# MODELLING AND POLICY INTEGRATION OF SUSTAINABLE RICE FARMING SYSTEMS IN BANGLADESH

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# MODELLING AND POLICY INTEGRATION OF SUSTAINABLE RICE FARMING SYSTEMS IN BANGLADESH

**by**

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# TABLE OF CONTENTS

**CHAPTER 4 - RESULTS AND DISCUSSION**

**CHAPTER 5 - CONCLUSIONS AND RECOMMENDATIONS**

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF ABBREVIATIONS

| | |
|---|---|
| ADB | Asian Development Bank |
| ASA | American Society of Agronomy |
| BARC | Bangladesh Agricultural Research Council |
| BBS | Bangladesh Bureau of Statistics |
| BARI | Bangladesh Agricultural Research Institute |
| BRRI | Bangladesh Rice Research Institute |
| CI | Composite Indicator |
| CPD | Centre for Policy Dialogue |
| CVM | Contingent Valuation Method |
| CBA | Cost Benefit Analysis |
| DAE | Department of Agricultural Extension |
| DFID | Department for International Development |
| DoE | Department of Environment |
| EF | Ecological Footprint |
| EIA | Environmental Impact Assessment |
| EPI | Environmental Policy Integration |
| FAO | Food and Agriculture Organization |
| FGD | Focus Group Discussion |
| GDP | Gross Domestic Product |
| GO | Government Organisation |
| GoB | Government of Bangladesh |
| HYV | High Yielding Variety |
| HPI | Horizontal Policy Integration |
| HRD | Human Resource Development |
| IRRI | International Rice Research Institute |
| MCA | Multi Criteria Assessment |
| MoA | Ministry of Agriculture |
| MOEF | Ministry of Environment and Forestry |
| MoP | Ministry of Planning |
| NRC | National Research Council |

| | |
|---|---|
| NGO | Non-Government Organisation |
| OECD | Organisation of Economic Cooperation and Development |
| PCA | Principal Component Analysis |
| PI | Policy Integration |
| PO | Private Organisation |
| PIHRD | Policy Integration of Human Resource Development |
| SA | Sustainable Agriculture |
| SAAO | Sub-Assistant Agricultural Officer |
| SD | Sustainable Development |
| SIA | Strategic Impact Assessment |
| VPI | Vertical Policy Integration |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UNEP | United Nations Environment Programme |
| UN | United Nations |
| USM | Universiti Sains Malaysia |
| WB | World Bank |
| WEF | World Economic Forum |
| WCED | World Commission on Environment and Development |
| WEHAB | Water and sanitation, Energy, Health, Agriculture, Biodiversity protection and ecosystem management |

**PEMODELAN DAN POLISI INTEGRASI SISTEM PENANAMAN PADI YANG MAMPAN DI BANGLADESH**

## ABSTRAK

Menyedari tentang keadaan kekurangan makanan dan pencemaran daripada amalan pertanian di dunia, penanaman padi telah muncul sebagai usaha penting dalam pembangunan sosio-ekonomi. Beras merupakan makanan ruji kepada lebih daripada setengah bilangan penduduk dunia dan kegiatan penanaman padi ini membekalkan sumber rezeki tunggal serta terbesar kepada kawasan luar bandar di negara Asian. Objektif kajian ini termasuk: (i) membangunkan satu set penunjuk penting bagi kegiatan penanaman padi yang mampan (ii) menilai kemampanan penanaman padi berdasarkan pengalaman dan memeriksa penentu kepada kemampanan melatui saliran air dan kawasan yang mengalami hujan untuk tanaman padi; (iii) membangunkan satu modal bagi kegiatan penanaman padi yang mampan; dan (iv) menilai integrasi dasar pembangunan sumber manusia (semenjak penilaian menyimpulkan bahawa pembangunan sumber manusia merupakan penunjuk yang paling berpengaruh) serta menyediakan beberapa cara dan langkah meningkatkan integrasi dasar pembangunan sumber manusia dalam penanaman padi - sektor pertanian yang dominasi. Berdasarkan objektif-objektif di atas, metodologi melibatkan gabungan penggunaan pendekatan atas ke bawah dan pendekatan bawah ke atas untuk membangunkan beberapa faktor dan petunjuk wakil. Berdasarkan kepada empat tonggak kemampanan, contohnya ekonomi, beberapa perkakas statistik digunakan dan indeks komposit regresi dibina untuk menilai penanaman padi mampan. Data dikumpulkan dan diperiksa secara silang masing-masing dari lima belas kampung dengan tiga ekosistem utama penanaman padi di Bangladesh,

iaitu pengairan, rainfed tanah rendah dan tanah tinggi secara kaji selidik terhadap isi rmah pertanian dan temuduga pemberi maklumat utama denga pihak yang berkepentingan,. Kajian semula instrumen dasar dan penyelidikan kajian kes telah dijalankan untuk menilai integrasi dasar. Dapatan kajian menunjukkan bahawa kurang daripada separuh penanaman padi mampan dari segi daya maju ekonomi, kewajaran alam sekitar serta pembangunan sosial dan politik. Penanaman padi Boro didapati paling mampan, diikuti dengan penanaman padi Aman dan Aus. Berdasarkan dapatan kajian, model penanaman padi secara mampan direka dengan merujuk kepada petunjuk berpengaruh, strategi dan maklumat dimensi, faktor yang berdasarkan persekitaran yang kondusif serta isu-isu budaya dan etika. Selain itu,kajian juga menunjukkan bahawa isu pembangunan sumber manusia berkaitan dengan semua dasar dan strategi manakala kelemahan utama masih merupakan masalah pelaporan, peraturan kewangan dan proses penilaian. Kajian menyimpulkan bahawa dimensi penanaman padi mampan yang dinyatakan diatas, majoriti penanam menghadapi beberapa cabaran dan ini secara munasabahnya akan menjadi lebih teruk lagi dalam konteks perubahan ilkim. Selain itu, pembangunan sumber manusia merupakan aspek utama kepada pembangunan pertanian mampan. Beberapa dasar input telah dilakarkan, contohnya melabur dalam penjanaan dan penyebaran amalan dan teknologi sumber memulihara, memberi keutamaan isu pembangunan sumber manusia dalam perancangan, serta strategi dan dasar-dasar yang diperlukan untuk menggalakkan sistem penanaman padi mampan yang menyumbang kepada pembangunan mampan di Bangladesh.

**MODELLING AND POLICY INTEGRATION OF SUSTAINABLE RICE FARMING SYSTEMS IN BANGLADESH**

## ABSTRACT

Realising the state of food insecurity and agricultural pollution in the world, rice farming has emerged as a crucial concern of socio-economic development. Rice is the staple food for more than one-half of the world's population and rice farming provides the single largest source of the livelihood for rural Asians. Objectives of this study includes (i) the development of an essential set of indicators of sustainable rice farming (SRF); (ii) empirically assessing the sustainability of rice farming and examining the determinant of sustainable irrigated and rain-fed rice farming; (iii) developing a model of SRF; and (iv) evaluating policy integration of human resource development (HRD) (since assessment deduced HRD is the most influential indicator) and providing means and measures to enhance HRD policy integration in rice-dominated agricultural sector. Towards the above objectives, the methodology involves developing a representative set of factors and indicators by employing an assemblage of top-down and bottom-up approaches. Based on the four pillars of sustainability, e.g. economic, and using several statistical tools, e.g. regression, composite indices were constructed for assessing rice farming sustainability. Data were collected and cross-checked using a farm household survey and key informant interview with stakeholders, respectively from fifteen villages of three major rice growing ecosystems in Bangladesh, namely, irrigated, rainfed lowland and upland. A review of policy instruments and case study research was conducted for evaluating policy integration. Results reveal that less than half of the rice growers were sustainable in terms of economical viability, environmental soundness, and socio-

political development. Categorically, Boro rice farming was found to be the most sustainable, followed by Aman and Aus rice farming. Based on the findings, a model of SRF is designed, consisting of influential indicators, strategies and goals of dimensions, drivers of a conducive policy environment as well as cultural and ethical issues. Additionally, result shows that HRD issue was fairly included in all policies and strategies and the main weakness remains in its reporting, financial arrangement and evaluation process. This study concludes that in terms of aforementioned dimensions of SRF, the majority of growers face several challenges and these will reasonably be aggravated in the context of climate change. Moreover, HRD is a key aspect for weaving sustainable farming development. Several policy inputs are drawn, e.g. investing in the generation and dissemination of resource conserving practices and technologies and mainstreaming HRD issue in planning, strategies and policies are required for promoting SRF systems, which contributes to sustainable development in Bangladesh.

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of the study

### 1.1.1 Bangladesh- an Agro-based Country

Bangladesh, a South Asian country, is one of the largest deltas in the world formed mainly by the Ganges-Brahmaputra-Meghna rivers system. This country is also known as 'the land of rivers'. There are about 310 rivers in Bangladesh. Of this number 57 are trans-boundary rivers, i.e. 54 are common with India and 3 with Myanmar. A large number of rivers deposits alluvial soil that has created highly fertile plains for agricultural production, which is the mainstay of the economy of Bangladesh. The contribution of agriculture including crop cultivation, livestock and poultry rearing and fishery to GDP is 19.29% (MoA, 2013). Bangladesh is one of world's largest producers of: jute ($2^{nd}$), tropical fruit ($5^{th}$), fisheries ($5^{th}$), rice ($6^{th}$), mango ($9^{th}$), potato ($11^{th}$), tea ($11^{th}$), pineapple ($16^{th}$), onion ($16^{th}$) and banana ($17^{th}$) (FAOSTAT, 2008; IRRI, 2013). **Table 1.1** presents the main features of agriculture in Bangladesh.

Agriculture is not only the key source of fulfilling livelihoods (i.e. means of securing the basic necessities) of the majority of people, but also playing a leading role in keeping active the drivers of socio-economic development. For instance, it provides employment to almost half of the labour force (Table 1); supplies lion share percentages of raw materials to agro-processing industries and earns foreign exchange from its exports. Moreover, agriculture is the main buyer of agricultural inputs such as fertilisers, pesticides, agricultural tools and machineries, which are

Table 1.1: Agriculture at a glance in Bangladesh

| Feature | Amount |
|---|---|
| Total farm holding | 1,51,83,183 |
| Total area | 14.86 million hectare |
| Forest | 2.599 million hectare |
| Cultivable land | 8.52 million hectare |
| Cultivable waste[1] | 0.268 million hectare |
| Current fellow | 0.469 million hectare |
| Cropping intensity[2] | 191% |
| Single cropped area | 2.236 million hectare |
| Double cropped area | 4.107 million hectare |
| Triple cropped area | 1.485 million hectare |
| Net cropped area | 7.837 million hectare |
| Total cropped area | 14.943 million hectare |
| Contribution of agriculture sector to GDP | 19.29% |
| Contribution of crop sector to GDP | 13.44% |
| Manpower in agriculture (% of total manpower) | 47.5% |
| Total food crop production | 37.266 million metric ton |

Source: MoA (2013), BBS (2012)

[1] This includes land available for cultivation, whether taken up or not taken up for cultivation once, but not cultivated during the last five years or more in succession including the current year for some reason or the other. Such land may be either fallow or covered with shrubs and jungles which are not put to any use.

[2] It is number of crops grown in a year multiplied by 100. Cropping intensity = (gross cropped area/net cropped area) X 100.

domestically manufactured, as a corollary, it helps to develop and expand a medium scale industry as well as provides handsome source of income to a substantial number of people. Agriculture is largely dominated by rice production, which contributes to about 10% GDP. Only recently, initiatives of the government have been showed to increase other food crops such as maize, potato, etc. However, studies (e.g. MoEF, 2008; IAASTD, 2009; BARC, 2011) indicate that agriculture is at a crossroads for several reasons, inter alia: land degradation, salinity ingress, water scarcity and possible climate change induced hazards (i.e. floods and droughts). Other problems are agriculture marketing, post-harvest losses, ineffective extension services, and poor access to finance and credit (MoEF, 2012).

### 1.1.2 Global Scenarios of Rice farming

Rice production is not only one of the most important economic activities in the globe, but also the single most important source of employment and income for rural people. It is the staple food of about half of the world's population and a principal source of livelihood of the majority of Asian people, where approximately 90% of rice is produced and consumed (Hossain, 2005). Global Rice Science Partnership (GRiSP) (2013) estimates about 93 million ha of irrigated lowland rice provide 75% rice production in the world. Rice occupies 30–35% of the irrigated area in South Asia, 64–83% in Southeast Asia, and 46–52% in East Asia (GRiSP, 2013).

China is the top rice producer in the world, whereas Bangladesh is the 4$^{th}$ largest rice producer. Second and third largest producers are India and Indonesia, respectively (FAOSTAT, 2012). However, rice yield varies across the world. Broadly, the average yields of rice in Asia, Africa and United States are about 5 t/ha, 1.8 t/ha and 7 t/ha, respectively in 2010 (FAOSTAT, 2012). This variation can be attributed by different factors, in general (i) most of the rice growers and eaters are the world's poor and (ii) rice is grown on some 144 million farms, mostly smaller than 1 hectare, and particularly, Asian and African growers are accustomed with subsistence farming and they cultivate following traditional ways, whereas some countries like USA and Italy rice farming is totally mechanised and produced by using cutting-edge technologies in all aspects of farming.

Over the years, globally, rice farming raised several major environmental concerns, for instance, (i) pervasive water pollution, since rice farming is largely agro-chemicals, e.g. pesticides and herbicides dependent (ii) in irrigated areas; rice is

grown as a monoculture with one/two crops a year that is in the long term detrimental for soil health and keeping soil's productivity, (iii) irrigation water is becoming a scare commodity in an era of climate change, and the scenario in Africa is rather acute, (iv) rice farming releases (e.g. Ammonia) or sequestrate gases or compounds that affect the environment by contributing to global climate change.

### 1.1.3 Rice[1] farming in Bangladesh

Agrarian structure of Bangladesh is predominantly rice dominated. In a true sense, rice is more than just an everyday food item. People assumes 'rice signifies both life and culture' and its cultivation deeply ingrained in Bangladeshi culture and even the words 'food' and 'rice' are largely synonymous in this country. Rice cultivation occupies about 77% of the total cropped area, provides 95% of the whole food grain production and consumption, and 17% of the national income (BARC, 2011), these figures indicate that rice farming is a key driver of food security, poverty alleviation and development of this country.

Bangladesh's rice economy has made notable progress. In particular, the total production and area have increased by 231% and 24%, respectively over the last 40 years (BBS, 2011). This progress is largely attributed to the evolution of minor irrigation such as shallow tubewells and introduction of high-yielding rice varieties (HYVs) (Hossain, 2009). The percentages of cultivating HYVs of Aus, Aman and Boro are reported to collectively increase around five times over the last few decades. Likewise, the total irrigated area has increased by four folds, particularly,

[1]Rice in Bangladesh is classified into three types, namely, Boro, Aman and Aus. Boro rice is irrigated and cultivated in dry season. Aman rice is partially irrigated, transplanted and grown in monsoon, whereas, Aus rice is direct seeded or transplanted, cultivated in pre-monsoon and in rain-fed or limited irrigation conditions.

from the end of the 1980s to 2010, irrigated area of Boro rice has increased by 330%. All the figures clearly indicate that rice production has achieved a good progress and this progress can be equated with the impacts of the so called 'Green Revolution'[1]. Rice-based farming has been proven to be inextricably linked with socio-economic development, political stability and overall growth of economy in Bangladesh (Roy et al., 2014a).

Despite the success in rice production, this country is still labelled as 'food insecure' and has 50 millions of impoverished people (MoEF, 2012). The country faces numerous challenges of degrading natural resources and adverse impacts of climate change (IRRI, 2013). Yet, these problems have been compounded by ever growing population and consequently, other problems such as urbanisation, pollution, etc. that produce unstable socio-economic conditions that are largely dependent on foreign remittances and foreign aids, albeit the government has taken many initiatives including food for work programmes, Aus rehabilitation programme and introducing subsidies for rice growers to improve rice production. However, presently it is apparent that taken these initiatives are not enough and are incapable of coping with the food demand of about 160 million people and these scenarios are expected to be exacerbated in the future.

### 1.2 Problem Statements

Sustainable rice farming (SRF) and agriculture are important concerns of policy-makers, development planners, researchers and academicians and these concerns are reflected in several key documents of the government such as National

[1] It refers to a series of initiatives such as agricultural research, technological breakthrough and development that revolutionise farming production worldwide, particularly in the developing world.

Agriculture Policy 2010, Poverty Reduction Strategic Papers (PRSP)-II 2012, Sixth Five Year Plan (Fiscal Year 2011-2015) and Rio+20 National Report on Sustainable Development 2012. The probable reasons for this concern are as follows: (i) land is becoming an extremely scarce commodity and declining by 1% per annum (MoA, 2010; MoEF, 2012), (ii) the price of fertilisers, pesticides and fuels for irrigation is gradually increasing (MoA, 2006a; IRRI, 2013), (iii) pervasive groundwater arsenic contamination in the South Western part of the country (Brammer, 2009; World Bank, 2010), (iv) rice based monoculture pushing out major non-cereal crops such as oilseeds and pulses (Hossain, 2009) and (v) rice farming is vulnerable to climate change[1] (ActionAid, 2011; Sarker et al., 2012). Researchers (Alauddin and Quiggin, 2008; Rahman et al., 2008; Shahid and Behrawan, 2008; Chowdhury, 2009; Roy and Chan, 2012) show that the sustainability of agriculture, particularly rice farming is in a threatened state because of continual declining, degrading land and soil resources, increasing salinity, water pollution and environmental hazards.

Moreover, ever-increasing population pressure (annual population growth 1.59% (2013 est.), widespread rural poverty and severely declining organic matter in rice producing areas are the grave threats for rice farming sustainability. This situation has been aggravating due to the critical condition of world's as well as country's food insecurity and rapid increase of food (mainly rice) price. Therefore, the current situation (e.g. rice growers are poor) and trend (e.g. soil and water pollution) indicates that rice farming is not sustainable.

[1] Major climate change impacts on rice production are erratic rainfall patterns and warmer temperature that accelerates evapo-transpiration and moisture loss from soils, which causes heavier rainfall and flood during the monsoon (Yu et al., 2010; Sarker et al., 2013).

Realizing these challenges, the government has been taking initiatives to curb these problems such as formulation and implementation of several agricultural policies and strategic plans. Many completed and on-going development projects have been implemented by the Department of Agricultural Extension (DAE) to equip the extension agents and to develop capacity of growers by providing training, logistic and economic supports. However, the achievements obtained by these initiatives are inadequate due to resource constraints, inefficient leadership, weak extension services and lack of coordination among agencies (MoA, 2006b). Mandal (2006) reported that most of the policy documents were prepared based on notional ideas and lack of empirical analysis, largely due to lack of reliable data and ministerial inefficiencies (Roy et al., 2013a). More recently, the government had introduced fertilisers and irrigation subsidies, which are negligible, when compared with those implemented in other countries such as India (MoA, 2006a). Moreover, studies showed that the subsidies are not so beneficial for marginal and small farmers as a major share of subsidy benefits is grabbed by the fertiliser traders (Mandal, 2006).

With a view to formulate overarching policy inputs, this study addresses two major aspects: (i) modelling, which consists of indicator development, farming sustainability assessment and accordingly, a model development and (ii) policy integration[1] that is based on the results of assessment of rice farming sustainability. According to an empirical evaluation of the former part the latter one has examined

[1] The integration of certain policy objective such as environment, climate change, gender into other policy sectors such as agriculture, transport has been referred to as policy integration (Persson 2004; Mickwitz and Kivimaa 2007; Jordan and Lenschow, 2010), which facilitates more rational policy making and enhances policy coherence.

the integration of human capital development in agricultural sector, since this sector is highly dominated by rice farming. Here, capital means farming knowledge, skills and competencies of growers. To capture the broader gamut of development, the term 'human resource development' will be used instead of human capital development hereafter.

Literature on developing a model of SRF and human resource development policy integration is difficult to find. Gómez-Limón and Sanchez-Fernandez (2010) evaluated agricultural sustainability in Spain using a composite indicator (CI). Similarly, by developing an index, Gowda and Jayaramaiah (1998) compared sustainability of four rice production systems in India, and rainfed lowland was found the most sustainable. However, Gowda and Jayaramaiah neither described the methodology in detail nor followed essential steps of CI development, as suggested by the OECD (2008). In the present study, these research gaps are fulfilled by conducting an empirical evaluation. It is better to mention here that academic literature on the application of CI established by the OECD in assessing rice farming system sustainability is not available. Overarching policy implications are drawn on the basis of the problem framing.

### 1.3 Conceptual Framework

Despite the impressive amount of scientific literature on sustainability, there is a lot of complexity and vagueness inherent in the concept. It is observed that the concept of 'sustainability' is normative and cannot be defined singularly (Bond et al., 2012). This is one of the major hurdles for the quantification of sustainability, which is subjected to value judgements (Bell and Morse 2008), which necessitates multi-stakeholder participation in the assessment procedure (Roy and Chan 2012). For

these reasons, researchers define and interpret the concept based on their intellectual understandings. Farming sustainability is the use of agricultural land in such a way that ensures profitable production, maintains and improves the Earth's life-support systems and natural resource base, enhances social equity as well as the quality of life of producers and society as a whole over long periods (at least two generations) of time (Roy et al., 2014). This interpretation implies a relative temporal scale. In fact, relativity lies at the heart of the sustainability concept. However, none of the timescales would ensure the future production of agricultural goods and services that embraces the idea of 'futurability'—an ideal form of sustainability (Handoh and Hidaka 2010). Sustainability can be measured at different spatial scales such as local, regional, and national. The scales are interlinked, which creates difficulty in measurement. The present study deals with farm level sustainability.

Despite the diversity of concepts on sustainable farming, there is a consensus on some of its basic features. These are: (i) maintenance of environmental quality, (ii) maintaining economic viability and (ii) social development and equity

On the basis of the past literature, sustainable rice farming systems in this study are conceptualised as follow (**Figure 1.1**):

- Conservation and enhancement of natural resources is the key to sustainable farming that can be promoted through integrated management of nutrients, pests, and diseases. Moreover, indiscriminate use of agrichemicals is an increasing concern of water pollution. In addition, cultivating more than one crop, particularly pulse is proven for improving soil condition and productivity. However, topography, soil and climate have a good influence on types of farming.
- First of all, a farm has to be profitable before sustainability can be considered. Farm productivity and profitability can be increased by maximising the use of

resources, including farming practices, knowledge and balanced use of inputs. Moreover, avoiding the risk of natural hazards and a good product market price are important determinants of productivity and profitability.

- Sustainable farming is seemed to serve society, including rural women and disadvantaged groups. As a socio-political dimension, a number of elements are required to foster farming sustainability, for example, available and effective extension services for necessary farming information, grower's social and human capital, good organisational networks, equitable access to resources and so on.

Based on the above discussion of conceptual framework and particularly considering the three key aspects of farming sustainability, the study, on the one hand, develops a model of sustainable rice farming, which is founded by indicator development and sustainability assessment and backed by employing statistical tools and other data collection approaches, while on the other hand, this study evaluates policy integration of human resource development (HBD), which is deduced as the most influential indicator and provides means to enhance HRD policy integration in rice-dominated agricultural sector.

### 1.4 Research Questions

1. How can important factors be identified and an essential set of indicators of sustainable rice farming and an indicator generating methodology be developed, employing a truly participatory approach (i.e. stakeholder's involvement following the proposition of the UN Agenda 21[1])?

[1] It is an action plan of the United Nations in order to promote sustainable development (WCED, 1987). Agenda 21 is a product of the UN Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, in 1992.

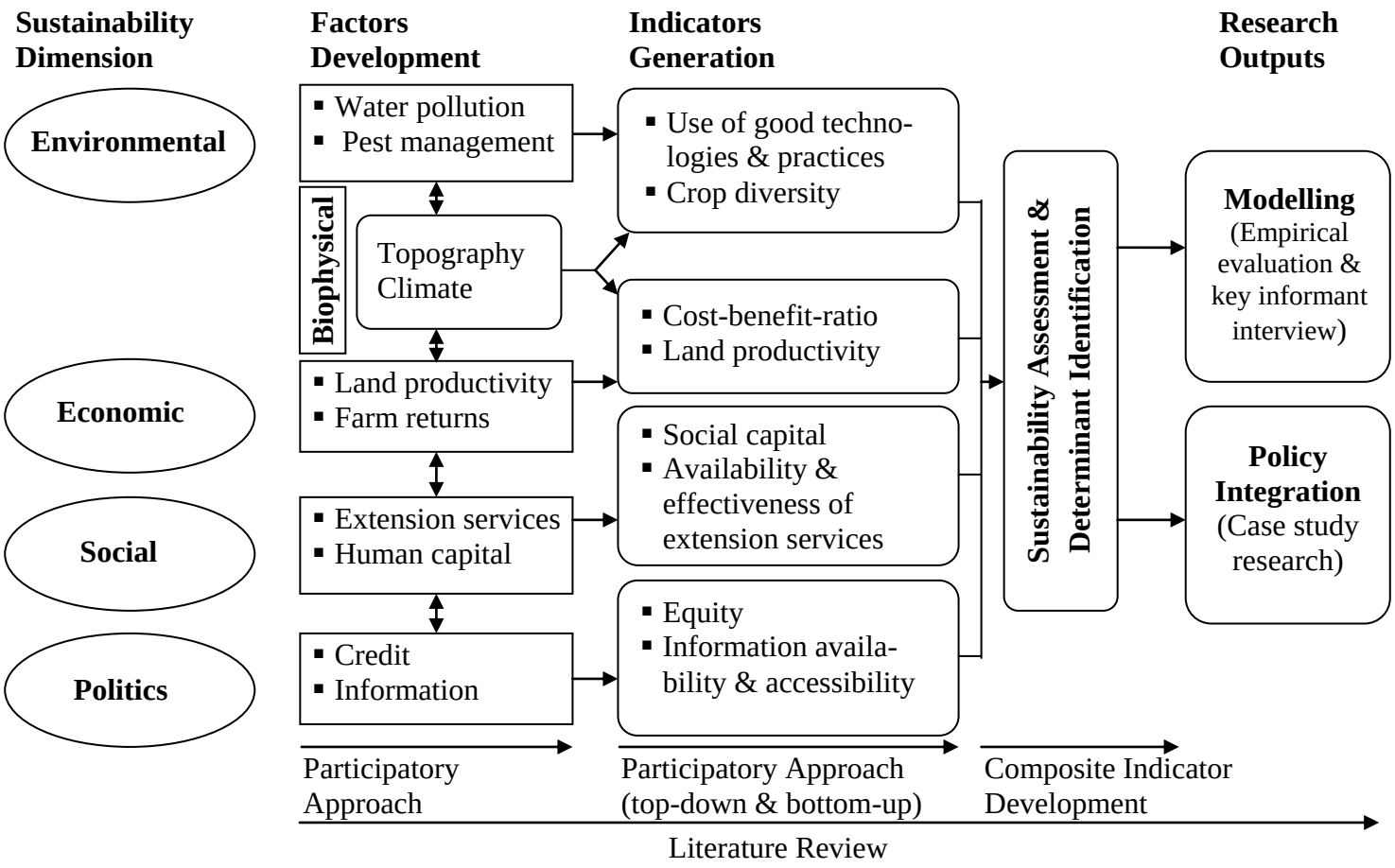


Figure 1.1: Conceptual framework of promoting sustainable rice farming systems

2. How can rice farming sustainability be assessed and what are the determinants of sustainable irrigated and rainfed rice farming?
3. How can an overarching model of sustainable rice farming (SRF) be developed for the promotion of environmentally sound, economically viable and socially acceptable and equitable rice farming?
4. How can human resource development (HRD) policy integration in rice-dominated agricultural sector be evaluated, drawing perspective of multi-level governance and what are the means and measures to enhance HRD policy integration in this sector?

### 1.5 Research Objectives

1. To identify important factors and develop an essential set of indicators of sustainable rice farming and an indicator development methodology, employing participatory approaches;
2. To assess the sustainability of rice farming and examine the determinants of sustainable irrigated and rainfed rice farming;
3. To develop a model of sustainable rice farming that is appropriate for Bangladesh and applicable for other countries in promoting rice farming sustainability;
4. To evaluate HRD policy integration in rice-based agricultural sector, drawing perspective of multi-level governance, and to suggest means and measures- to enhance HRD policy integration.

## 1.6 Importance of the Study

An empirical assessment is a foundation for transitioning to sustainability. However, sustainability evaluation needs a manageable set of indicators that should entail several attributes such as data availability, communication ability, etc. Based on assessment and determination of influential factors as well as identifying pillar's goal and strategies, an inclusive model of sustainable rice farming can be formulated. Considering the research gaps (based on literature review) in mind and realising the present context of world's food insecurity, this study, first developed a set of factors of SRF. Secondly, identifying methodological gaps, a framework for participatory indicator development is proposed and employing this framework a representative set of indicators were generated. Based on generated indicators and administering farm households' survey, this study, then assessed the sustainability of rice farming. In addition, determining major factors and goal and strategies of dimensions, a model is developed, which is appropriate in Bangladesh as well as applicable for others rice producing regions, since this model has ample theoretical and empirical bases. Moreover, this study assessed policy integration of human resource development (HRD) in agricultural sector which is largely dominated by rice farming and recommended measures to enhance HRD policy integration. In the end, based on the findings of the study, overarching policy implications are drawn.

The bottom line of this study is to evaluate the sustainability of rice farming system with a view to improve policy. Recapping the main points of research objectives, major expected outputs of this study are drawn below-

- ❖ Developing a participatory indicator generating methodology;
- ❖ Assessing rice farming sustainability adopting OECD's composite indicators;
- ❖ Determining the contributed factors for sustainable rain-fed lowland and upland and irrigated rice farming;
- ❖ Developing an inclusive model of sustainable rice farming;
- ❖ Evaluating HRD policy integration in rice-based agricultural sector and finding means and measure to enhance HRD policy integration in this sector.

### 1.7 Outline of the thesis

The content of this thesis is approved by the Special Evaluation Committee (SEC), the School of Humanities and endorsed by the MPSU (the University Council of Postgraduate Studies), Universiti Sains Malaysia (USM) to evaluate by adopting 'Alternative Track of PhD Thesis Examination'—a relatively new approach for evaluating PhD theses in USM (http://www.ips.usm.my/infolink/INFO0212.pdf). This thesis is mainly based on six published articles and one under reviewed manuscript that conforms to the regulation of this track. Articles are categorised into two headings, namely, 'Modelling' and 'Policy Integration' of sustainable rice farming systems and presented in 'Results and Discussion' chapter. Besides this chapter, rests of the four chapters are 'stand-alone' and 'Literature Review' is substantiated by a published reviewed article (See **Appendix A**). Hence, including this article the total number of published article is seven. 'Conclusion and Recommendations' are presented in chapter five, whereas, chapters one, two and three are covered by 'Introduction', Literature Review' and 'Methodology', respectively.

The problem framing and research question presents a collective picture of works that started from an extensive review of indicator systems (see **Appendix** A) and ended up by developing a model of sustainable rice farming as well as suggesting means and measures to enhance HRD policy integration in rice-dominated agricultural sector- an indication of a good contribution to promote sustainable rice farming systems. Therefore, it can be said that aforementioned articles (refers to **Chapter 4** and **Appendix D**) illustrates an integrated whole of works of the given research title of sustainable rice farming systems. More clearly, **Figure 1.2** presents an outline of the association of published articles and collectively demonstrating the contribution of PhD research entitled 'Modelling and Policy Integration of Sustainable Rice Farming Systems in Bangladesh'.

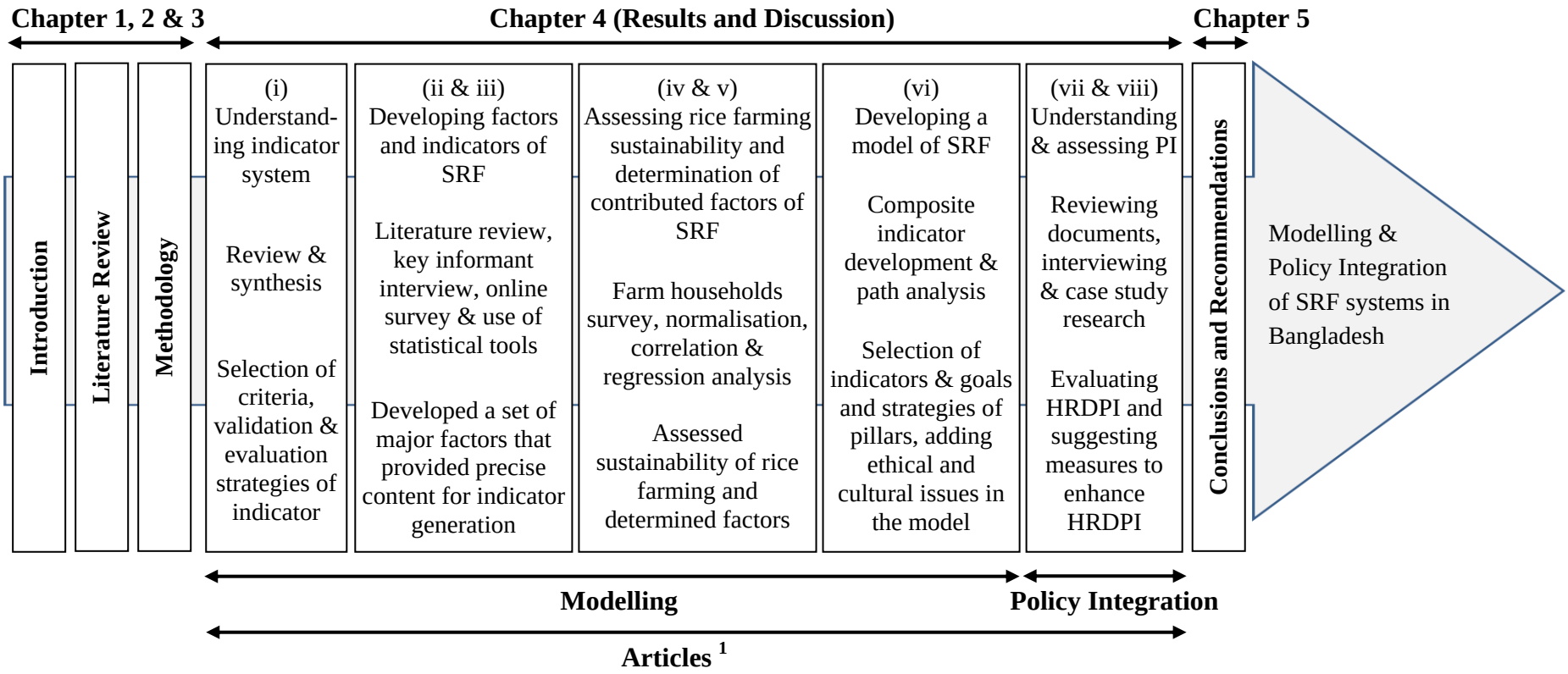


Figure 1.2: An outline of PhD research, indicating the interrelationships between the publications and body of text in the thesis

Notes: SRF means sustainable rice farming; PI refers to policy integration and HRDPI means human resource development policy integration.

[1] Articles' sequence, content, major methods and outputs are presented.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

Although ‘sustainable agriculture’ is an established concept, the investigator did not find an indicator development methodology that combines top-down and bottom-up approaches and an inclusive model of sustainable rice farming (SRF) that could be used to draw an overarching policy inputs for achieving SRF. The purpose of this chapter is to review of the extant literature and identify pertinent gaps with a view to develop a model of SRF and evaluate policy integration of a key indicator (based on assessment) for promoting SRF.

## 2.2 Sustainability and sustainable development: A theoretical foundation

### 2.2.1 Sustainability

Sustainability means different things to different people. The concept of ‘sustainability’ is both amb tious and ambiguous and therefore, its precise definition is scarce. Generally, it is a capacity of any system that’s environmental, social and economical dimensions that is capable to maintain and improve itself over the longer period of time (i.e. two generations). Sustainability has been described as the ability to obtain overarching societal aims in a way that can be maintained indefinitely without unwanted negative effects (NRC, 2010). For instance, agri-environmental sustainability is the capacity of farming systems to maintain themselves indefinitely by applying ecologically non-degrading agricultural practices that conserve and improve natural resources. Most definitions of sustainability are framed in terms of three broad social goals, namely economic, environmental and social health or well-being. In Europe, these three goals of sustainability are sometimes referred to as the 3Ps: people, prosperity and planet, or, alternatively, as the ‘triple bottom line’ (NRC, 2010).

In defining sustainability, researchers put emphasis on various issues and reported that it: derives an ethical concern for future generations (Perman et al., 2003), has strong association with the economic concepts of production and utility functions (Pezzey, 2002), deduces from generic attributes of efficiency plus intergenerational equity (Stavins et al., 2002) and requires the long-term preservation of the viability of the systems (Spangenberg et al., 2002). However, three key points have emerged as vital for addressing sustainability: effective and efficient resource management, addressing intra-generational and inter-generational equity, and fulfilling long-tem criteria. The debate on 'sustainability' stresses several key points such as explicit discrepancy between the practical and theoretical sustainability (Van der Hamsvoort, 2006) and substantial dispute concerning the visions about the limits of economic growth and the carrying capacity of the Earth (Van Passel, 2007).

In addition, keeping in mind the situational and contextual condition of diverse systems and processes, a number of issues are required to make sustainability operational that is essential for promoting sustainable production and consumption as well as development. These includes signifying the multidimensionality; effectively integrating the multiple spatial levels such as national, regional, local; emphasising on the nested temporal scale; and focusing broad strategies.

### 2.2.2 Sustainable development (SD)

The idea 'sustainable development' has come to the forefront of scientific debate and policy agenda (Roy and Chan, 2012) and received an authoritative status that acting as a guiding principle of social and economic development (Lafferty and Meadowcroft, 2000). However, concerns over the ecologically legitimate development or SD have started a long time ago, which can be traced back to the renowned scholar Thomas Robert Malthus and William Stanley Jevons (see **Table 2.1**). In a broadest sense, SD is a kind of development of human wellbeing that

maintains the harmony with the biophysical system of the planet over time. It refers to a process involving change or development that improves the quality of life, and hence, focuses on sustaining the process of improving human wellbeing. Researchers

Table 2.1: Evolution of the idea sustainable development (SD)

| Era/Year | Name of the initiative | Achievement |
|---|---|---|
| 18th- and 19th-century[1] | Anonymous | Initial concerns about resource scarcity in the context of population rise (Malthus) and shortages of (coal) energy (Jevons). |
| The 1960s and the 1970s | Anonymous | The intensification of anxiety about the environment (i.e. proven cause of health hazards due to industrial pollution) |
| 1972 | Club of Rome report 'The Limits to Growth' (Meadows et al., 1972) | Reporting the carrying capacity of the planet would be exceeded within the next 100 years, if the present trend of population growth, food production, resource use and pollution continues. |
| 1972 | The UN Conference on the Human Env., Stockholm | A beginning of the new era of international cooperation on the environment, e.g. the establishment of the UNEP. |
| 1980 | World Conservation Strategy (IUCN, 1980) | The term 'sustainable development' came into the public arena. Strategy yielded due to numerous cause-effects of the past. |
| 1982 | Stockholm + 10 Conference | Establishing the World Commission on Environment and Development (WCED), led by Gro Harlem Brundtland. |
| 1987 | WCED published report 'Our Common Future' | Establishing the landmark development of the SD idea, including a well accepted definition and normative principle[2] of SD. |
| 1992 | The Rio Earth Summit | Proposing 27 principles of SD, agreed 'UN Agenda 21', signed the UNFCCC and the CBD conventions[3] and formed the Commission on Sustainable Development. |
| 1997 | The Earth Summit + 5 | Confirmation of the political commitment to the promotion of SD. |
| 2002 | World Summit on SD (Rio + 10) | Publishing the Johannesburg Declaration on SD, Plan of Implementation of SD and WEHAB initiatives[4]. |
| 2012 | UN Conference on SD (Rio + 20) | Resolution adopted particularly on green economy in the context of SD and poverty eradication and formulated an institutional framework for SD. |

[1] This period includes Malthus (1766-1834) and William Stanley Jevons (1835-82) time.
[2] Common but differentiated responsibilities, inter-generational equity, intra-generational equity, justice, participation and gender equality.
[3] The Convention on Biological Diversity
[4] Water and sanitation, energy, health, agriculture, biodiversity protection and ecosystem management.

(Prezzey, 1989; Lélé, 1991) elaborately reviewed the definition of SD and provided pretty divergent opinions. However, a convergence of interest is deduced in contributing the three dimensions (economic, social and ecological) in SD.

The term 'sustainable' has been combined with a lot of terms to express a number of concepts such as 'sustainable cities', 'sustainable growth' and 'sustainable culture'. All concepts have confusion (at least to a certain extent) in accurately defining, since SD is a dynamic concept. It is not like that a system reaching to an end state, nor is it about developing a static structure or determining fixed qualities of three dimensions (Baker, 2007). In the current discourse, Meadowcroft (1999) reported the major terms on SD (**Table 2.2**)

Table 2.2: Key terms on sustainable development

| Terms | What is meant? |
|---|---|
| Environmental sustainability | Preservation of natural environmental systems and processes, or addressing environmental issues to maintain social institutions and processes. |
| Sustainable yield | Maintaining the regenerative capacity of natural systems – for example, forests. |
| Sustainable society | Living within boundaries established by ecological limits, but linked with ideas of social equity and justice |
| Sustainable development | Maintaining a positive process of social change |

In 1987, the Brundtland commission has given a widely used definition of SD: 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987).

This definition stipulates two key issues: the concept of 'needs', particularly an essential need of the world's poor and the idea of 'limitations' imposed by the

state of technology and institutions on the ecosystem's ability to meet present and future needs. The former issue makes a link between the fulfillment of the needs of the world's poor and reduction of the wants of the world's rich. However, it is not easy to draw boundary line for needs and wants, since they are culturally and socially determined. The richer nations consume excess resources and an excessive consumption creates problems: putting pressure to the planet's ecological resource base and producing more per capita carbon dioxide that is one of the responsible factors for creating environmental hazards, particularly for the poorer nations, like those in South Asia. As the Bruntland report states that 'yet developing countries are part of an interdependent world economy: their prospects also depend on the levels and patterns of growth in industrialised nations' (WCED, 1978). The latter issue of the definition indicates an optimistic view of our common future, presenting a ground for progress through technological and institutional development and social change. However, the concept of SD does not mention that growth is both possible and desirable in all circumstances.

Although in terms of providing structured guidelines and procedure the Brundtland report is innovative (Spangenberg et al., 2002), yet everyone is not motivated by the usefulness of the SD concept. For instance, Beckerman (1994) states this report conceptualise SD in a way that is either morally repugnant or logically redundant, since the only development that is sustainable now is development that improves a better qualities of life (Beckerman, 2003). In the same fashion, Pezzey (1992) says despite the fact that the Brundlandt definition of SD captures the essence of SD, it is difficult to apply in economic analysis because of the inexplicit expression of the concept of need.

Overall, due to the comprehensive normative principles of the idea of SD, it opens up a development for all that has to be ecologically sound, socially justified and equitable economic development by improving economic and environmental efficiency, integrating regenerative technologies and redesign with communities (Pretty, 1998). In addition, iterative evaluation and coherent strategies and policies are essential for promoting SD.

### 2.3 Understanding sustainable rice farming: sustainable agriculture revisited

The terms ‘agriculture’ and ‘farming’ are closely related and most of the time they are used interchangeably. According to National Research Council (NRC) (1989), “agriculture encompasses the entirety of the system that grows, processes, and provides food, feed, fiber, ornamentals, and bio-fuel for the nation. It includes the management of natural resources and other lands for commercial or recreational uses, and wildlife; the social, physical, and biological environments; and the public policy issues that relate to the overall system”. While a farm refers to “a single, identifiable operational unit that manage natural resources such as water, forests, and other lands to provide food, feed, fiber, ornamentals, energy, and a range of environmental and other services” (NRC, 2010). Usually, agriculture consist a wide range of farming activities, crop farming, aquaculture, animal husbandry, etc. A particular type of farming such as rice farming is a part of the whole agriculture which embeds a spatial and temporal dynamic context and interacts with the biological, social, economical variables of that environment. Farms apply different types of cultivating techniques and strategies known as ‘farming practices’.

The definition and conception of sustainable agriculture (SA) differs considerably, as it is a complex, dynamic and political concept that has an inherent association with contextual aspects. NRC broadly reports four key goals in defining SA:

- To satisfy human food, feed and fiber needs;
- To enhance environmental quality and the resource base;
- To sustain the economic viability of agriculture and
- To enhance the quality of life for farmers, farm workers, and society as a whole.

Similarly, the American Society of Agronomy (ASA) (1989) said "a sustainable agriculture is one that, over the long term, enhances environmental quality and the resource base on which agriculture depends, provides for basic human food and fibre needs, is economically viable, and enhances the quality of life for farmers and society as a whole. On the other hand, Unilever (2002) focuses "SA is productive, competitive and efficient while at the same time protecting and improving the natural environment and conditions of the local communities".

There are numerous definitions provided by the researchers, particularly Hansen (1996) reviewed the definitions of SA, considering literature differs in focus, scope and degree of details. Despite the fact that a number of scholars documented several conceptualisations of SA, a set of attributes have recurrently drawn. Collectively, it is found that SA must:

- Provide food and fibre of adequate quantity and quality;
- Effective and efficient in natural resource management so that agricultural practices conserve and improve resource in the long run;

- ❖ Not degrade the planet's life support systems, namely agro-biodiversity, the climate system;
- ❖ Be socially just and equitable to all.

As mentioned earlier, agriculture is inextricably intertwined with farming. Therefore, the definition and conception of SA is largely similar with the term 'sustainable farming'. This issue is more justified in agro-based country, like Bangladesh where agriculture is highly dominated by rice farming. Rice production is not an important factor for the economy of this country, but also poverty alleviation, securing food and employment of mass population are relied on rice production. Rice accounts for over 60% of the total crop agriculture value (Yu et al., 2010; Asaduzzaman et al., 2010) and more than 90% of the total cereal production (GoB, 2009).

Sustainability is a 'contextual concept'. Thus, considering the context of Bangladesh sustainable rice farming should have the following characteristics:

- ❖ Maintain a high yield and productivity of rice that ensure economic viability;
- ❖ Less environmentally degrading production systems with special emphasis on the preservation and improvement of the natural resources;
- ❖ Signify the quality of producers' life in terms of adequate access to information, education, market and decision making.

### 2.4 Sustainable rice farming in Bangladesh: A stocking of challenges

Rice is one of the vital crops to feed the world's growing population (Shimono et al., 2010). It has been reported that rice farming is inextricably linked with households' and national food security, reduction of poverty and hunger,