Mustard** under specific limiting factors in Nakla upazila, Bangladesh.

Soil group	Suitability			Limiting factors							
	S	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Pritimpasha		x					2				
Nalitabari			o			2	2	3	3		2
Nakla		x						2	2		
Sherpur	√										
Sonatola HL		x					2				
Sonatola MHL		x					2				
Silmondi MHL		x					2				
Silmondi MLL		x				2	2				
Ghatail MHL			o				2	3	3		
Ghatail MLL			o			2	2	3	3		
Balina MLL			o			3	3	3	3		
Balina LL			o	2		3	3	3	3		
Melandoho		x					2	2			
Dhamrai		x				2	2				
Brahmaputra silty alluvium MHL		x					2				
Brahmaputra silty alluvium MLL		x					2				
Brahmaputra silty alluvium LL			o	2		3	2				
Brahmaputra sandy alluvium MHL			o				2	3	3		
Brahmaputra sandy alluvium MLL			o				2	3	3		
Brahmaputra sandy alluvium LL			o	3		3		3	3		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief, WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency, PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.19 Land suitability for the crop of **Pointed gourd** under specific limiting factors in Nakla upazila, Bangladesh.

	Suitability			Limiting factors							
Soil group	**S**	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar		x									2
Pritimpasha		x		2			2				
Nalitabari			o	2		2	2	3	3		2
Nakla		x									2
Sherpur	√										
Sonatola HL	√										
Sonatola MHL		x	x								
Silmondi MHL		x	x				2				
Silmondi MLL			o	3		2	2				
Ghatail MHL			o	2			2	3	3		
Ghatail MLL			o	3		2	2	3	3		
Balina MLL			o	3			3	3	3		
Balina LL			o	3		3	3	3	3		
Melandoho		x		2			2				
Dhamrai			o	3		2	2				
Brahmaputra silty alluvium MHL		x		2			2				
Brahmaputra silty alluvium MLL			o	3		2	2				
Brahmaputra silty alluvium LL			o	3		3	2				
Brahmaputra sandy alluvium MHL			o	2			2	3	3		
Brahmaputra sandy alluvium MLL			o	3				3	3		
Brahmaputra sandy alluvium LL						2	2				

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief, WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency, PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.20 Land suitability for the crop of **Potato** under specific limiting factors in Nakla upazila, Bangladesh.

Soil group	Suitability			Limiting factors							
	S	MS	NS	LT	RE	WR	DR	Tex	Con	PAM	pH
Ramnagar		x									2
Pritimpasha	√										
Nalitabari		x				2		2	2		2
Nakla		x									2
Sherpur	√										
Sonatola HL	√										
Sonatola MHL	√										
Silmondi MHL		x				2					
Silmondi MLL		x						2			
Ghatail MHL		x						2	2		
Ghatail MLL		x				2		2	2		
Balina MLL			o			3	3	2	2		
Balina LL			o	3		3	3	2	2		
Melandoho	√										
Dhamrai		x				2					
Brahmaputra silty alluvium MHL	√										
Brahmaputra silty alluvium MLL		x				2					
Brahmaputra silty alluvium LL			o	2		3					
Brahmaputra sandy alluvium MHL			o					3	3		
Brahmaputra sandy alluvium MLL			o			2		3	3		
Brahmaputra sandy alluvium LL			o	2		3		3	3		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief,
WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency,
PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.21 Land suitability for the crop of **Radish** under specific limiting factors in Nakla upazila, Bangladesh.

	Suitability			Limiting factors							
Soil groups	**S**	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar	√										
Pritimpasha		x		2			2				
Nalitabari			o	2		2		3	3		
Nakla	√										
Sherpur	√										
Sonatola HL		x					2				
Sonatola MHL		x		2			2				
Silmondi MHL		x		2			2				
Silmondi MLL		x		2		2	2				
Ghatail MHL			o	2			2	3	3		
Ghatail MLL			o	2		2	2	3	3		
Balina MLL			o	2		3	3	3	3		
Balina LL			o	3		3	3	3	3		
Melandoho		x		2			2				
Dhamrai		x		2		2	2				
Brahmaputra silty alluvium MHL		x		2			2				
Brahmaputra silty alluvium MLL		x		2		2	2				
Brahmaputra silty alluvium LL			o	3		3	2				
Brahmaputra sandy alluvium MHL			o	2			2	3	2		
Brahmaputra sandy alluvium MLL			o	2		2	2	3	2		
Brahmaputra sandy alluvium LL			o	3		2	2	3	2		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief,
WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency,
PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.22 Land suitability for the crop of **Red amaranth** under specific limiting factors in Nakla upazila, Bangladesh.

	Suitability			Limiting factors							
Soil group	**S**	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar		x									2
Pritimpasha		x				2					
Nalitabari			o			3		2	2		2
Nakla		x						2			2
Sherpur	√										
Sonatola HL	√										
Sonatola MHL		x				2					
Silmondi MHL		x				2					
Silmondi MLL			o	3		3					
Ghatail MHL		x		3		2		2	2		
Ghatail MLL			o	3		3		2	2		
Balina MLL			o	3		3	3	2	2		
Balina LL			o	3		3	3	2	2		
Melandoho			o	3		3					
Dhamrai		x				2		2			
Brahmaputra silty alluvium MHL		x				2					
Brahmaputra silty alluvium MLL			o	3		2					
Brahmaputra silty alluvium LL			o	3		3					
Brahmaputra sandy alluvium MHL			o	3		3					
Brahmaputra sandy alluvium MLL			o			2		3	3		
Brahmaputra sandy alluvium LL			o	3		2		3	3		

**** In the suitability**

√ Suitable

x Moderately suitable

o Not suitable

***** In the limiting factor**

1 (Blank boxes) Non limiting

2 Moderately limiting

3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief,
WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency,
PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.23 Land suitability for the crop of **Snake gourd** under specific limiting factors in Nakla upazila, Bangladesh.

	Suitability			Limiting factors							
Soil groups	**S**	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar		x					2				
Pritimpasha			o	3		3	3				
Nalitabari			o	3		3	3	2	2		
Nakla		x						2			
Sherpur	√										
Sonatola HL			o				3				
Sonatola MHL			o	3		3	3				
Silmondi MHL			o	3		3	3				
Silmondi MLL			o	3		3	3				
Ghatail MHL			o	3		3	3		2		
Ghatail MLL			o	3		3	3	2	2		
Balina MLL			o	3		3	3	2	2		
Balina LL			o	3		3	3	2			
Melandoho			o	o		3	3	2	2		
Dhamrai			o	o		3	3				
Brahmaputra silty alluvium MHL			o	o		3	3				
Brahmaputra silty alluvium MLL			o	o		3	3				
Brahmaputra silty alluvium LL			o	o		3	3				
Brahmaputra sandy alluvium MHL			o	o		3	3	3	3		
Brahmaputra sandy alluvium MLL			o	o		3	3	2	3		
Brahmaputra sandy alluvium LL			o	o		3	3	3	3		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief, WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency, PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.24 Land suitability for the crop of **Spinach** under specific limiting factors in Nakla upazila, Bangladesh.

Soil group	Suitability			Limiting factors							
	S	MS	NS	LT	RE	WR	DR	Tex	Con	PAM	pH
Ramnagar		x									2
Pritimpasha		x				2					
Nalitabari			o			3		2	2		2
Nakla		x						2			2
Sherpur	√										
Sonatola HL	√										
Sonatola MHL		x				2					
Silmondi MHL		x				2					
Silmondi MLL			o	3		3					
Ghatail MHL		x		3		2		2	2		
Ghatail MLL			o	3		3		2	2		
Balina MLL			o	3		3	3	2	2		
Balina LL			o	3		3	3	2	2		
Melandoho			o	3		3					
Dhamrai		x				2		2			
Brahmaputra silty alluvium MHL		x				2					
Brahmaputra silty alluvium MLL			o	3		2					
Brahmaputra silty alluvium LL			o	3		3					
Brahmaputra sandy alluvium MHL			o	3		3					
Brahmaputra sandy alluvium MLL			o			2		3	3		
Brahmaputra sandy alluvium LL			o	3		2		3	3		

**** In the suitability**

√ Suitable

x Moderately suitable

o Not suitable

***** In the limiting factor**

1 (Blank boxes) Non limiting

2 Moderately limiting

3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief, WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency, PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.25 Land suitability for the crop of **Teasle** under specific limiting factors in Nakla upazila, Bangladesh.

Soil group	Suitability			Limiting factors							
	S	MS	NS	LT	RE	WR	DR	Tex	Con	PAM	pH
Ramnagar		x					2				
Pritimpasha			o	3		3	3				
Nalitabari			o	3		3	3	2	2		
Nakla		x						2			
Sherpur	√										
Sonatola HL			o				3				
Sonatola MHL			o	3		3	3				
Silmondi MHL			o	3		3	3				
Silmondi MLL			o	3		3	3				
Ghatail MHL			o	3		3	3		2		
Ghatail MLL			o	3		3	3	2	2		
Balina MLL			o	3		3	3	2	2		
Balina LL			o	3		3	3	2			
Melandoho			o	o		3	3	2	2		
Dhamrai			o	o		3	3				
Brahmaputra silty alluvium MHL			o	o		3	3				
Brahmaputra silty alluvium MLL			o	o		3	3				
Brahmaputra silty alluvium LL			o	o		3	3				
Brahmaputra sandy alluvium MHL			o	o		3	3	3	3		
Brahmaputra sandy alluvium MLL			o	o		3	3	2	3		
Brahmaputra sandy alluvium LL			o	o		3	3	3	3		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief,
WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency,
PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.26 Land suitability for the crop of **Tomato** under specific limiting factors in Nakla upazila, Bangladesh

Soil group	Suitability			Limiting factors							
	S	MS	NS	LT	RE	WR	DR	Tex	Con	PAM	pH
Ramnagar		x									2
Pritimpasha	√										
Nalitabari		x				2		2	2		2
Nakla		x						2			2
Sherpur	√										
Sonatola HL	√										
Sonatola MHL	√										
Silmondi MHL	√										
Silmondi MLL		x		2		2					
Ghatail MHL		x						2	2		
Ghatail MLL		x		2		2		2	2		
Balina MLL			o	2		3	3	2	2		
Balina LL			o	3		3	3	2	2		
Melandoho		x						2			
Dhamrai		x		2		2					
Brahmaputra silty alluvium MHL	√										
Brahmaputra silty alluvium MLL		x		2		2					
Brahmaputra silty alluvium LL			o	3		3					
Brahmaputra sandy alluvium MHL			o					3	3		
Brahmaputra sandy alluvium MLL			o	2		2		3	3		
Brahmaputra sandy alluvium LL			o	3		3		3	3		

**** In the suitability**

√ Suitable

x Moderately suitable

o Not suitable

***** In the limiting factor**

1 (Blank boxes) Non limiting

2 Moderately limiting

3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief, WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency, PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.27 Land suitability for the crop of **Turnip** under specific limiting factors in Nakla upazila, Bangladesh.

Soil group	Suitability			Limiting factors							
	S	MS	NS	LT	RE	WR	DR	Tex	Con	PAM	pH
Ramnagar	√										
Pritimpasha		x		2			2				
Nalitabari			o	2		2		3	3		
Nakla	√										
Sherpur	√										
Sonatola HL		x					2				
Sonatola MHL		x		2			2				
Silmondi MHL		x		2			2				
Silmondi MLL		x		2		2	2				
Ghatail MHL			o	2			2	3	3		
Ghatail MLL			o	2		2	2	3	3		
Balina MLL			o	2		3	3	3	3		
Balina LL			o	3		3	3	3	3		
Melandoho		x		2			2				
Dhamrai		x		2		2	2				
Brahmaputra silty alluvium MHL		x		2			2				
Brahmaputra silty alluvium MLL		x		2		2	2				
Brahmaputra silty alluvium LL			o	3		3	2				
Brahmaputra sandy alluvium MHL			o	2			2	3	2		
Brahmaputra sandy alluvium MLL			o	2		2	2	3	2		
Brahmaputra sandy alluvium LL			o	3		2	2	3	2		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief, WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency, PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -2

Table 2.28 Land suitability for the crop of **Wheat** under specific limiting factors in Nakla upazila, Bangladesh.

	Suitability			Limiting factors							
Soil group	**S**	**MS**	**NS**	**LT**	**RE**	**WR**	**DR**	**Tex**	**Con**	**PAM**	**pH**
Ramnagar		x									2
Pritimpasha	√										
Nalitabari		x				2					2
Nakla		x						2			2
Sherpur	√										
Sonatola HL	√										
Sonatola MHL	√										
Silmondi MHL	√										
Silmondi MLL		x				2					
Ghatail MHL	√										
Ghatail MLL		x				2					
Balina MLL			o			3	3				
Balina LL			o	2		3	3				
Melandoho		x						2			
Dhamrai		x				2					
Brahmaputra silty alluvium MHL	√										
Brahmaputra silty alluvium MLL	√										
Brahmaputra silty alluvium LL			o	2		3					
Brahmaputra sandy alluvium MHL			o					3	3		
Brahmaputra sandy alluvium MLL			o					3	3		
Brahmaputra sandy alluvium LL			o	2		3		3	3		

**** In the suitability**
√ Suitable
x Moderately suitable
o Not suitable

***** In the limiting factor**
1 (Blank boxes) Non limiting
2 Moderately limiting
3 Strictly limiting

S - Suitable, MS - Moderately suitable, NS - Not suitable, LT – Land type, RE – Relief,
WR – Water recession, DR – Drainage, Tex- Texture, Con – Consistency,
PAM – Plant available moisture, pH – Soil reaction

APPENDIX B -3

Table 3.1: Suitable and moderately suitable soils for selected crops

Crops	Suitable			Moderately Suitable		
	Soil group	Area, ha	Percentage, out of the total area	Soil group	Area, ha	Percentage, out of the total area
T Aus HYV IR	Ghatail MHL	984	5.67	Ramnagar	5703	32.86
				Pritimpasha		
				Nalitabari		
				Silmondi MHL		
				Brahmaputra silty alluvium MHL		
				Sonatala HL		
				Sonatala MHL		
B Aus Local	Pritimpasha	1274	7.34	Ramnagar	8716	50.23
	Silmondi MHL			Nalitabari		
	Brahmaputra silty alluvium MHL			Nakla		
				Sonatala HL		
				Sonatala MHL		
				Ghatail MHL		
				Ghatail MLL		
				Dhamrai		
T Aman HYV IR	Ghatail MHL	984	5.67	Ramnagar	5703	32.86
				Pritimpasha		
				Nalitabari		
				Sonatala HL		
				Sonatala MHL		
				Silmondi MHL		
				Brahmaputra silty alluvium MHL		
T Aman Local	Ghatail MHL	984	5.67	Ramnagar	8726	50.29
				Pritimpasha		
				Nalitabari		
				Sonatala HL		
				Sonatala MHL		
				Silmondi MHL		
				Silmondi MLL		

APPENDIX B -3

Table 3.2: Suitable and moderately suitable soils for selected crops

Crops	Suitable			Moderately Suitable		
	Soil group	**Area, ha**	**Percentage, out of the total area**	**Soil group**	**Area, ha**	**Percentage, out of the total area**
B Aman	Silmondi MLL	554	3.19	Pritimpasha	7250	41.78
	Dhamrai			Nalitabari		
				Sonatala MHL		
				Silmondi MHL		
				Ghatail MHL		
				Ghatail MLL		
				Brahmapura silty alluvium MLL		
				Brahmapura silty alluvium LL		
Boro HYV	Ghatail MHL	3762	21.68	Ramnagar	7288	42.00
	Ghatail MLL			Pritimpasha		
	Balina MLL			Nalitabari		
Wheat	Pritimpasha	9384	50.08	Ramnagar	4279	24.66
	Sherpur			Nalitabari		
	Sonatola HL			Nakla		
	Sonatola MHL			Silmondi MLL		
	Silmondi MHL			Ghatail MLL		
	Ghatail MHL			Melandoho		
	Brahmaputra silty alluvium MHL			Dhamrai		
	Brahmaputra silty alluvium MLL					
Maize	Pritimpasha	8954	51.6	Ramnagar	4832	27.85
	Silmondi MHL			Nalitabari		
	Silmondi MLL			Nakla		
	Dhamrai			Ghatail MHL		
	Brahmaputra silty alluvium MHL			Ghatail MLL		
	Brahmaputra silty alluvium MLL			Melandoho		
	Sherpur			Brahmaputra silty alluvium LL		
	Sonatola HL					
	Sonatola MHL					

APPENDIX B -3

Table 3.3: Suitable and moderately suitable soils for selected crops

Crops	**Suitable**			**Moderately Suitable**		
	Soil group	**Area, ha**	**Percentage, out of the total area**	**Soil group**	**Area, ha**	**Percentage, out of the total area**
Crop Mustard HYV	Sherpur	2506	14.44	Ramnagar	7925	45.67
				Pritimpasha		
				Nakla		
				Silmondi MHL		
				Silmondi MLL		
				Melandoho		
				Dhamrai		
				Brahmaputra silty alluvium MHL		
				Brahmaputra silty alluvium MLL		
				Sonatola HL		
				Sonatola MHL		
Jute, Tosha	Sherpur	2506	14.44	Ramnagar	8134	46.87
				Pritimpasha		
				Nalitabari		
				Nakla		
				Sonatola HL		
				Sonatola MHL		
				Silmondi MHL		
				Ghatail MHL		
				Melandoho		
				Brahmaputra silty alluvium MHL		
Jute, Local	Pritimpasha	6448	37.16	Ramnagar	5235	29.65
	Sonatola HL			Pritimpasha		
	Sonatola MHL			Nalitabari		
	Silmondi MHL			Nakla		
	Silmondi MLL			Sherpur		
	Brahmaputra silty alluvium MHL			Ghatail MHL		
	Dhamrai			Melandoho		
	Brahmaputra silty alluvium MLL					

APPENDIX B -3

Table 3.4: Suitable and moderately suitable soils for selected crops

Crops	Suitable			Moderately Suitable		
	Soil group	Area, ha	Percentage, out of the total area	Soil group	Area, ha	Percentage, out of the total area
Crop Potato	Pritimpasha	7732	44.56	Ramnagar	5931	34.18
	Melandoho			Nalitabari		
	Brahmaputra silty alluvium MHL			Nakla		
	Brahmaputra silty alluvium MLL			Silmondi MHL		
	Sherpur			Silmondi MLL		
	Sonatola HL			Ghatail MHL		
	Sonatola MHL			Ghatail MLL		
				Dhamrai		
Cauliflower,cabbage	Pritimpasha	8000	46.11	Ramnagar	5663	32.64
	Silmondi MHL			Nalitabari		
	Brahmaputra silty alluvium MHL			Nakla		
	Sherpur			Silmondi MLL		
	Sonatola HL			Ghatail MHL		
	Sonatola MHL			Ghatail MLL		
				Melandoho		
				Dhamrai		
				Brahmaputra silty alluvium MLL		
Crop Tomato	Pritimpasha	8000	46.11	Ramnagar	5663	32.64
	Silmondi MHL			Nalitabari		
	Brahmaputra silty alluvium MHL			Nakla		
	Sherpur			Silmondi MLL		
	Sonatola HL			Ghatail MHL		
	Sonatola MHL			Ghatail MLL		
				Melandoho		
				Dhamrai		
				Brahmaputra silty alluvium MLL		
Brinjal, Lady's Finger	Sonatola HL	4220	24.32	Ramnagar	6241	35.97
	Sherpur			Pritimpasha		
				Nakla		
				sonatala MHL		
				Dhamrai		
				Silmondi MHL		
				Ghatail MHL		
				Melandoho		
				Brahmaputra silty alluvium MHL		

APPENDIX B -3

Table 3.5: Suitable and moderately suitable soils for selected crops

Crops	Suitable			Moderately Suitable		
	Soil group	Area, ha	Percentage, out of thje total area	Soil group	Area, ha	Percentage, out of the total area
Crop Spinach, red amaranth	Pritimpasha	8000	46.11	Ramnagar	2431	14.01
	Silmondi MHL			Nakla		
	Brahmaputra silty alluvium MHL			Silmondi MLL		
	Sherpur			Melandoho		
	Sonatola HL			Dhamrai		
	Sonatola MHL			Brahmaputra silty alluvium MLL		
Crop Chilli	Pritimpasha	8000	46.11	Ramnagar	2431	14.01
	Silmondi MHL			Nakla		
	Brahmaputra silty alluvium MHL			Silmondi MLL		
	Sherpur			Melandoho		
	Sonatola HL			Dhamrai		
	Sonatola MHL			Brahmaputra silty alluvium MLL		
Crop Potol, Lady's Finger	Sherpur	4505	25.96	Ramnagar	2751	15.85
Kharif	Sonatola HL			Pritimpasha		
				Nakla		
				Silmondi MHL		
				Melandoho		
				Brahmaputra silty alluvium MHL		
				Sonatala MHL		
Crop Raddish Turnip Carrot	Ramnagar	3500	20.17	Pritimpasha	2711	15.62
	Nakla			Silmondi MHL		
	Sherpur			Silmondi MLL		
				Melandoho		
				Dhamrai		
				Brahmaputra silty alluvium MHL		
				Brahmaputra silty alluvium MLL		
				Sontala HL		
				Sonatala MHL		
Crop Bitter gourd,snake gourd and stripe gourdl	Sherpur	2506	14.44	Ramnagar	994	5.73
				Nakla		

APPENDIX B -4

Table 1: Growing season of major crops

Crop	Time of sowing/transplanting	Time of harvest
1.Aus paddy:		
(a) Local broadcast	Mid March to mid April	Mid July to early August
(b) HYV Transplant	Mid March to mid April	July to August
(c) HYV Broadcast	Mid March to mid April	Late July to August
2.Aman Paddy:		
(a) Local Transplant	End June to early September	December to early January
(b)Local broadcast	Mid March to mid April	Mid November to mid December
(c) HYV Transplant	Late June to mid August	December to early January
3.Boro paddy:		
(a) Local	Mid November to mid January	April to May
(b) HYV	December to mid February	Mid April to June
4.Wheat:	November to December	March to mid April
5.Maize(rabi)	Mid October to late December	Early April to end May
6.Jute:		
(a) Local	Early March to mid April	July to August
(b) Tossa	Mid April to early May	August to September
7.Mustard	Mid October to mid November	Late January to mid February
8.Chillies:		
(a) Kharif	Mid April to mid July	3-4 months after sowing
(b) Rabi	Mid November to mid January	3-4 months after sowing
9.Cauliflower	Late October to mid November	Early January to early March
10.Cabbage	October to mid November	Early January to early March
11.Tomato	Mid August to late November	Beginning December to mid January
12.Radish	Mid August to early October	Early January to mid February
13.Carrot	September to mid December	December to January
14.Turnip	September to mid December	Mid November to mid February
15.Potato	Mid September to November	Mid January to March
16.Brinjal	October to mid November	Late November to mid April
17.Spinach	September to mid November	1-4 months after sowing
18.Red amaranth	Throughout the year	Throughout the year
19.Bottle gourd	Mid July to early November	Early January to early March
20.Bitter gourd:		
(a)Uchcheya	Mid February to early June	Mid June to mid October
(b) Karala	Mid April to mid June	Mid June to mid August
21.Lady's finger/Okra	Mid April to mid June	June to mid September
22.Pointed gourd	Mid August to mid October	Mid January to March
23.Snake gourd	Mid February to end April	July to September
24.Teasle	Mid April to mid June	Mid July to mid September
25.Stripe gourd	Mid April to mid July	Mid June to mid August
23.Indian Spinach	Mid March to early June	Late August to mid November

APPENDIX C-1

Table 1: Income from crop (Rabi) (Continuation of table 1)

Soil group	Area, ha	Veg. & crop	Income Tk /ha	Total income Tk/soil group
Silmondi MLL	284	Maize	45305	12866620
		Mustard *	24259	6889468
		Boro HYV*	37173	10557047
Dhamrai	270	Maize	45305	12232350
		Mustard*	24259	6549845
		Chilli *	83602	22572622
		Potato*	352656	95217120
		Boro HYV*	37173	10036629
Ghatail MLL	2069	Boro HYV	37173	76910316
Balina MLL	709	Boro HYV	37173	26355444
Balina LL	508	Boro HYV*	37173	18883732
Brahmaputra silty alluvium MLL	400	Wheat	29375	11750040
		Potato	352656	141062400
		Maize	45305	18122000
		BoroHYV*	37173	14869080
		Mustard*	24259	9703476

Note *-crops are moderately suitable, yield calculated as 30 percent less from suitable crops.

APPENDIX C-2

Table 2: Income from crop (Kharif 1)

Soil group	Area, ha	Veg. & crop	Income/ha	Total income Tk/soil group
Ramnagar	30	Bitter gourd*	165580.80	4967424
		Teasle gourd*	115059.04	3451771
		Av: Veg	140319.92	4209598
		B Aus local*	11788.20	353646
Pritimpasha	89	B Aus local	11788.20	1049150
		T Aus HYV*	23810.18	2119106
		Jute local	57041.25	5076671
Nakla	964	Bitter gourd*	82130.00	79173320
		Teasle gourd*	74882.00	72186248
		Stripe Gourd*	67200.00	64780800
		Av: Veg	74737.33	72046789
Sherpur	2506	Bitter gourd	165580.80	414945485
		Stripe Gourd	166682.88	417707297
		Snake gourd	64761.76	162292971
		Lady's Finger	46422.72	116335336
		Av: Veg	110862.04	277820272
		B Aus local*	11788.20	29541229
		Tossa Jute	78137.33	195812136
Sonatala HL	1999	B Aus local	11788.20	23564612
		Jute, local	57041.25	114025459
		Lady's Finger	46422.72	92799017
		Jute, Tossa*	78137.33	156196513
Sonatala MHL	2221	B Aus local	11788.20	26181592
		Jute, local	57041.25	126688616
Melandaha	483	Jute local MS	57041.25	27550924
Silmondi MHL	1151	B Aus local	11788.20	13568218
		T Aus HYV*	23810.18	27405511
		Boro HYV*	37172.70	42785778
Ghatail MHL	984	T Aus HYV	23810.18	23429212
Brahmaputra silty alluvium MHL	34	B Aus local	11788.20	400799
		Jute local	57041.25	1939403
Silmondi MLL	284	Jute local	57041.25	16199715
Brahmaputra silty alluvium MLL	400	Jute local	57041.25	22816500

Note *****-crops are moderately suitable, yield calculated as 30 percent less from suitable crops.

APPENDIX C-3

Table 3: Income from crop (Kharif 2)

Soil group	Area, ha	Veg. & crop	Income/ha	Total income Tk/soil group
Pritimpasha	89	T Aman HYV*	23938	2130464
Nalitabari	179	T Aman local*	17525	3137058
Sonatala HL	1999	T Aman HYV*	23938	47851652
Sonatala MHL	2221	T Aman HYV*	23938	53165843
Silmondi MHL	1151	T Aman HYV*	23938	27552402
Ghatail MHL	984	T Aman HYV	23938	23554790
		T Aman local	17525	17245055
Brahmaputra silty alluvium MHL	34	T Aman HYV*	23938	813885
Silmondi MLL	284	B Aman	42375	12034500
Dhamrai	270	B Aman	42375	11441250
Ghatail MLL	2069	B Aman*	42375	87673875
		T Aman local*	17525	36260182

Note *****-crops are moderately suitable, yield calculated as 30 percent less from suitable crops.

DEFINITIONS

Agricultural holding- An agricultural holding is a techno-economic unit of agricultural production under single management comprising all livestock kept and all lands used wholly or partly for agricultural production purpose, without regard to title, legal form or size.

Agricultural labour household –It refers to a holding whose major source of income was obtained by working as agricultural labour.

Calorie –Calorie is the unit of heat. It is the amount of heat that requires to change the temperature of water to 1 degree Celsius. In case of poverty measure, Kcal is used as the unit.

Earner- An earner is person who brings material return in cash or kind for services rendered and for the use of good.

EL Nino- EL Nino is a sgift in ocean temperatures and atmospheric conditions in the tropical Pacific that disrupt weather around the world. It is a poorly understood recurrent climatic phenomenon that primarily affects the Pacific coast of South America, but has dramatic impacts on weather pattern all over the world.

Farm holding- A farm holding is a techno-economic unit of agricultural production comprising all livestock kept and all lands used wholly or partly for agricultural production purpose and is operated under single management by one person alone or with others or by judicial person with out regard to title, legal form, size or location. Household with less than 0.02 ha of cultivated area are treated as non-farm household.

Homestead area- The area of residence of the holder's household with all its structures, courtyard and the land occupied by the passage for entrance and exit.

Household –A household means a group of persons normally living together and eating in one mess, (i.e. with common arrangement of cooking) with their dependents and relatives.

Human carrying capacity- Ehrlich (1994) defined carrying capacity of an ecosystem as the "maximum population size of a species that an area can support without reducing its ability to support the same species in the future".

Income – Income means material return in cash or kind received in exchange of goods and services in a particular period.

Land type –Land levels in relation to seasonal normal flooding have generated 5 grades of depth of flooding. These grades have generally and conveniently become known as land type.

Plant available moisture- With retreat of south westerly monsoon or cessation of rainy season, high water mark of ground water drops down, desiccation starts and at a certain stage soil attains field capacity. Subsequently, depletion of soil moisture takes place and only a portion of stored soil moisture is available for plants.

Rural area – The rest of the area of the country including other urban areas is treated as rural areas.

Soil consistence –Soil consistence comprises the attributes of soil material that are expressed by the degree and kind of cohesion and adhesion or by the resistance to deformation or rupture.

Soil drainage – Soil drainage refers to frequency and duration of period when the soil is free of saturation or partial saturation.

Soil group- Considering soil from its land use point of view, same in parent material, having similar physical, physico-chemical properties and use potential are stored in one compartment called "soil group".

Soil reaction (pH)- Soil reaction or pH is a measure of the intensity of acidity or alkalinity.

Soil texture _ soil texture refers to the relative proportions of the clay, silt and sand below 2mm in diameters in a mass of soil.

Top soil – It includes the surface horizon. Continuous cultivation by plough results in the formation of a hard pan immediately below the cultivated layer, which is also included in top soil.

Water recession- After cessation of rainy season, free standing water from land surface drains out in different periods depending on local factors.

Upazila – Lower administrative unit