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# Mapping marginality hotspots and agricultural potentials in Bangladesh

Mohammad Abdul Malek, Md. Amzad Hossain, Ratnajit Saha, Franz W. Gatzweiler

# Abstract

Although Bangladesh made some remarkable achievements in reducing poverty and in improving social and economic outcomes in recent decades, about one-third of the rural population still lives below the upper poverty line most of whom depend on agriculture as their primary source of income. One of the reasons for their poverty is the low productivity that results from sub-optimal use of inputs and other technology. To foster agricultural productivity and rural growth, technology innovations have to reach all strata of the poor among small farming communities in rural Bangladesh. For that purpose, technology opportunities need to be brought together with systematic and location-specific actions related to technology needs, agricultural systems, ecological resources and poverty characteristics to overcome the barriers that economic, social, ecological and cultural conditions can create. The first step towards this is to identify underperforming areas, i.e. rural areas in which the prevalence of poverty and other dimensions of marginality are high and agricultural potential is also high since in such areas yield gaps (potential minus actual yields) are high and productivity gains (of main staple crops) are likely to be achieved. The marginality mapping presented in this paper has attempted to identify areas with high prevalence of societal and spatial marginality-– based on proxies for marginality dimensions representing different spheres of life-–and high (un/der utilized) agricultural (cereal) potentials. The overlap between the marginality hotspots and the high (un/der utilized) agricultural potentials shows that *Rajibpur (Kurigram), Dowarabazar (Sunamgonj), Porsha (Naogaon), Damurhuda (Chuadanga), Hizla (Barisal), Mehendigonj (Barisal), Bauphal (Patuakhali) and Bhandaria (Pirojpur)* are the marginal areas where most productivity gains could be achieved.



**Keywords**: Marginality, agricultural potentials, marginality hotspot mapping, agricultural potential mapping, crop suitability mapping, marginality and potential overlap mapping.

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# 1 Introduction

Bangladesh had made remarkable achievements in reducing poverty and in improving other social and economic outcomes in recent decades, but 31% of the population still lives below the upper poverty line[1] (BBS[2] 2010d).With almost 80 out of 100 poor people living in rural areas, poverty in Bangladesh is largely a rural phenomenon (World Bank 2012). Most of the rural people depend on agriculture as the main source of income. Almost 54% of the rural population is employed in agriculture and the remainder is in the rural non-farm (RNF) sector. Agriculture contributes to about 20% of Bangladesh's GDP (BBS 2010a), whereas another 33% of GDP is contributed by the rural non-farm economy, which is to a large extent linked to agriculture (World Bank 2012). Since agricultural growth is essential for fostering economic development and feeding growing populations in most less developed countries (Datt & Ravallion 1996), improved economic performance of the agricultural sector is crucial to reduce poverty in Bangladesh.

Bangladesh recently achieved self-sufficiency in food, particularly rice. That was a major milestone in reducing poverty in the country that was mainly accomplished through the green revolution and facilitated by the research of several national and international agricultural research institutions. At present in Bangladeshi agriculture there is very limited scope for expansion of the land frontier and the intensity of cropping has almost reached the limit, and thus, the growth of crop production now depends almost entirely on technological progress (Hossain 2005). However, the current agricultural technology system is unable to effectively generate, transfer and promote the use of modern technologies to increase agricultural productivity and meet the changing needs of all strata of farmers (World Bank 2012; Reardon *et al.* 2012). A dynamic agricultural technology innovation system that can address the technology needs of different strata of the farmers is therefore crucial to ensure national food security and reduce poverty in the face of a declining agricultural land base and an increasing population. To reach all strata of the poor among small farming communities with innovations that foster agricultural productivity and rural growth, technology opportunities need to be brought together with systematic and location-specific actions/interventions adjusted to technology needs, agricultural systems, ecological resources and poverty characteristics to overcome the barriers that economic, social, ecological and cultural conditions can create. In recent decades, marginal regions especially in poor developing countries and emerging economies in Sub-Saharan Africa and South Asia are gaining much attention in the development literature (Conway 1999; Fan & Hazell 2000; Pinstrup-Anderson &Pandya-Lorch 1994; Ruben, Pender & Kuyvenhoven 2007; Pender 2007; Reardon *et al.* 2012). The first step towards designing systematic interventions is to identify underperforming areas, i.e. rural areas in which the prevalence of poverty and other dimensions of marginality are high and agricultural potential is also high since in such areas yield gaps (potential minus actual yields) are high and productivity gains (of main staple crops) are likely to be achieved.

Thus, this paper identifies areas (sub-districts in Bangladesh) with high prevalence of societal and spatial marginality– based on proxies for marginality dimensions representing different spheres of life  which are overlaid with areas of high (un/der utilized) agricultural crop potentials. For the marginality mapping, data were taken or calculated from the Household Income and Expenditure Survey (HIES) 2010[3] (BBS 2010f) and the Multiple Indicator Cluster Survey (MICS)

[1] The upper poverty line is a measure used by Bangladesh Bureau of Statistics (BBS) to denote the moderate poor- estimated by adding to the food poverty lines with the upper non-food allowances.

[2] Bangladesh Bureau of Statistics

[3] HIES 2010 was carried out by BBS which followed a two-stage sample design. For the survey 612 Primary Sampling Units (PSUs) were selected systematically from 16 strata as a subset of Integrated Multi-purpose Sample (IMPS) design. The sample size was 12,240 households where 7,840 were from rural area and 4,400 from urban area. A number of innovative techniques were adopted in the survey operation and also in methodology for conducting HIES 2010.

2009[4] (UNICEF 2010) and the district series of Yearbook of Agricultural Statistics (BBS 2010b). The crop suitability assessment was done using crop zoning data from the Bangladesh Agricultural Research Council (BARC) 2012. The data on agricultural potentials were taken from the Yearbook of Agricultural Statistics (BBS 2010b).

The marginality hotspot map identifies the North-East and the South-East regions, some sub-districts of Haor region and the hill track region. The agricultural potentials map shows that the Southern Coastal area and some sub-districts of the Haor basins have the highest underused agricultural potentials. The overlap between these two maps shows that *Rajibpur (Kurigram), Dowarabazar (Sunamgonj), Porsha (Naogaon), Damurhuda (Chuadanga), Hizla (Barisal), Mehendigonj (Barisal), Bauphal (Patuakhali) and Bhandaria (Pirojpur)* are the marginal sub-districts where potential in agriculture could still be explored.

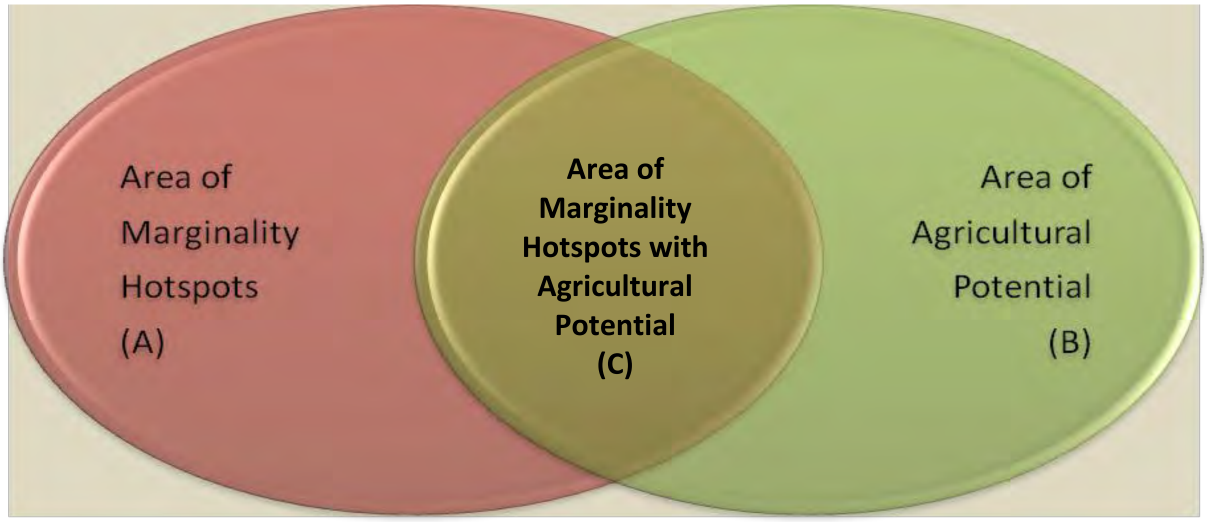
The organization of the paper goes as follows: Section 2 discusses the rationale behind the mapping and the approach to mapping. Section 3 outlines the conceptual issues regarding marginality and identifies the marginality hotspots of Bangladesh based on different dimensions of marginality. Section 4 maps the agricultural potentials of different sub-districts based on several indicators. Section 5 overlays the marginality hotspot map with the agricultural potential map to find the marginal areas with highest agricultural potentials. Finally, Section 6 draws overall conclusions and highlights some limitations.

[4]The MICS survey is a UNICEF developed household survey which fills data gaps for monitoring human development, particularly regarding the situation of children and women. With technical support from UNICEF, BBS conducted the 2009 survey among 300,000 households. The 2009 MICS used a much larger sample size than previous MICS, and is the first time that data has been collected at upazila (sub-district) level. It is the only multi-sectoral household survey providing disaggregated data on 23 socio-economic indicators relating to child protection, education, health and water and sanitation.

# 2 Why mapping marginal hotspots and agricultural potential?

Maps are powerful tools not only for governments and policy makers, but also the local communities since they encourage visual comparison and make it easier to look for spatial trends, clusters or other patterns by presenting information in a way that is easily comprehensible by a non-specialist audience (Deichmann 1999, p.3).Mapping and spatial analysis have become useful tools to reduce poverty and vulnerability (Gauci 2005, Graw and Ladenburger 2012) We can thus identify areas which are marginalized in different dimensions by combining data of different types and sources. Furthermore, comparisons between different regions may be made by analyzing the spatial relationships between variables (Davis 2003).

Figure 1 Overlap of marginality hotspots with agricultural potential




Various approaches have been taken to marginality mapping such as the Mexican Marginalization Index (López-Calva *et al.* 2007); Cost-distance map (Reusing & Becker 2003); Enumeration District Marginality Index (EDMI) (Skoufias 2005); vulnerability mapping (UNU-EHS 2011); combination of vulnerability and poverty assessments (Thornton *et al.* 2006)[5]. However, most of these marginality mapping approaches focus on socio-economic and in particular income-related data and do not take into account important other dimensions that relevant for agricultural development. Therefore we have followed the marginality mapping approach taken by Graw and Ladenburger (2012) which covers a wide variety of important spheres of life representing different dimensions in which marginalization can occur and eventually cause poverty. However the indicators we used for marginality mapping to represent different spheres of life are different to a large extent as the indicators have been chosen specific to Bangladesh. Furthermore the map has been developed at the sub-district level using comprehensive data from different large surveys and census to give a better visualization of the marginality hotspots. For agricultural potentiality mapping we have developed a two-stage approach which accounts for agro-edaphic suitability (e.g. soil permeability, effective soil depth, available soil moisture, nutrient status, soil reaction (pH), soil salinity, soil consistency, drainage, depth of inundation, floods hazards and slope) and agro-climatic suitability (e.g. temperature and rainfall) in addition to various dimensions representing land utilization, use of agricultural input, technology adoption and institutional support.

Thus the marginality hotspot map will allow us to visualize the areas with high prevalence of societal and spatial marginality– based on proxies for marginality dimensions representing different spheres

[5] For a broader review of different approaches to marginality mapping, see Graw and Ladenburger (2012).

of life. The map of agricultural potential, on the other hand, identifies the areas where agricultural potential can be exploited more efficiently through low cost interventions. Finally an overlay of the marginality hotspots with the map of agricultural potential will allow us to identify areas where yield gaps (potential minus actual yields) are high and productivity gains (of main staple crops) are likely to be achieved. The hypothesis is that the marginalized poor in the overlapping region (Area C in figure 1) can move out of poverty by making use of unused productivity potentials and thereby their income through suitable innovations and interventions. For bringing the marginalized poor located in areas with little or no agricultural potential (Area A) out of poverty income diversification strategies may need to be considered.

# 3 Mapping Marginality Hotspots in Bangladesh

## 3.1 Marginality: definition and conceptual framework

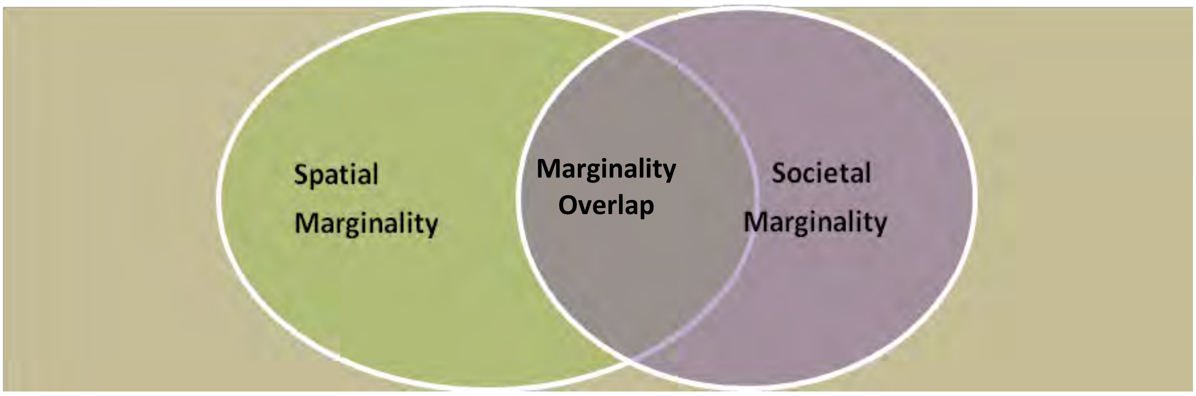
The Oxford Dictionary defines "*marginal*" in general terms as "*relating to or situated at or in the margin"* or "*of minor importance*" (Stevenson 2010). The International Geographical Union defines marginality as the temporary state of having been put aside of living in relative isolation, at the edge of a system (Gurung & Kollmair 2005). Somers *et al.* (1999) describe socio-economic marginality as a condition of socio-spatial structure and process in which components of society and space in a territorial unit are observed to lag behind an expected level of performance in economic, political and social well-being compared with average condition in the territory as a whole (). The definition of marginality we refer to in our paper is from Gatzweiler *et al.* (2011) who define marginality as

> "*an involuntary position and condition of an individual or group at the margins of social, political, economic, ecological and biophysical systems, preventing them from access to resources, assets, services, restraining freedom of choice, preventing the development of capabilities, and eventually causing extreme poverty*".

Thus, marginality is generally defined by two major conceptual frameworks, i.e., societal and spatial (Gurung & Kollmair 2005). The societal framework focuses on human dimensions such as demography, religion, culture, social structure (e.g., caste, hierarchy, class, ethnicity, and gender), economics and politics in connection with access to resources by individuals and groups. Therefore, the emphasis is placed on understanding the underlying causes of exclusion, inequality, social injustice and spatial segregation of people (Brodwi 2001; Darden 1989; Davis 2003; Hoskins 1993; Leimgruber 2004; Massey 1994; Sommers *et al.* 1999).The explanation of the spatial dimension of marginality is primarily based on physical location and distance from centers of development, or as being poorly integrated (Larsen 2002; Müller-Böker *et al.* 2004).

Social as well as spatial marginality occurs everywhere from highly developed to less developed areas around the globe, and therefore creates an overlap (Figure 2) between the two (Gurung & Kollmair 2005).

Figure 2: Marginality Overlap



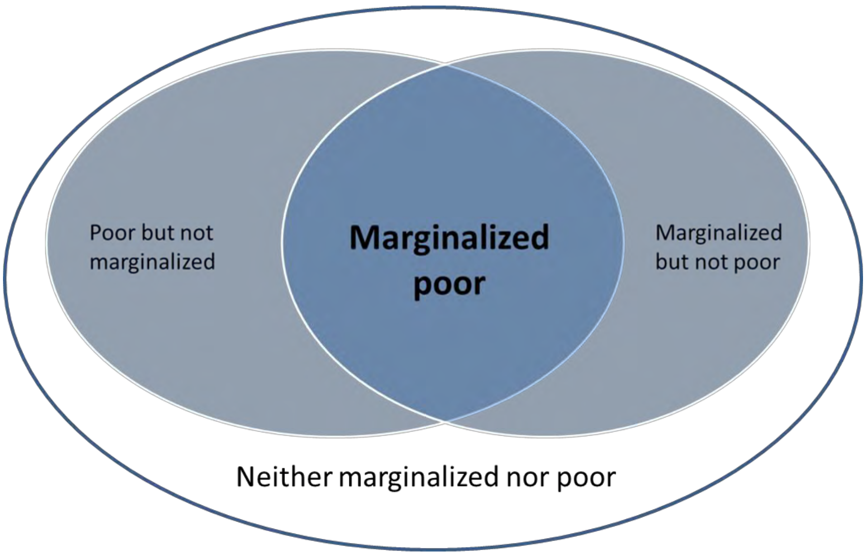

Source: Gurung & Kollmair 2005

In particular, the societal marginality in the context of age, gender, race, ethnicity and social hierarchy exists in the most geographically isolated locations or those distanced from major economic and service centers. Similarly, marginality exists in the context of urban slums of metropolitan cities (both in developed and less developed regions) where geographical proximity to services might prove irrelevant (Müller-Böker *et al.* 2004).

The overlap between spatial and societal marginality is not only within a specific space and social setting, but also at all scales ranging from individuals to the global community and from a particular geographical area to global levels. Thus, prevalence of marginality can be observed among families, communities and countries, ranging from household to country/global level.

Marginality and poverty are often used as synonyms since both describe a situation that people want to escape or turn into opportunities (Gurung & Kollmair 2005). For instance UNDP defined poverty as a "*state of economic, social and psychological deprivation occurring among people or countries lacking sufficient ownership, control or access to resources to maintain minimal acceptable standards".* This interpretation of poverty parallels the fundamental indicators of marginality, although there exists conceptual and application differences between the two. In fact, whereas marginality primarily deals with the process of marginalization, poverty focuses more on measuring the situation, in light of inequity (Gerster 2000). The marginality concept also parallels Sen's concept of poverty as a relative concept and as a concept of deprivation of capability (Sen 1981) though it further includes spatial and environmental dimensions and therefore refers to the constraints which need to be lifted in order to recognize capabilities and transform them into functioning (Gatzweiler *et al.* 2011). Apart from being excluded from growth, being excluded from other dimensions of development and progress is an indication for the extreme poor being at the margin of society. Thus, marginality is frequently cited as a root cause of poverty (Von Braun, Hill and Pandya-Lorch 2009), since in many respects the root causes of poverty such as inequality, vulnerability and exclusion (Mizuuchi, 2003; UNDP 2001) are closely linked with spatial and societal marginality. People affected by both marginalization and poverty are regarded as marginalized poor (Figure 3).

Figure 3: The marginalized poor




Source: Gatzweiler *et al* 2011

Marginality is manifested in causal complexes (or marginality patterns) which have societal and spatial dimensions. The indicators listed in Table 1 provide an overview of various dimensions of both spatial and societal marginality. These are mainly based on the spheres of life identified by Gatzweiler *et al.*(2011) with additional input from the literature (Davis 2003; Darden 1989; Geiser 2003; Graw & Ladenburger 2012; Gurung & Kollmair 2005;J ussila, Leimgruber & Majoral 1999). Data for most of these indicators can be obtained from United Nations (UN) organizations, government departments and research institutes. These indicators help to understand social, economic and political disparities within, among and between individuals, groups, and regions. Each indicator in isolation may not serve alone to provide a sharp picture of marginality, but as a package, this could help to illustrate the overall picture and help to deepen understanding. However, they can only provide a general overview of marginality (mostly at the national level). Information within the context of particular regions and communities is quite difficult to find.

Table 1: Dimensions of marginality

| Sphere of Life | Description |
|---|---|
| **A. Economy** | Production, consumption, different types of income, income inequality, assets, ownership of land or other property, social- and network capital, access to social transfer systems, prices, labor supply/demand, resource flows, investments, unemployment, poverty, trade |
| **B. Demography and quality of life** | Population size, -density, birth/death rates, migration, ethnicity, standard of living, sanitation, access to clean water, security, human rights, social connectedness, exclusion, social segregation/integration, crime, ethnic tensions, civil war, aspirations, happiness, mutual support, alienation |
| **C. Health** | Life expectancy, infant mortality, under- and malnutrition security, maternal mortality |
| **D. Societal** | Societal child labor, gender inequalities, social exclusion, human rights violations |
| **E. Education** | Adult literacy rate, gross enrolment ratio, secondary school enrollment |
| **F. Infrastructure** | Transport system (e.g. road, rail), market places, hospitals, schools, universities, distance to transportation, bank, power supply system, water supply system and energy supply |
| **F. Communication** | Landline or mobile use, access to post office |
| **G. Governance and institutions** | Regulations, laws, contract, contract enforcement, conflict resolution mechanisms, formal and informal institutions, tenancy |

Source: Adapted after Gatzweiler *et al.* (2011); Gurung & Kollmair(2005)

## 3.2 Indicators used in mapping marginality hotspots of Bangladesh

In this section we attempted to map the marginality hotspots in Bangladesh by sub-districts. A marginality hotspot is an area where several dimensions of societal and spatial marginality overlap. For this purpose we used the eight dimensions listed in Table 1. Single indicators were identified for each of the dimensions except for the societal and education dimension for which indexes were developed. For each dimension, represented by one indicator/index, a cut-off point defines the threshold below which an area is considered to be marginalized in the respective dimension (Table 2). Indicators for the different dimensions of marginality are overlaid to find the areas where low performances in the single indicators overlap – the marginality hotspots.

All of the dimensions were given equal weight for mapping purposes. This is because although the importance of these dimensions may be perceived differently in each area, no information is available to introduce such a weighting of importance. As mentioned earlier, the maps draw on sub-district data from various sources: HIES 2010 (BBS 2010e), MICS 2009 (UNICEF 2010) and Yearbook of Agricultural Statistics (BBS 2010b).

### *3.2.1 Economic dimension*

**`Income per capita´** was used to represent the economic sphere. Income per capita represents "*a more accurate measure of a country´s economic welfare*" (UNDP 2010) as it includes international flows such as remittances and aid. The World Bank also uses GNI per capita as a key indicator for classifying[6] economies into high-, middle- and low-income countries. The groups are: low income, $1,005 or less; lower middle income, $1,006 - $3,975; upper middle income, $3,976 - $12,275; and high income, $12,276 or more. But since per capita income in Bangladesh stands at $848, this classification would not be appropriate to identify the marginal sub-districts in economic dimension. Therefore, we regarded the areas marginal in the economic dimension if its per capita income was in the lower (first) quartile. The per capita income data were taken from the HIES 2010(BBS 2010e).

### *3.2.2 Demography and quality of life*

**`Use of improved sanitary facility´** is used to represent the demography and quality of life dimension. Studies (Dillingham and Guerrant 2004) show the impact of diseases caused by poor sanitation among children to their cognitive development. Studies (IRC 2009; UN Water 2008) also show that the education of children, especially girls, is significantly impacted by poor sanitation. Another impact of poor sanitation and the resultant illnesses is the loss of productivity of the family members. Thus, the use of improved sanitation facilities is the key to enhancing the quality of life. Accordingly, we used data for improved sanitary facilities from MICS 2009 and considered the lower (first) quartile as marginal in the demography and quality of life dimension.

### *3.2.3 Health dimension*

Following the multidimensional poverty index (MPI) in the Human Development Report (UNDP 2011), `**child mortality´** was used to represent the health dimension. The under-5 mortality rate is a leading indicator of the level of child health and overall development (MEASURE DHS 2012). The infant mortality rate (IMR) has in the past been regarded as a highly sensitive (proxy) measure of population health (Blaxter 1981). This reflects the apparent association between the causes of infant mortality and other factors that are likely to influence the health status of whole populations. More recently it is argued that proxy measures of population health like IMR are problematic (Murray 1996). More comprehensive measures such as disability adjusted life expectancy (DALE) have come into favor as alternatives. However showing that there is a strong (generally) linear association between DALE and IMR, Reidpath and Allotey (2002) argued that more comprehensive measures of population health, are more complex, and for resource poor countries this added burden could mean diverting funds from much needed programs. Therefore, they suggest that for many developing countries IMR may remain an effective and cheaper alternative to the theoretically more appealing DALE. The upper (third) quartile of the child mortality data taken from MICS 2009(UNICEF 2010) was considered as marginal in the health dimension.

### *3.2.4 Societal dimension*

Gender inequality was used to represent the societal dimension. The **`gender inequality in education´**, as measured by the Gender Parity Index (GPI), i.e. the ratio of girls to boys in secondary school, is used to represent gender inequality. It is often argued that quality education is crucial for gender equality (Aikman & Unterhalter 2005) while quality education requires gender sensitive use of resources and budget allocations. The authors further argued that “*quality education cannot be achieved without gender equality and equity*” (Aikman & Unterhalter 2005, p.4). Gender inequality in education is also used as a component of the gender inequality index (GII) (UNDP 2011). Taking data from MICS 2009, the GPI was calculated and its lower (first) quartile was used for marginality in societal dimension.

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[6]http://data.worldbank.org/about/country-classifications

### 3.2.5 *Education dimension*

Education is used as a measure of economic development and quality of life, which is a key factor determining whether a region is developed, developing, or underdeveloped. We used the UNDP **education index** to represent the education dimension (Appendix A). The education index is measured by the adult literacy rate (with two-thirds weighting) and the combined primary, secondary, and tertiary gross enrollment ratio (with one-third weighting) (UNDP 2011). While the adult literacy rate gives an indication of the ability to read and write, the gross enrollment ratio gives an indication of the level of education from nursery/kindergarten to post-graduate education. Taking data from MICS 2009 on adult literacy and gross enrollment ratio, the education index was developed and the lower (first) quartile was considered as marginal in educational attainment.

### 3.2.6 *Infrastructure*

**`Use of electricity´** was used to represent the infrastructure dimension. An economy's production and consumption of electricity are basic indicators of its size and level of development. Expanding the supply of electricity to meet the growing demand of increasingly urbanized and industrialized economies without incurring unacceptable social, economic, and environmental costs is one of the great challenges facing developing countries (World Bank 2012).Use of electricity is used as a proxy of infrastructure in many studies(for example, Castro, Regis & Saslavsky 2007; Issakson 2009).We used the electricity use data taken from the HIES 2010 (BBS 2010e) for this dimension and the cut-off point is the lower (first) quartile.

### 3.2.7 *Communication dimension*

Studies from Newly Industrialized Countries (NICs) and the developed world show that information and communication technology (ICT) can positively contribute to economic growth and development (Hamelink 1997). It is also argued that ICT has the potential to reduce poverty and improve livelihoods by empowering users with timely knowledge and appropriate skills for increasing productivity and by reducing transaction costs (Kenny *et al.* 2000).In line with the other economic sectors, effective agricultural development requires access to information on all aspects of agricultural production, processing and marketing (Jones 1997).Lower growth in agriculture can be attributed to some extent to the lack of communication facilities. Use of mobile phones has been used as a proxy of ICT development in many studies (Andrianaivo & Kpodar 2011) and so **`use of landline and mobile phones´ (per 100 household)** was used for the communication dimension. We used the HIES 2010 data for this dimension and considered the lower (first) quartile as marginal in communication dimension.

### 3.2.8 *Governance and institutions*

We used **`prevalence of tenancy´** as a proxy of governance and institutions. Tenancy is becoming a more encompassing phenomenon in agrarian relations in Bangladesh, practiced through diverse and co-existing forms. In the context of demographic pressure and resource scarcity, the tenancy arrangement, on the one hand, offers resource poor farmers shared access and temporary entitlements to land and other forms of property; and on the other hand, serves as a dominant mode of food and agricultural production. In 2008, nearly 44% of the farmers were tenants (pure or mixed-tenant) and they operated nearly 45% of the cultivated land in the country (Hossain & Bayes 2009). However these tenant farmers have been generally marginalized with little owned land, poor economic conditions, little access to credit and very limited technology adoption. Thus the tenancy ratio (share of tenant farmers to total farmers) is used to represent marginality in the institutional dimension. We used the tenancy data from the district series of Yearbook of Agricultural Statistics (BBS 2010f) and considered the upper (third) quartile as marginal in governance and institution dimension.

Table 2: Indicators used for mapping marginality hotspots

| | Dimensions of marginality/ Sphere of life | Indicator | Cut-off points | Data Source |
|---|---|---|---|---|
| **1** | Economy | Income per capita | Lower (1st) quartile | HIES 2010 (BBS2010e) and Updating poverty maps of Bangladesh (BBS 2010c) |
| **2** | Demography and Quality of life | Percentage of population using improved sanitary facilities | Lower (1st) quartile | MICS 2009 (UNICEF 2010) |
| **3** | Health | Child mortality rate per 1000 | Upper (3rd) quartile | MICS 2009 (UNICEF 2010) |
| **4** | Societal | Ratio of girls to boys for secondary school | Lower (1st) quartile | MICS 2009 (UNICEF 2010) |
| **5** | Education | The education Index as measured by the adult literacy rate (with two-thirds weighting) and the combined primary, secondary, and tertiary gross enrollment ratio (GER) (with one-third weighting) | Lower (1st) quartile | MICS 2009 (UNICEF 2010) |
| **6** | Infrastructure | Percentage of households having access to electricity | Lower (1st) quartile | HIES 2010 (BBS2010e) |
| **7** | Communication | Percentage of households with a landline or mobile phone | Lower (1st) quartile | HIES 2010 (BBS2010e) |
| **8** | Governance and institution | Ratio of tenant farmers | Upper (3rd) quartile | District Series of Yearbook of Agricultural Statistics (BBS, 2010f) |

## 3.3 Cross-validation of the marginality indicators with poverty

As mentioned earlier we define marginality as the root cause of poverty. Therefore to validate the representativeness of the marginality indicators mentioned above, we have exercised a correlation matrix among the variables of concern. This exercise has been done using HIES 2010 (BBS 2010e) data. The main variable of concern is poverty which is a binary variable taking a value 1 if the household lives below the lower poverty line and 0 if not. The proxies for representing various spheres of life are (a) **income per capita** which takes a value 1 if the household income in the lower quartile and 0 otherwise (b) **No access to sanitary facilities** which takes a value 1 if the household do not have access to sanitary facilities and 0 otherwise (c) **No access to electricity** which takes a value 1 if the household do not have access to electricity and 0 otherwise (d) **No access to mobile** which takes a value 1 if the household do not have access to mobile and 0 otherwise (e) **Illiteracy** which takes a value 1 if the household head is illiterate and 0 otherwise (f) **tenancy** which takes a value 1 if the household is a tenant farmer and 0 otherwise. We could not include the gender parity index and child mortality rate in this analysis since they are calculated at community level, not at household level. The correlation matrix (table 3) shows that all the indicators are statistically significantly correlated with poverty (even at 1% level of significance). Besides there exist statistically significant relationships among the indicators themselves. An Ordinary Least Square (OLS) regression and a

Probit regression[7] of these indicators on poverty also reveals that all of the indicators affect poverty significantly (appendix D). Therefore we can deduce that the indicators we used to represent different sphere of life are quite relevant in the context of Bangladesh.

Table 3: Correlation matrix

| | Per capita income (lower quartile) | No access to sanitary facilities | No access to electricity | No access to mobile | Illiteracy | tenancy | Poverty |
|---|---|---|---|---|---|---|---|
| **Per capita income (lower quartile)** | 1.00 | | | | | | |
| **No access to sanitary facilities** | 0.19* | 1.00 | | | | | |
| **No access to electricity** | 0.23* | 0.36* | 1.00 | | | | |
| **No access to mobile** | 0.30* | 0.29* | 0.40* | 1.00 | | | |
| **Illiteracy** | 0.19* | 0.25* | 0.31* | 0.34* | 1.00 | | |
| **Tenancy** | 0.09* | 0.06* | 0.01 | 0.13* | 0.13* | 1.00 | |
| **Poverty** | 0.81* | 0.21* | 0.25* | 0.30* | 0.21* | 0.12* | 1.00 |

(N.B. * denotes significance at 1 percent level of significance), Source: Authors' calculation from HIES 2010 (BBS 2010e)

## 3.4 The map of marginality hotspots in Bangladesh

Using ArcGIS developed by the Environmental Systems Research Institute (ESRI), a marginality hotspot map was produced showing areas where several dimensions of marginality overlap (Map1). Map wise area distribution has also been shown through spatial analysis (Appendix C). The map includes all 485 sub-districts of Bangladesh. The map shows that the coastal region (such as Satkhira, Barisal, Potuakhali), hill tracts, the *Haor* region (Sunamgonj, Hobigong) and some sub-districts of the North-Western regions in Bangladesh are the most marginal areas, i.e. they are marginalized in four to seven (out of eight) dimensions. This finding is consistent with the existing literature. Zohir (2011) for instance, states that there is ample evidence to suggest that ecologically vulnerable areas (areas with lower endowment of natural capital) are also the pockets of higher incidence of poverty. Interestingly, all pockets of high marginality in map 1 fall into the category of ecologically vulnerable areas– coastal belt, *haor* areas and those facing regular river erosions. The marginality hotspots map also echoes the findings of IFAD (2012), which argues that poverty is especially persistent in three areas: the north-west, the central northern region (*Haor* Basin), and the southern coastal zones. The marginality hotspot map also parallels with the poverty map[8] of Bangladesh (BBS 2010c) which

[7] Since the dependent variable is a binary variable, we have used the Probit model whereas the Ordinary least Square (OLS) will serve as a benchmark.

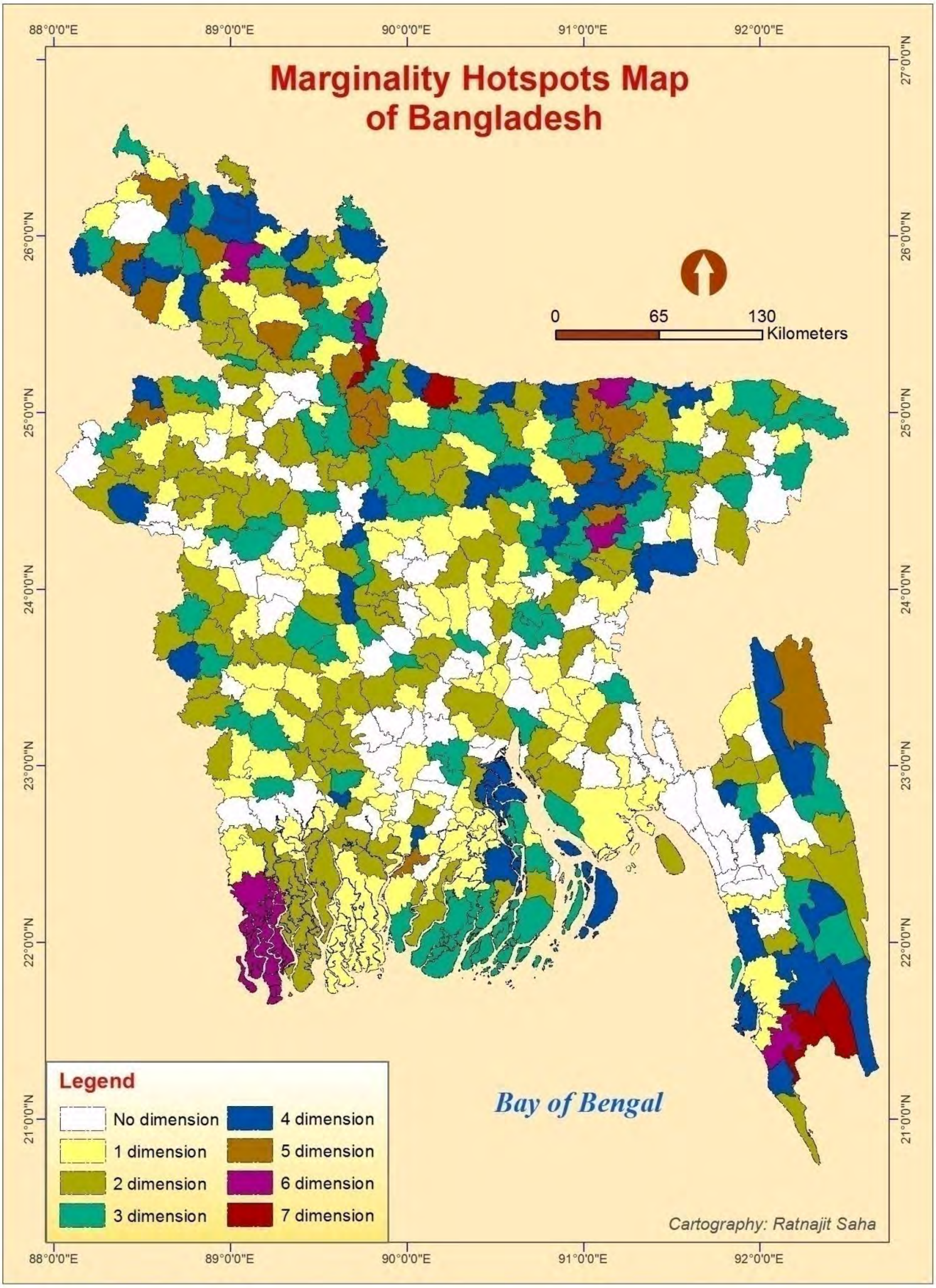
[8] In response to increasing demand for updating the poverty maps of 2001, BBS and the World Bank, in collaboration with the World Food Programme (WFP), produced a new set of poverty maps of 2005. Amongst the many methodologies available for poverty mapping, the team selected the "Small Area Estimation" method developed by Elberts. *et al.* (2003) that took advantage of the strengths of both the population census 2001 and HIES 2005. The final version of the poverty maps were completed in February, 2009.

suggests that the north-western region, the central northern region, the southern coastal region and the hill tracks are the poverty pockets in Bangladesh. This is not surprising since in many respects, the root causes of poverty such as inequality, vulnerability and exclusion (Mizuuchi 2003; UNDP 2001) are closely linked with spatial and societal marginality (Gurang & Kolmair 2005).

Although the marginality hotspots are more dependent on agriculture and less industrialized (GED 2008), the causes and nature of marginality are not all the same. A range of vulnerabilities and an untapped potential for development are the main features of the *coastal belt* (Wilde 2000). On a day-to-day basis the people living on the coastal belt have to address vulnerabilities which are diverse in nature, such as drainage congestion and the salinity of the soil which constrain agricultural yields, cyclones and storms which pose risks to lives and property, and a heterogeneous social environment with undue influence of well positioned land grabbers (Wilde 2000). Wilde further argued that, in the newly formed areas along the coast of the Bay of Bengal, the government is hardly present, leading to low access to public services. The *Haor Basin* in north-eastern Bangladesh suffers from extensive annual flooding. This makes livelihoods extremely vulnerable and limits the potential for agriculture production and rural enterprise growth. For 6 to 7 months of the year, the cropped land is completely inundated. Strong wave action adds to the vulnerability as it can potentially wash away the land and poses a major threat to many villages in the *Haor*. Poor rural households depend on fisheries and off-farm labor (IFAD 2011).The single most acute cause of chronic poverty in the *Haor* areas is an underdeveloped communication system, which makes it extremely difficult for people to access basic services such as information, health and hygiene, medication, water and sanitation, markets, etc (D.Net 2012). The North-western region has relatively unfavorable climatic conditions for agriculture. This region is largely affected by drought (drought prone areas) and river erosion (*Northern Chars*). *Chars* in the northwest Bangladesh (in the basins of three major rivers – *Padma, Jamuna* and *Teesta*) constitute one of the most backward regions of the country in terms of socio-economic status and progress of MDGs (Unnayan Shamannay 2008).The land distribution in the region is characterized by a concentration of land ownership in the hands of relatively small number of large land holders (Amin & Farid 2005).

On the contrary, the C*entral and Eastern regions* were found to be less marginal. These regions benefited from integration with growth poles, namely Dhaka and Chittagong– the former being the capital of Bangladesh whereas the latter is the commercial capital of Bangladesh; in contrast, the Northwest and Southwest remained isolated without an urban growth pole (World Bank 2008). The WB report suggested that most regions in the East moved closer to the greater Dhaka region in terms of incomes and poverty during the period between 2000 and 2005, while the West continued to lag behind. In addition, a combination of factors contributed to a high degree of marginality in these regions – lack of investment, relative lack of remittance income, inadequate public infrastructure like electricity and roads to markets, lack of growth poles within these regions, and deficiencies in assets and endowments among households. For instance Zohir (2011) argues that a map of road network clearly indicates the bias against the South, particularly the coastal belt, as well as against the other three high-poverty areas (CHT, north-central and *Haor* areas).

Map 1: Marginality hotspots of Bangladesh

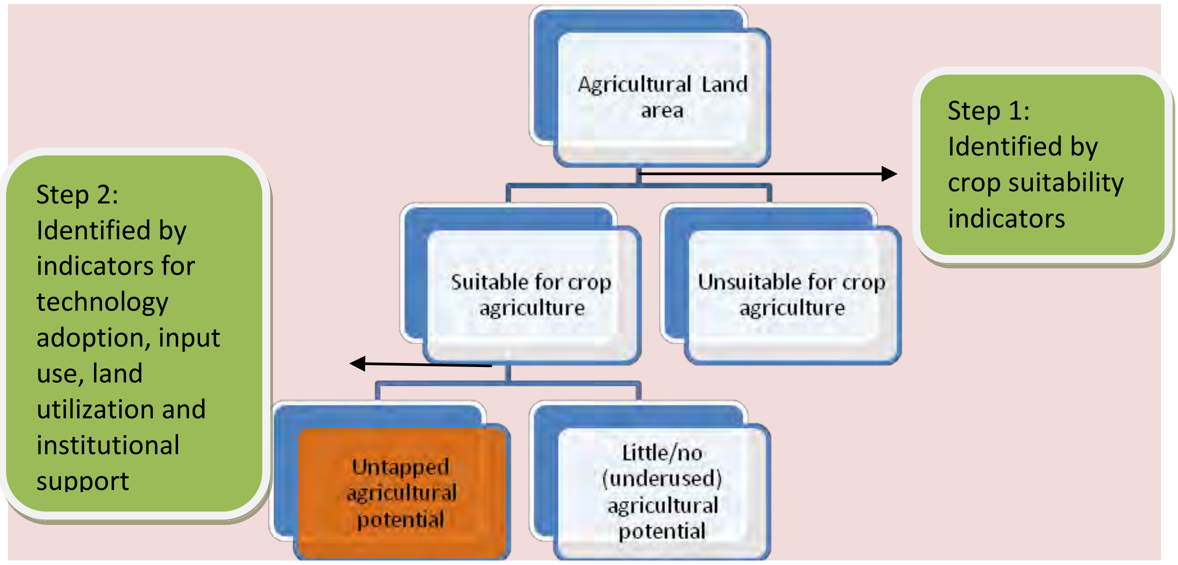



Source: BBS and UNICEF

# 4 Crop agricultural potentiality mapping

This section attempts to map crop agricultural potentials of Bangladesh. For mapping unused agricultural potentials we did not take into account the areas in which the agricultural potentials could not be unleashed or could be exploited only under costly interventions. For example, the hill tracts of Chittagong are not at all suitable for crop cultivation (except a few places where the indigenous people cultivate 'Zoom'[9]-one form of rice cultivation). Thus although there may be potentials (e.g. in terms of crop technology adoption, irrigation or cropping intensity), it would be very costly and probably cost inefficient to invest in agricultural development here. The *Haor* region, on the other hand, is submerged for months at a stretch. Thus exploring the agricultural potentials there requires integrated water resource management which requires large scale public sector intervention. Therefore we followed a two-step procedure to map the unused agricultural potential areas.

Figure 4: Steps in identifying the area of agricultural potentials




For the first step, we conducted crop suitability mapping for different crops and excluded the areas that are unsuitable for crop agriculture. Once we found areas suitable for crop agriculture, in the second step, we identified the areas in which most potential can be found in terms of various dimensions (Table 4). Although it might be better to use actual on farm yield gaps as an indicator, countrywide comprehensive data on yield gaps for Bangladesh has been difficult to access. For this reason we identified the areas suitable for crop production by means of ecosystem, soil constraints, natural resources and climate.

Then from the suitable areas for crop agriculture, we identified the areas with sub-optimal use of inputs, utilizing land more inefficiently, lacking technology and getting less attention from policymakers. Since lower agricultural productivity mainly results from sub-optimal use of inputs and technology, these are the areas where more (underused) agricultural potential can be exploited through optimal use of inputs, technology and practice. We will refer to them as areas of untapped agricultural potentials.

[9] Zoom is a special form of cultivation practiced by the ethnic farmers in the hilly regions of Bangladesh, the Chittagong Hill Tracts in particular, where traditional method of cultivation is not suitable.

Table 4: Indicators of agricultural potentials

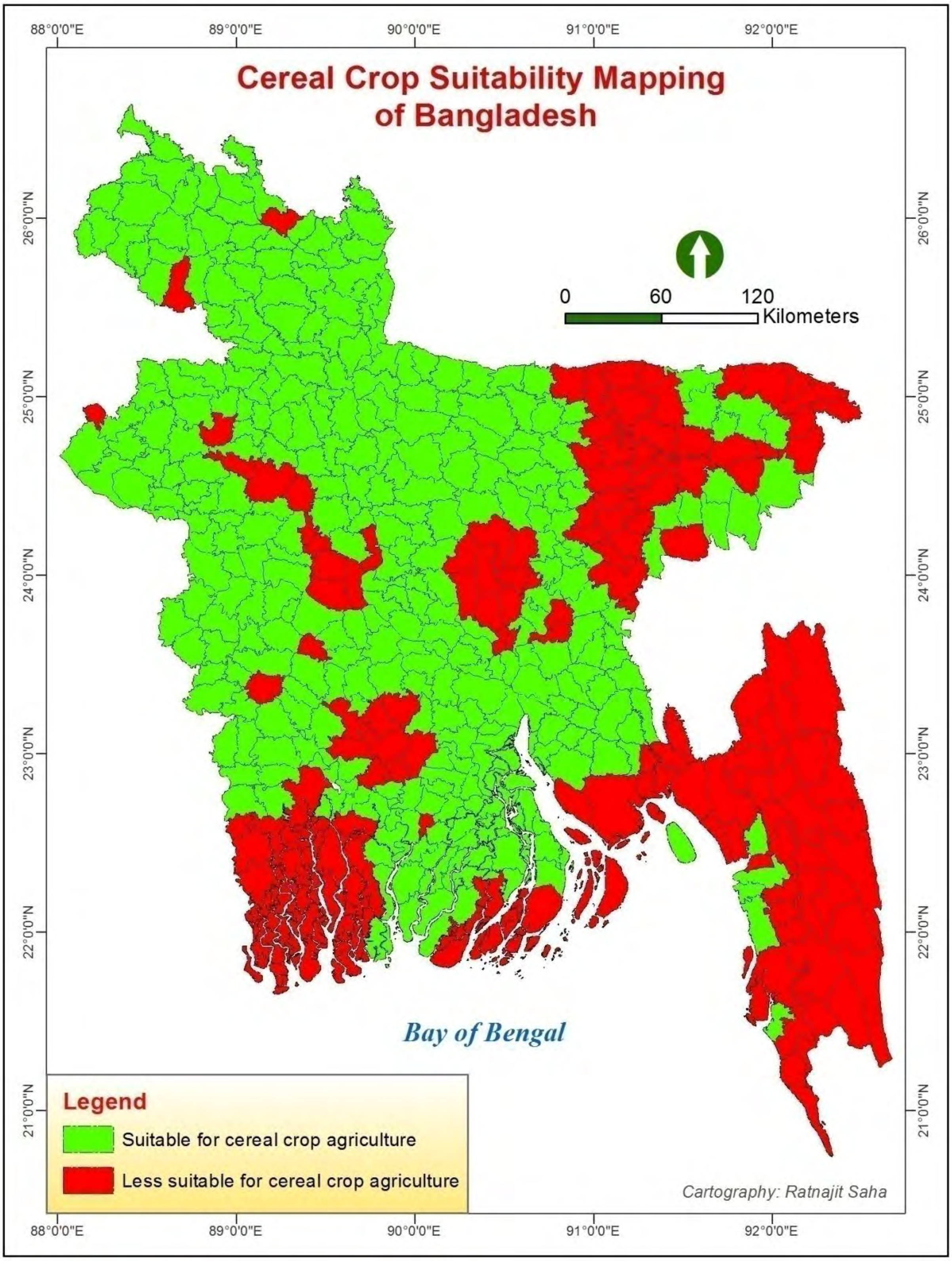
| Mapping Type | Dimension | Indicators |
|---|---|---|
| **Crop Suitability mapping** | Ecosystems, natural resources and climate | Precipitation, soil fertility, soil erosion, biodiversity, ecosystem intactness, goods and services, environmental pollution; conditions of natural resources |
| **Agricultural potentiality mapping** | Government and institution | Agricultural credit, provision of extension service |
| | Land utilization | Cropping intensity |
| | Technology | Modern varieties, machineries |
| | Agricultural input | Irrigation, fertilizer, insecticides |

Source: Adopted and extended from Gatzweiler and Malek (2013)

## 4.1 Crop suitability mapping

To determine the crop suitability of different sub-districts of Bangladesh, we used the land suitability assessment and crop zoning data from the Bangladesh Agricultural Research Council (BARC) 2012.The land suitability assessment was based on both agro-edaphic and agro-climatic suitability. This exercise clearly reflects the ecosystem, natural resource and climate dimension mentioned in Table 2. The agro-edaphic and agro-climatic suitability was determined separately based on soil/land factors and agro-climatic factors. Expert knowledge was used to characterize the agro-edaphic and agro-climatic suitability. The agro-edaphic factors included soil permeability, effective soil depth, available soil moisture, nutrient status, soil reaction (pH), soil salinity, soil consistency, drainage, depth of inundation, floods hazards and slope whereas climatic factors included temperature and rainfall. The soil, inundation and landform data of land resources inventories of BARC were used for the crop suitability assessment and classification. The agro-climatic data maintained at BARC was utilized for the climatic analysis. Finally, the agro-edaphic and agro-climatic suitability maps were overlaid to get the overall land suitability maps of different crops. The crop suitability analysis was done for different crops (cereals) for all the 485 sub-districts. Results show that 353 out of 485 sub-districts were suitable for at least one cereal crop (rice, wheat or maize) in at least two seasons of a year (Map 2).

Map 2: Cereal Crop suitability map of Bangladesh




Source: BARC

## 4.2 Agricultural potentiality mapping

After identifying the suitable regions for cereal crop agriculture, we mapped the area of agricultural potentials by sub-districts based on the dimensions listed in Table 5. Single indicators were identified for each of the dimensions and a **cut-off point** defines the threshold below which an area would be considered potentials in the respective dimension. The lower (first) quartile was taken as the cut-off point for potentiality mapping. Indicators for the different dimensions of agricultural potentials are overlaid to find the areas where potentiality in the single indicators overlaps – the **agricultural potentiality map.**

Table 5: Indicators used for mapping agricultural potential

| Dimension | Indicator | Cut-off point | Data Source |
|---|---|---|---|
| **Land utilization** | Cropping intensity (data by sub-districts) | Lower(1st) quartile | District series of Yearbook of Agricultural Statistics 2010 (BBS 2010f). |
| **Technology adoption** | Use of Modern varieties (data by sub-districts) | Lower(1st) quartile | District series of Yearbook of Agricultural Statistics 2010 (BBS 2010f) |
| **Agricultural input use** | Irrigation coverage (data by sub-districts) | Lower(1st) quartile | District series of Yearbook of Agricultural Statistics 2010 (BBS 2010f) |
| **Governance and institution** | Disbursement of agricultural credit per agricultural household (data by sub-districts) | Lower(1st) quartile | District series of Yearbook of Agricultural Statistics 2010 (BBS 2010f) |

### *4.2.1 Land utilization*

**`Cropping intensity´** was used to represent the land utilization dimension. Usually cropping intensity is defined as the ratio between gross cropped area and net sown area. It thus indicates the additional percentage share of the area sown more than once to net sown area. Thus the intensity of cropping refers to cultivating several crops from the same land during the same agricultural year. For instance, the cropping intensity is 100 if only one crop is grown in a year and it is 200 if two crops are grown during the year. The higher the cropping intensity, the greater is the efficiency of land use. A lower cropping intensity of a region implies inefficiency of land use. Thus more potential can be explored by increasing cropping intensity of those areas, perhaps by means of using short duration varieties or crop rotation. The sub-district data on crop intensity was taken from district series of Yearbook of Agricultural Statistics (BBS 2010f). The lower quartile has been considered to have more agricultural potential by increasing efficiency in land utilization.

### *4.2.2 Technology adoption*

**`Use of modern varieties´ (MVs)** was used to represent adoption of technology. The yield from MVs is much higher than that of traditional varieties. Bangladesh has made remarkable progress in sustaining a respectable growth of paddy production over the last three decades through the adoption of MVs (Hossain & Bayes 2009). Since the adoption of MVs is highly input intensive, lower adoption of MVs means lower extent of technology adoption. Although MVs of paddy are now spread over four-fifth of the cultivated land, there are wide regional disparities in the adoption of

MVs. In regions where MV adoption is low compared to others, there is a potential to increase the yield through the adoption of MVs. The data on use of MVs was taken from district series of Yearbook of Agricultural Statistics (BBS 2010f). The lower quartile has been considered to have more agricultural potential by increasing technology adoption.

### *4.2.3 Agricultural inputs*

**`Irrigation coverage´** was used to represent the use of agricultural inputs. Irrigation coverage includes areas irrigated under different means, i.e. power pumps, tube-wells and different traditional methods. However irrigation systems in Bangladesh have become highly mechanized with around 80% of irrigation being mechanized (BBS 2010b). In the dry season, farmers are in dire need of water for growing crops and scarcity of water adversely affects agricultural production. Moreover, MVs of paddy require more agricultural inputs like irrigation. Therefore, irrigation is of vital importance to agriculture. Although four-fifth of total cultivated land is now under irrigation coverage (BBS 2010b), irrigated land is not equally distributed. There are still some regions where irrigation coverage is low implying a greater potential to foster production by bringing those un-irrigated land under irrigation coverage. The data on irrigation coverage was taken from the district series of Yearbook of Agricultural Statistics (BBS 2010f). The lower quartile has been considered to have more agricultural potentials by increasing irrigation coverage.

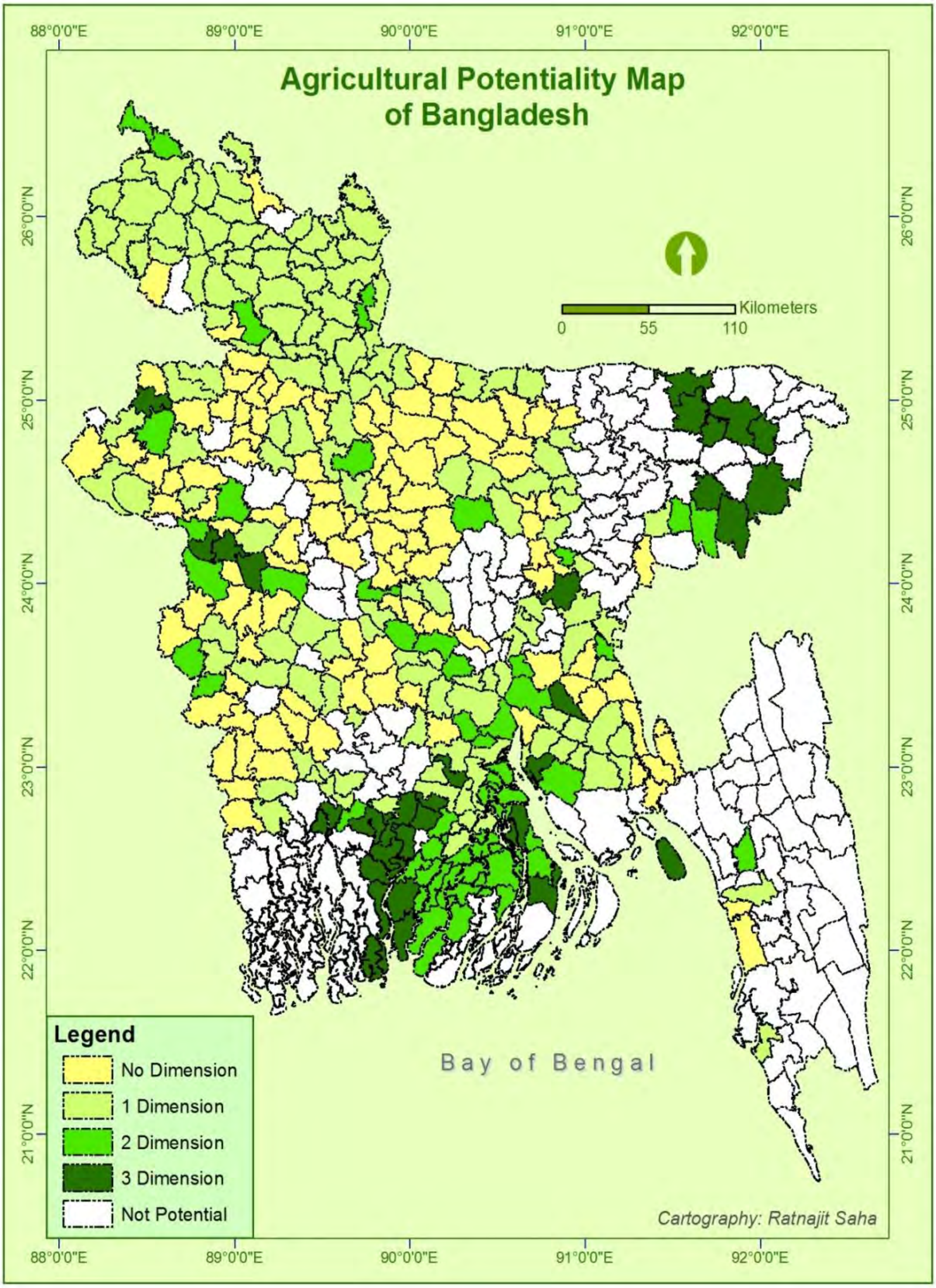
### *4.2.4 Institutional support*

The **`disbursement of agricultural credit per agricultural household´** was used to represent the governance and institutional dimension. Institutional credit has been conceived to play a pivotal role in agricultural development (Kumar *et al.* 2010). Agricultural credit allows farmers to undertake new investments and adopt new technologies. The fact that a region receives less agricultural credit per farm household compared to other regions implies the negligence of institutional agencies in credit disbursement to that region (Panda 2005). It may also reflect the lower attention paid in that region to institutionalizing credit schemes in agriculture. The data on agricultural credit was taken from district series of Yearbook of Agricultural Statistics (BBS 2010b). The lower quartile has been considered to have more agricultural potential by increasing disbursement of agricultural credit.

## 4.3 Map of agricultural potentials in Bangladesh

An agricultural potential map of Bangladesh was produced using ArcGIS showing areas where several dimensions of agricultural potential overlap (Map 3). The map shows that some regions of coastal areas and some areas of the *Haor* basin and northwestern regions have the highest agricultural potential – unused potential in two to three (out of four) dimensions. Most of these regions are agro-ecologically fragile and have lower productivity due to salinity, submergence and drought. Among them the north-west is affected by droughts and river erosion; the central northern region is subject to serious seasonal flooding that limits crop production; and the southern coastal zones are affected by soil salinity and cyclones. Besides, public investment in agriculture has not been favorable towards the South for obvious natural factors which had implications for private investment. Thus, the pace of mechanization in agriculture has been slow in Barisal and other coastal districts (Zohir 2011).

Map 3: Agricultural potentials in Bangladesh by sub-districts



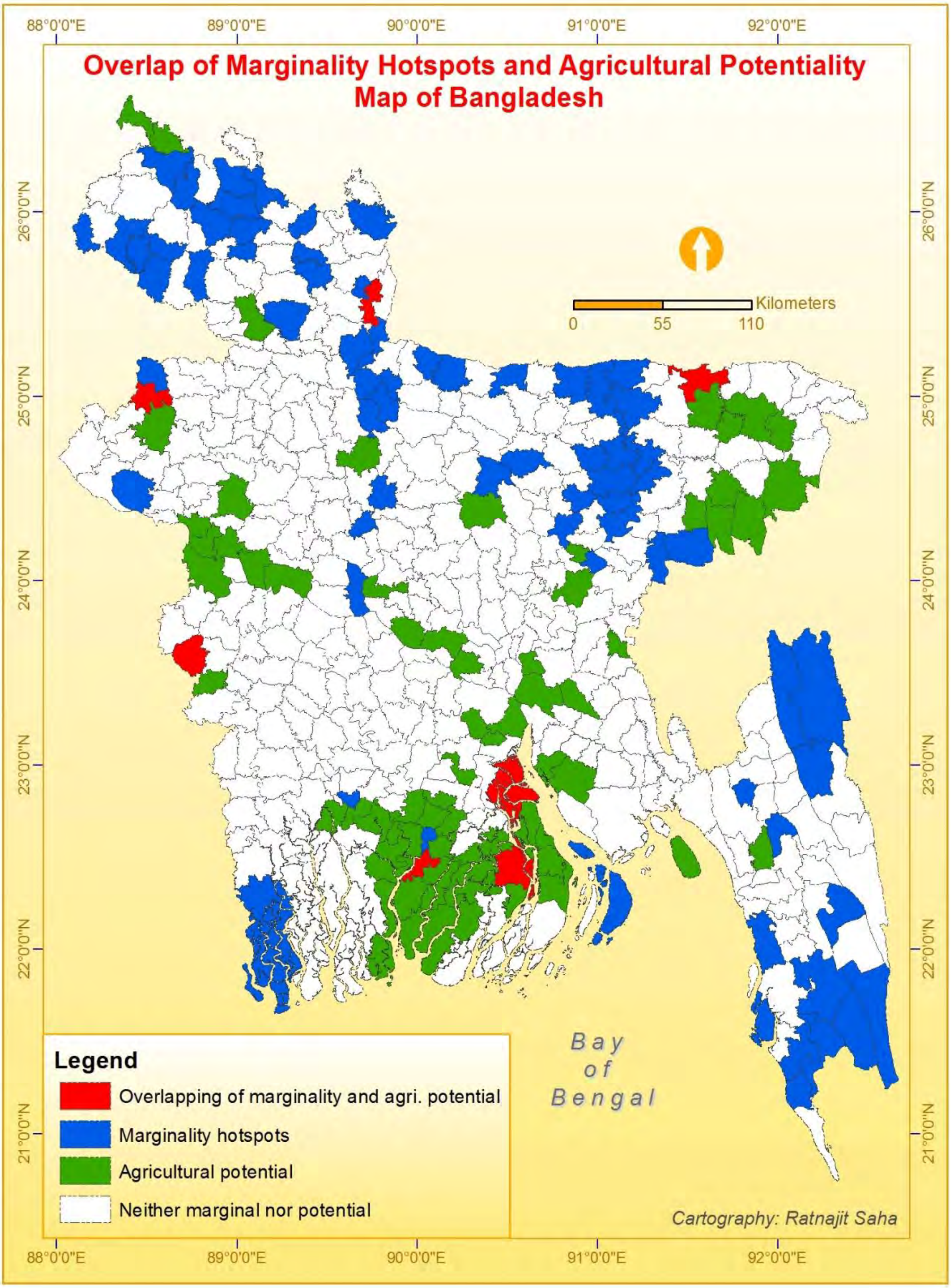

Source: BBS

# 5 Overlap between marginality and agricultural potentials

In section 3 we presented a map to identify the marginalized areas of Bangladesh by sub-districts based on eight dimensions. Section 4 mapped the exploitable agricultural potentials by means of four dimensions. Now, to identify the marginality hotspots with the highest agricultural potentials of agricultural land we need to overlay these two maps. The mapping of the overlap between the marginality hotspots and agricultural potentials is shown in map 4. It suggests that there are eight marginal sub-districts in seven districts with highest unused agricultural potentials. These are *Rajibpur (Kurigram), Dowarabazar (Sunamgonj), Porsha (Naogaon), Damurhuda (Chuadanga), Hizla (Barisal), Mehendigonj (Barisal), Bauphal (Patuakhali) and Bhandaria (Pirojpur)*. These areas are mostly in unfavorable agro-ecological Zones (AEZs). An AEZ in Bangladesh is defined broadly. While most of the areas within an unfavorable AEZ are not suitable for crop agriculture, there may still be some areas which are suitable for agriculture. This will become clear if we compare the map of suitability mapping (Map 2) and the map of unfavorable AEZ (in the appendix) which suggests that there are some areas within the unfavorable AEZ which are suitable for agriculture (both agro-climatically and agro-edaphically). Among those marginal areas, Patuakhali, Pirojpur and Barisal are in the coastal region, Kurigram is in the Northern Char region, Sunamgong in the *Haor* region and Naogaon is in the drought prone areas. Only Chuadanga, among these seven districts, is not in agro-ecologically vulnerable region (Appendix B) but in food in-secured region (HKI & JPGSPH 2011). Another point to note is that four out of these eight sub-districts are adjacent to the Indian border, whereas the other four sub-districts are located in the coastal region. The concentration of marginality and agricultural potentials overlap in the aforementioned areas may be due to their limited connectivity with the main growth centers and ecological vulnerability (Zohir 2011).

These areas are bypassed due to the general perception of AEZs as uniform entities and therefore receive less attention. For that reason there is a lot of unused potential in these areas which can be tapped by means of small scale inexpensive technology (Mondal 2012). For example, flood tolerant paddy, developed by BRRI in 2005, may benefit the farmers in the northern districts of the Brahmaputra River (*Haor* Basin). The new paddy has the potential to withstand flood waters for ten consecutive days as compared to traditional varieties of rice that could survive for a maximum of three days underwater (Suryanarayanan 2010). New saline-resistant paddy can be introduced in the coastal districts. Drought tolerant paddy (which can survive up to a month without irrigation) and short duration *Aman* varieties may minimize the irrigation cost of the farmers of the North-West region to a large extent. Besides, a change in the traditional cropping pattern can unleash a lot of agricultural potentials in these regions. A shift from *Boro* rice to maize or wheat, for example, can increase the land productivity remarkably in the Northern Chars and drought prone regions of North-West Bangladesh.

Map 4: Overlap of marginality hotspot and agricultural potential in Bangladesh



# 6 Conclusion

The mapping approach presented was developed as the first step of an ex-ante assessment of promising technology innovations project (TIGA) at the Center for Development Research in collaboration with BRAC and partners in India, Ethiopia and Ghana. The mapping is an instrument to identify marginalized agricultural areas with untapped potentials. It can be used in combination with other instruments in order to improve targeting and priority setting for agricultural development. There are however also limitations. The indicators listed in the indicators and indices used in Table 1 and Table 2 to represent different dimensions of marginality can be subject to debate. However, this may not be a big issue, since most of the indicators used in the marginality mapping have been substantiated by relevant literature. The definition of the cut-off points (below which an area is considered marginal) in a certain dimension is debatable and therefore, further research is needed to assess how different cut-off points change the mapping outcomes. The availability of actual on-farm yield gap data (Type 3, in particular) could have facilitated our mapping of agricultural potential further. Despite these limitations this mapping approach has several advantages. It is part of a systematic attempt to identifying areas with agricultural potential in marginalized areas which would otherwise be neglected or overlooked. Usually investment opportunities are sought in non-marginalized areas with visible opportunities for immediate returns to investment. Seeking opportunities for productivity growth in marginalized areas is more challenging but not impossible. The mapping presented here contributes to an attempt of fine-tuning instruments for identifying untapped agricultural potentials in areas inhabited by poor rural populations. One thing to note is that the negative consequences of marginality can even serve as the starting point for searching for suitable agricultural technology innovations to exploit the potentials. Japanese innovation and development after the Second World War has illustrated that marginality can provide even an extra edge to start development (Mizuuchi 2003; Davis 2003). Thus this mapping can be helpful to researchers and policy makers since it helps to identify agricultural areas with potential in Bangladesh. Priorities can be given to the marginal areas with highest level of agricultural potentials to achieve the maximum gain through appropriate agricultural technology innovations by fulfilling the dual objectives of poverty reduction and agricultural productivity growth.

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# 8 Appendices

## Appendix A

**Education index**

The education index has been calculated using the following formula

Education Index= $\frac{2}{3}$ x ALI + $\frac{1}{3}$ x GEI

Adult Literacy Index (ALI) = $\frac{ALR-0}{100-0}$

Gross Enrollment Index (GEI) = $\frac{CGER-0}{100-0}$

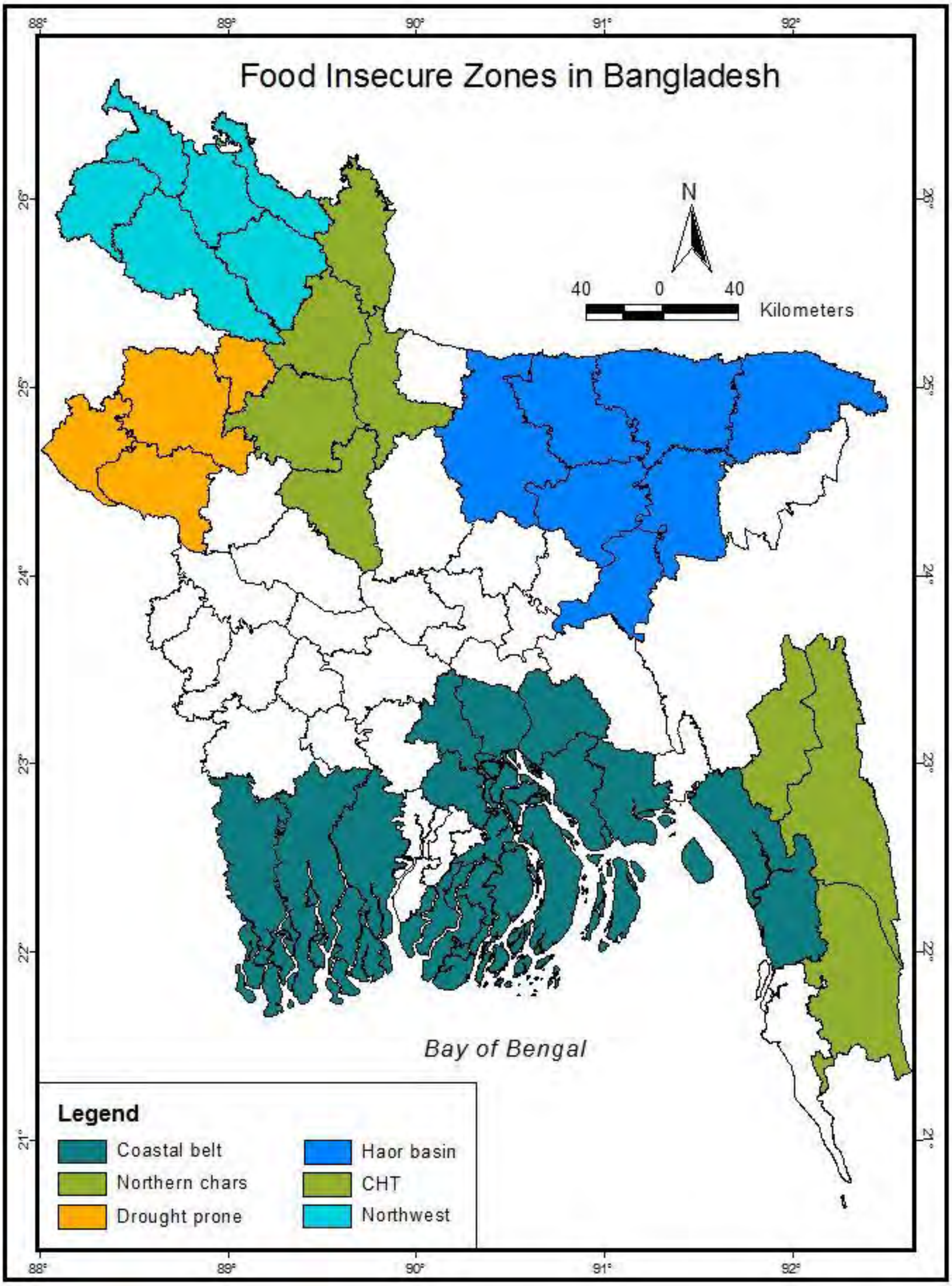
## Appendix B

Table B.1: Fragile Agro ecological Zones in Bangladesh

| Agroecological zone | Districts |
|---|---|
| **Chittagong Hill tracts** | Bandarban, Khagrachari, Rangamati |
| **Coastal Belt** | Bagerhat, Bhola, Barishal, Barguna, Chandpur, Chittagong, Khulna, Lakshmipur, Madaripur, Noakhali, Satkhira, Shariatpur |
| **Drought prone** | ChapaiNawabgonj. Joypurhat, Naogaon, Rajshahi |
| **Haor Basin** | Brahmanbaria, Habiganj, Kishoreganj, Mymensingh, Netrokona, Sunamganj, Sylhet |
| **Northern *chars*** | Bogra, Gaibandha, Kurigram, Jamalpur, Sirajganj |
| **Northwest** | Dinajpur, Lalmonirhat, Nilphamari, Panchagar, Rangpur,, Thakurgaon |

Source: HKI & JPGSPH (2011)

Figure A: Fragile Agro ecological Zones in Bangladesh




Source: HKI & JPGSPH

## Appendix C

Table C.1: Map Wise Area Distribution in Bangladesh

| Sl. No | Title | Legend | Area | |
|---|---|---|---|---|
| | | | Sq. Km | % |
| Map 1 | Marginality hotspots of Bangladesh | No dimension | 23419 | 16.75 |
| | | 1 dimension | 30365 | 21.71 |
| | | 2 dimension | 34357 | 24.57 |
| | | 3 dimension | 24187 | 17.30 |
| | | 4 dimension | 15641 | 11.18 |
| | | 5 dimension | 7033 | 5.03 |
| | | 6 dimension | 3133 | 2.24 |
| | | 7 dimension | 1712 | 1.22 |
| Map 2 | Crop suitability map of Bangladesh | Not suitable for cereal crop agriculture | 51899 | 37.11 |
| | | Suitable for cereal crop agriculture | 87948 | 62.89 |
| Map 3 | Agricultural potentials in Bangladesh by sub-district | No dimension | 30372 | 21.72 |
| | | 1 dimension | 37059 | 26.50 |
| | | 2 dimension | 12148 | 8.69 |
| | | 3 dimension | 8974 | 6.42 |
| | | Not potential | 51294 | 36.68 |
| Map 4 | Overlap of marginality hotspot and agricultural potential in Bangladesh | Neither marginal nor potential | 93484 | 66.85 |
| | | Marginality Hotspots | 25241 | 18.05 |
| | | Agricultural Potentiality | 18844 | 13.47 |
| | | Overlap of Marginality and Potentiality | 2278 | 1.63 |

*Area calculated by ArcGIS 10

## Appendix D

Table D.1: Result of Ordinary Least Square (OLS) regression of poverty on different indicators

| Dependent variable: Poverty dummy taking a value 1 if poor , 0 otherwise | | | |
|---|---|---|---|
| Independent variables | Co-efficient | Standard error | P-value |
| per capita income (lower quartile) | 0.852605 | 0.004702 | 0.00 |
| No access to mobile/telephone | 0.037020 | 0.006609 | 0.00 |
| No access to electricity | 0.032605 | 0.006178 | 0.00 |
| No access to Sanitary facilities | 0.024142 | 0.00563 | 0.00 |
| Illiteracy | 0.025317 | 0.005593 | 0.00 |
| Tenancy | 0.036752 | 0.004933 | 0.00 |
| Constant | 0.047314 | 0.004089 | 0.00 |
| Number of observations=12236 | | | |
| F( 6, 12229) =15280.29 | | | |
| Probability> F = 0.0000 | | | |
| R-squared = 0.6740 | | | |

Source: Authors' calculation from HIES 2010, BBS 2010e

Table D.2. Result of Probit regression of Poverty on different Indicators

| Dependent variable: Poverty dummy taking a value 1 if poor , 0 otherwise | | | |
|---|---|---|---|
| Independent variables | Co-efficient | Standard error | P-value |
| No access to sanitary facilities | 0.253044 | 0.026667 | 0.00 |
| No access to electricity | 0.341846 | 0.0281 | 0.00 |
| No access to Mobile/Telephone | 0.516724 | 0.028311 | 0.00 |
| Illiteracy | 0.216922 | 0.026935 | 0.00 |
| Tenancy | 0.243933 | 0.025811 | 0.00 |
| Constant | -1.18366 | 0.026062 | 0.00 |
| Number of observations = 12236 | | | |
| Wald chi square(5) = 1603.14 | | | |
| Probability > chi square = 0.0000 | | | |
| Pseudo R Squared = 0.1067 | | | |

Source: Authors' calculation from HIES 2010, BBS 2010e

Table D.3. Average marginal effects after Probit Regression

| Independent Variables | Elasticity of Poverty | Delta-method Standard Error | P value |
|---|---|---|---|
| No access to sanitary facilities | 0.1109253 | 0.010781 | 0.00 |
| No access to electricity | 0.1245256 | 0.009162 | 0.00 |
| No access to Mobile/Telephone | 0.1375816 | 0.00616 | 0.00 |
| Illiteracy | 0.1053506 | 0.012276 | 0.00 |
| Tenancy | 0.1542084 | 0.01541 | 0.00 |

Source: Authors' calculation from HIES 2010, BBS 2010e

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