The Prospects of Organic Farming in Bhutan

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Abstract

The potential harmful effects of conventional agriculture (CA) and the alleged multiple benefits of organic agriculture (OA) in conjunction with the prevalence of coherent conceptual linkage between the principles of OA and Bhutan's development philosophy of Gross National Happiness have motivated the Bhutanese government to declare in 2008, to fully convert farming in the country to OA by 2020.

However, the benefits accruing from OA along with the practicality and performance of OA are being increasing questioned globally. Amidst these controversies and accentuated by the lack of empirical data from Bhutan, questions arise as to whether or not the country should convert its agricultural sector to fully organic. Therefore, to determine the possible performance and prospects of OA in Bhutan, using paddy rice as the model crop, this study investigates wide-ranging issues between OA and CA in terms of yield, soil nutrient contents and economics in Bhutan. This study also compares organic and conventional farmers' happiness as well as analyzes the strengths, opportunities, weaknesses and threats (SWOT) of OA.

The comparative investigation on yield and different soil parameters, conducted during two cropping seasons (2012 and 2013) in three agro-ecological zones (AEZs) (low, mid and high altitude) of the country, involved 120 organic and 120 conventional farmers. The socio-economic study was based on randomly selected 393 organic and 353 conventional farmers from all 20 districts of Bhutan. The SWOT analysis was conducted among 35 agricultural experts, policy makers, NGO officials and private sector members to assess experts' views on pros and cons as well as the potentials and challenges of OA, and its promotion in Bhutan. The study thus provides the first empirical data of paddy rice production, the country's most important crop, under OA and CA schemes in various parts and AEZs of Bhutan.

The comparative study on paddy yield and various soil properties, including soil organic matter (OM), nitrogen, phosphorus and potassium in the three AEZs did not reveal significant differences between organic and conventional production systems within each AEZ. However, the three factorial interaction analysis involving farm types, AEZs and years found significant differences in SOM, P, K, cation exchange capacity (CEC), bulk density and yield. Furthermore, significantly higher gross production cost (61,892 Nu ha^{-1}) and total labor cost (49,483 Nu ha^{-1}) in organic, and significantly higher inputs costs (11,600 Nu ha^{-1}) and benefit-cost ratio (BCR) (2.8) in the conventional system were found. The premium price that organic paddy generally attracts was not considered in calculating either BCR or other costs/returns, yet there was no significant difference in gross and net returns between OA and CA. The happiness rating shows that the proportion of organic farmers who were subjectively happy or very happy was marginally higher at 87% as compared to conventional ones at 77%. The findings of the SWOT analysis show a considerable number of opportunities and strengths in favor of OA, together with many weaknesses and threats constraining the approach.

Based on the findings of this study, it can be concluded that OA, using paddy rice as the model crop, is in no agronomic aspect inferior to CA in Bhutan and their performances are comparable. On the basis of this and given the alleged ill effects of CA on human and ecosystem health, Bhutan may heed precautionary principle and thereby continue to adhere to its declaration to convert its entire agriculture to fully organic. Whether or not converting to OA can help to achieve food self-sufficiency (FSS) is hard to answer, because agriculture in Bhutan is constrained by several factors. But considering OA's alleged superior adaptability to the threat of looming climate change and is multiple benefits, it has the potential to achieve FSS. However, certain misgivings about OA and critical challenges, such as arranging adequate organic fertilizers and effective alternatives to conventional plant protection interventions must be addressed in order to smoothly transit to fully organic production.

Kurzfassung

Potentiell negative Auswirkungen konventioneller (KL) und der vielfältige Nutzen ökologischer Landwirtschaft (OL) sowie die Nähe letzterer zur Philosophie des Bruttonationalglücks haben die Regierung Bhutans bewegt, die Landwirtschaft des Landes bis 2020 vollständig auf ökologisch verträgliche Produktionsweisen umzustellen.

Da die Vorteile der OL jedoch insbesondere hinsichtlich ihrer Anwendbarkeit und ihrer Erträge immer wieder in kontrovers diskutiert warden und empirische Daten für Bhutan fehlen, stellt sich die Frage, ob das Ziel, die Landwirtschaft landesweit auf OL umzustellen, sinnvoll ist. Die vorliegende Studie bewertet am Beispiel von bewässertem Reisanbau anhand von Ertrags-,Boden-und sozio-ökonomischen Daten die Aussichten von OL in Bhutan. Auch wird die Zufriedenheit ökologisch und konventionell wirtschaftender Landwirte verglichen und die Stärken, Chancen, Schwächen und Risiken (SWOT) der OL analysiert.

Die vergleichenden Untersuchungen des Ertrags und unterschiedlicher Bodenparameter life über zwei jahre und wurde in drei agro-ökologischen Zonen (AÖZ) unter Beteiligung von je 120 organischer und konventionell Landwirte drchgeführt. Die sozio-ökonomische Studie basiert auf zufällig ausgewählten 393 ökologisch und 353 konventionell wirtschaftenden Landwirten aus allen 20 Provinzen des Landes. Die SWOT-Analyse wurde unter Teilnahme von 35 Landwirtschaftsexperten, Entscheidungsträgern, NGO-Vertretern und Vertretern des Privatsektors zur Beurteilung von Vor- und Nachteilen sowie Potentialen und Herausforderungen von OL und deren Föderung in Bhutan durchgeführt. Die Studie beinhaltet die erste empirische Datengrundlage über den Anbau von Reis, der wichtigsten Feldfrucht des Landes, unter OL und KL in drei AÖZs Bhutans.

Es konnten in keener der drei AÖZs Unterschiede zwischen OL und KL hinsichtlich Reisertrag und Bodenparametern wie organische Substanz des Bodens (SOM), Stickstoff, Phosphor und Kalium nachgewiesen warden. Jedoch ergabder dreifaktorielle Vergleich von Produktionsweise (OL, KL), AÖZ, und jahr (2012, 2013) signifikante Unterschiede hinsichtlich SOM, P, K, Kationenaustauschkapazität, Bodendichte und Ertrag. Daruber hinaus wurden significant höhere Produktions-(61.891 Nu ha^{-1}) und Arbeitskosten (49.483 Nu ha^{-1}) für OL gefunden. In der KL waren der Sachmittelaufwand (11.600 Nu ha^{-1}) und das Kosten-Nutzen-Verhältnis (2.8) significant erhöht. Vorzugspreise, die OL üblicherweise erzielt, sehr zufriedener und zufriedener Bauern bei OL mit 87% wenig h:oher war als bei KL (77%). Die SWOT-Analyse weist sowohl auf Chancen und Stärken der OL als auch auf Schwächen und Risiken hin.

Anhand der Ergebnisse für Reis wird deutlich, dass in Bhutan die OL der KL agronomisch in keinster Weise nachsteht, sondern beide Produktionsweisen vergleichbare Leistungsniveaus haben. Deswegen sowie aufgrund möglicher negative Auswirkungen von KL sollte Bhutan das vorsorgeprinzip anwenden und am Ziel, die Landwirtschaft landesweit auf OL umzustellen, festhalten. On durch den Umstieg auf OL dieSelbstversorgung mit Nahrungsmitteln erreicht warden kann, ist schwer zu beantworten, da die Landwirtschaft Bhutans von vielen Faktoren beeinflusst wird. Aufgrund der höheren Anpassungsfähigkeit an den klimawandel sowie anderer Vorteile hat die OL zumindest das Potential die Lebensmittelselbstversorgung Bhutans zu sichern. Vorbehalte gegenüber und anspruchsvolle wirkungsvoller Alternativen zu konventionellem pflanzenschutz, müssen berücksichtigt warden, um den reibungslosen Übergang von KL zu OL zu ermöglichen.

DEDICATION

This thesis is dedicated, with homage, to my old parents whose constant prayers and blessings continue to keep me going strong.

It is also dedicated, with profound love, to all the children, who were and are deprived of the war, company and loving-touch of their parents or either of their parents.

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List of Acronyms

AEZ	Agro-ecological Zone
BAFRA	Bhutan Agriculture and Food Regulatory Authority
BD	Bulk Density
BTF	Bhutan Trust Fund for Environment Conservation
CA	Conventional Agriculture
Ca	Calcium
CAN	Calcium Ammonium Nitrate
CBS	Centre for Bhutan Studies
CEC	Cation Exchange Capacity
CON	Conventional Field
CoRRB	Council of Renewal Natural Resources Research of Bhutan
DAMC	Department of Agricultural Marketing and Cooperatives
DAP	Di-Ammonium Phosphate
EDP	Economic Development Policy
FAO	Food and Agriculture Organizations
FiBL	Research Institute of Organic Agriculture
FSS	Food Self-sufficiency
FYM	Farm Yard Manure
Geog	(Bhutanese language) Group of villages
GHG	Green House Gas
GNH	Gross National Happiness
GNHC	Gross National Happiness Commission
ICS	Internal Control System
IFAD	International Fund for Agriculture Development
IFOAM	International Federation of Organic Agriculture Movements
IFPRI	International Food Policy Research Institute
K	Potassium
LEISA	Low External Input Sustainable Agriculture
MAFRI	Manitoba Food, Agriculture and Rural Initiatives
Masl	Meters above sea level
MoAF	Ministry of Agriculture and Forests
MoEA	Ministry of Economic Affairs
MoP	Muriate of Potash
MT	Metric tone

N	Nitrogen
NBC	National Biodiversity Centre
NFOFB	National Framework for Organic Farming in Bhutan
NGO	National Organic Program
NSB	National Statistical Bureau
NSSC	National Soil Science Centre
Nu	Ngultrum (Bhutanese currency; 100 Nu = 1.23 € as on 16 August 2014)
OA	Organic Agriculture
OCW	Organic Centre, Wales
OM	Organic Matter
ORG	Organic Field
P	Phosphorus
PPD	Policy and Planning Division
PGS	Participatory Guarantee System
PCS	Planning Commission Secretariat
RGoB	Royal Government of Bhutan
RNR	Renewal Natural Resources
RNRRDC	Renewal Natural Resources Research Development Centre
RUB	Royal University of Bhutan
SAC	Synthetic agro-chemical
SAP	School Agriculture Program
SCF	Synthetic Chemical Fertilizer
SFM	Soil Fertility Management
SOC	Soil Organic Carbon
SOM	Soil Organic Matter
SPAL	Soil and Plant Analytical Laboratory
SRI	System of Rice Intensification
SSP	Single Super Phosphate
SWOT	Strength Weakness Opportunity Threat
TWG	Technical Working Group
UNDP	United Nations Development Program
WB	World Bank
WPD	Weed Pest Disease
WSA	Water-Stable Aggregate
WTO	World Trade Organization
WWI	WorldWatch Institute

1 INTRODUCTION AND BACKGROUND

1.1 General Introduction

"The journey of a 1000 miles begins with a single step."

Lao Tzu (640 B.C. – 531 B.C.)

Conventional agriculture (CA), which involves the use of synthetic agro-chemicals and mono-cropping, is argued to intensify land degradation, pollution of water sources and loss of biodiversity (Lampkin 1990, Scialabba & Müller-Lindenlauf 2010). It is also alleged to increase socio-economic inequality and worsen poverty as noted in the Indian state of Punjab (IFRI 2002; Shiva 2013).

These increasing unintentional negative consequences strengthened the cause and a need for a more sound and sustainable method of producing food (Reddy 2010; Pingali 2012). Thus, the hitherto fringe organic agriculture (Vogt 2007), pioneered in the early nineteenth century, started to attract attention as a viable alternative to modern or conventional farming dependent on synthetic agro-chemicals (Kristiansen and Merfield 2006).

Organic agriculture (OA) is documented, albeit controversially, to be more socially acceptable, economically sound and environmentally benign than CA (Scialabba 2007; Rahmann 2011; UNEP 2011; Tuomisto et al. 2012). OA is also said to favor animal welfare, preserve biodiversity (Hole et al. 2005; Rahmann 2011), and reduce resource consumption (Nemecek et al. 2011) compared to conventional farming.

OA emphasizes the use of local, on-farm materials and crop rotation to foster the inherent biological capacity of soils instead of relying on external inputs and synthetic agro-chemicals usage (IFOAM 2002; Stockdale et al. 2002). In addition, the four principles (Appendix) on which OA hinges advocate care, fairness and health consideration of humans, animals and the environment for present and future generations. This set of profound values that gives a positive spin to farming and targets sustainability in theory and practice, has attracted many environmentalists and health conscious consumers (FAO 2013). The rising number of such consumers in turn has triggered further growth of organic agricultural land and the organic market (Kristiansen and Merfield 2006; FiBL-IFOAM 2014).

The latest statistics on OA published by FiBL (Research Institute of Organic Agriculture) and IFOAM (International Federation of Organic Agriculture Movements) show that the number of countries producing organic food has touched 164 in 2012, with Europe leading at 46. Worldwide the land under OA has grown to 37.5 million ha in 2012 from 15 million ha in 2000. Despite increasing by more than 100%, the land under OA represents only about 1% of the total global agricultural land. In tandem with the rise in land under OA, the global organic market also jumped to US $ 64 billion in 2012 from US $ 18 billion in 2000 (FiBL-IFOAM 2014).

The growing global OA movement, which is predicted to grow further (FiBL-IFOAM 2014) because of the continuing environmental ill effects and contentious poor food quality emanating from conventional farming, has also lured the Himalayan Kingdom of Bhutan into its fold. Bhutan, which has a forest cover and protected area cover of 72% and 51%, respectively, and further aspires to maintain 60% of the land under forest at all times, has expressed its commitment to protecting the environment (RNR 2013).

1.2 Background and rationale

Environment protection and sustainable socio-economic development through cautious planning are at the core of Bhutan’s development philosophy of Gross National Happiness (GNH) (UNDP 2011; Ura et al. 2012). As opposed to Gross National Product (GNP) and Gross Domestic Product (GDP), GNH, first propounded in 1972 by the Fourth King of Bhutan, is mainstreamed to measure wellbeing and growth (Bates 2009; Braun 2009). The philosophy of GNH underscores mental wellbeing over material growth, and embraces holistic wellbeing in all spheres (Braun 2009; Tideman 2011). Despite being economically poor and experiencing food deficit, Bhutan’s development policy objectives, guided by the philosophy of GNH, remain all inclusive and sustainability-oriented (Ura et al. 2012).

Therefore, the holistic approach of OA to food production with a strong emphasis on sustainability has much in common with the philosophies and aspirations of Bhutan’s development policy objective of GNH. Accordingly, it was natural for Bhutan to not only officially launch OA in 2003, but also to proclaim to become a fully organic country by the year 2020 (NFOFB 2007; Thinley 2011).

However, at this juncture, and for the purpose of this study, OA in Bhutan implies farming primarily without the use of synthetic agro-chemicals (SACs) and with no organic certification; it also means farming with organic “intent” and in compliance with organic principles. On the other hand, CA prevalent in Bhutan and referred to in this study implies farming with one or more SACs and other artificial growth hormones.

Arguably, Bhutan is in a rather comfortable position to convert to fully organic agricultural production (Leu 2011a), because the theory and practice of organic farming, with the emphasis on recycling of local organic materials, exclusion or restriction of SACs and encouraging crop rotation and diversification, are common practices in the country (Thimmaiah 2007; Pradhan et al. 2012). Having remained isolated from rest of the world until the 1960s, external influence, including the influence of conventional farming, has not gained a strong foothold in Bhutan (Tashi 2007; Duba et al. 2008).

Thus farming in Bhutan generally still relies primarily on organic materials such as the use of cattle manure, leaf litter and crop residues as fertilizers (Roder et al. 2003; Gurung 2008). Farming is largely based along traditional lines with heavy reliance on traditional knowledge and the avoidance of the use of SACs (Tobgay 2005; NFOFB 2007). As such, it already follows some principles of organic farming (Leu 2011a), even if only by default (Gurung 2008; Dosch 2011).

Indeed, in view of the prevalence of rich Buddhist values incorporated into farming practices and land use (Penjore and Rapten 2004), as well as the practice of scheduling farm activities around the lunar cycle, the farming systems in Bhutan could even be construed as a variant of biodynamic farming. The latter is a method of organic farming, which, besides emphasizing the interrelationship of the soil, plants, and animals as a closed, self-nourishing system, also uses an astronomical sowing and planting calendar, with its basis in a spiritual world-view as propounded by its founder Rudolf Steiner (Paull 2011; Chalker-Scott 2014).

Hence, theoretically converting to mainstream or certified organic production will not require major shifts in the prevailing farming paradigm of Bhutan. Moreover, there is a strong political support, both within and outside Bhutan, to convert to a fully organic country (Thinley 2011).

However, can these theoretical and philosophical grandiose of GNH and OA values and aspirations actually translate into practice and yield corresponding results in agriculture fields? Practicalities and realities in the field have not been sufficiently gauged yet.

Bhutan considers food self-sufficiency and food security issue extremely important and they are repeatedly featured in various important development plans and documents. Can OA deliver the much sought-after food self-sufficiency goal? Several studies conducted elsewhere contest the benefits associated with OA (Kirchmann et al. 2008; Jenkins et al. 2010; Seufert et al. 2012). These studies argue that the yield and profit from OA is low and soils nutrient-deficient, and hence the organic system of production is alleged to be inefficient and not capable of meeting the food demand of the growing global population (Kirchmann et al. 2008; Seufert et al. 2012).

On the other hand, there are approximately an equal number of studies comprising opposing claims (Nemes 2009). These studies document distinct benefits and advantages of the organic system of production in not only crop yield, farm profitability and soil nutrient status, but also in the whole ecosystem (Fookes 2001; Setboonsarng 2006; Badgley et al. 2007; Scialabba 2007).

Whilst these dichotomous claims and results on the benefits of OA are legitimate in their own right, several researchers argue that ultimately the biophysical conditions of a farm and the level and type of management practices employed influence the final outcome in the field (Badgley and Perfecto 2007; Hazarika et al. 2013). In other words, if management practices are sound and optimal and these are suitably attuned and adapted to specific biophysical conditions then the expected benefits from OA can be enhanced or OA can be expected to perform better.

Against this hypothesis and given a set of constraints prevalent in Bhutan (Neuhoff et al. 2014), it is unclear how and to what technological, management and social extent organic farming can meet the expectations of enhancing food production and lowering production costs, while maintaining the fertility of the soils in the country. Indeed, crop yield, farm profitability, soil fertility and people's perceptions are arguably the most important determinants for the adoption or rejection of any new method of food production. And for the government of the day, food self-sufficiency goal is a major concern and a top priority. Therefore, this study was undertaken to investigate these questions with the intention to provide the first empirical evidence of comparing crop production under the two production systems throughout a wide range ecological and social circumstances.

1.3 Objectives

This study, which is the first of its kind in Bhutan, was designed to assess the prospects of organic farming through the lens of a comparative study. The specific objectives of the study were to:

I. Compare soil nutrients and properties in organic and conventional paddy fields.
II. Compare paddy yields of organic and conventional production systems.
III. Compare social parameters of organic and conventional farmers.
IV. Compare contribution of women to organic and conventional paddy production.
V. Compare happiness of organic and conventional paddy farmers.
VI. Compare profession preferences of organic and conventional farmers.
VII. Compare cost-benefit of organic and conventional paddy production.
VIII. Compare paddy pest and disease incidences of organic and conventional paddy.
IX. Compare organic and conventional paddy field management.
X. Analyze strengths, weaknesses, opportunities and threats of OA.

Conducted in 2012 and 2013, this study compares the performance of organic and conventional production systems in terms of crop (paddy rice) yield, cost-benefit and soil nutrient status across all three agro-ecological zones of Bhutan. It was conducted under farmers' prevailing conditions and management practices without any external interventions, because it is often argued that the results obtained from research stations cannot be replicated in farmers' fields because of "practical limitations" (Reganold 2014) and that researchers' interventions generally do not align with farmers' usual management practices. For this comparative study paddy rice was selected.

Paddy is the most important subsistence and cash crop of Bhutan. To a large extent, paddy represents a typical strategic Bhutanese crop, as it is grown in all the AEZs and in all the 20 districts of the country (Ghimiray et al. 2007). It is cultivated following both organic and conventional methods. It is typically grown once a year, like most other crops in Bhutan. However, in 2012, double cropping of paddy has started in very small pockets in the two districts of Wangdue and Samdrup Jongkhar.

Of late, and unlike other agricultural crops, paddy has received more attention from the government, and plans are underway to commercialize it on a large scale. This is because more than 50% of paddy rice consumed in Bhutan is imported (RNR 2013). The thrust for commercialization to enhance production could potentially increase the use of synthetic agro-chemicals and this derail the ambitious plans of becoming a fully OA country. Hence, it was relevant and important to assess how paddy could fit into the organic production paradigm by performing this comparative study.

The comparative performance study was further supplemented by survey interviews of 746 farmers in all the 20 districts of the country to determine the socio-economic conditions, including the contribution of women to farming, and the state of happiness between organic and conventional farmers.

In addition to the socio-economic and comparative performance study, an experts' group meeting and personal interviews were conducted to analyze policy support and prospects of organic farming. Thirty five experts and specialists from various sectors took part in this exercise.

The study integrates the results of the comparative performance study, survey interviews and experts' group discussions to draw conclusions on the prospects of organic farming in Bhutan and to derive the constraints and conditions under which it could be recommended at the farm level. It is expected that the findings of this study will contribute to the national knowledge base for developing sustainable agricultural policies.

1.4 Outline of the study

This thesis is divided into eight chapters.

Chapter 1 provides a broad introduction, background and the rationale of the study, embedding it into the international and national context. It also outlines the objectives and the expectations of the study.

Chapter 2 introduces the concepts and the historical background of OA and explains how its philosophies link with the concept of GNH. This chapter also reviews some of the criticisms of organic farming and highlights contradictory results from some of the comparative studies between organic and conventional production systems in terms of soil nutrient status, crop yield and profitability.

Chapter 3 provides a brief background on Bhutan and describes the paddy rice production situation in the country. It also highlights some of the major constraints concerning paddy production.

Chapter 4 introduces the study sites and the various methods used to undertake this study. It also includes the relevant statistical analyses used to test and analyze the data of this study.

Chapter 5 presents the results in chronological order so as to align with the objectives of this study.

Chapter 6 discusses the results and their relevance and implications, which may be beneficial in shedding light on the prospects of organic farming in Bhutan.

Chapter 7 presents and synthesizes the prospects of organic farming derived from the previous chapters and the analysis of the SWOT test conducted with the experts' group. A simplified way forward based on these analyses and prospects is also provided.

Chapter 8 concludes and highlights the most important findings of the study and links these to draw final conclusions on the possible prospects of organic farming in Bhutan. Some of the important research gaps for future research area also suggested.

2 ORGANIC FARMING

"A nation that destroys its soils destroys itself."

Franklin Roosevelt (1937)

2.1 Introduction

In an attempt to provide a thematic context, this chapter synthesizes important literature that is critical and pertinent to the design and objectives of this study. To set the tone, the chapter begins with the definition and concept of OA, followed by a brief historical background, some of the important pioneers and the important drivers for the increasing growth of OA. The chapter continues with the highlights of some of the pertinent criticisms OA has attracted and proceeds to describe the conceptual link and harmony between GNH and OA and the policy support the latter enjoys in Bhutan. The chapter also describes the reasons for Bhutan to transit to a fully organic country by the year 2020, the strategies already put in place and other interventions which are planned to achieve this ambitious goal. The current OA scenario in Bhutan and the challenges Bhutan confronts in "going" fully organic are also described. The last part of the chapter covers systems comparisons. In conforming to the objectives of this study, this section mainly describes the economics, yield and soil nutrient status in paddy fields that were managed organically and conventionally, and wraps up with perils and consensus emanating from comparative systems studies.

2.2 Organic farming – definitions and history

Organic farming used to be known as humus farming when it first started to develop (Kuepper 2010). The nomenclature "Organic Farming", that is known today was first used by the British agronomist Lord Northbourne in his book *Look to the Land*, published in 1940 to describe farms as organisms and sustainable farming as 'organic' (Scofield 1986; Paull 2006).

Organic farming is known by several names: biological farming, ecological farming, regenerative farming, and sustainable farming (Lampkin 1990). As with names, different entities define organic farming in different ways (MacKerron et al. 2000: Hazarika et al. 2013).

For example, the definitions used by the Organic Centre, Wales or OCW (OCW 2005) underscores integrated and sustainable production practices:

> Organic farming can be defined as an approach to agriculture where the aim is to create integrated, humane, environmentally and economically sustainable agricultural production systems. Maximum reliance is placed on locally or farm-derived renewable resources and the management of self-regulated ecological and biological processes and interactions in order to provide acceptable levels of crop, livestock and human nutrition, protection from pests and diseases, and an appropriate return to the human and other resources employed. Reliance on external inputs, whether chemical or organic, is reduced as far as possible.

Like OCW, the definition of the International Federation of Organic Agriculture Movements (IFOAM 2002) emphasizes environmental as well as socio-economic aspects:

> Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved.

It can be thus surmised from different definitions and from its four principles of Ecology, Health, Fairness and Care (IFOAM 2005) that the essence of organic farming is a healthy soil, on which depends the health of life. Organic farming, as a holistic system, is a way of life (Lockeretz 2007). The four principles of organic farming provide insights into philosophies of organic production and also form guidelines for its practices (Kristiansen and Merfield 2006). The philosophies revolve around ethical principles, mainly because “people interact with living landscapes, relate to one another and shape the legacy of the future” (IFOAM 2002).

Organic farming is not a new concept (Delate 2011), rather it is argued to be the oldest form of farming on earth (Hazarika et al. 2013). This concept, however, was further developed in the early twentieth century mainly in Europe (Vogt 2007; Hazarka et al. 2013). The work of Rudolf Steiner in Austria and Germany, F.H. King in Asia, Lady Eva Balfour in the UK, Sir Albert Howard in India, and J. Rodale in the US are testimony to this (Scofield 1986; Heckman 2006; Vogt 2007; Kuepper 2010).

With the controversial consequences of the industrialization of agriculture, which started after the development of the Haber-Bosch process in 1909 (Kissel 2014), and picked up after the two World Wars, organic farming was sought as a safer alternative to food production (Kristiansen and Merfield 2006; Paull 2006). The rise in organic farming was further boosted by the work of Rachel Carson (*Silent Spring* published in 1962), numerous environmentalists from the industrialized west and the growing number of health-conscious consumers (Kristiansen and Merfield 2006; Scialabba 2007). Eventually, this growth culminated in the formation of IFOAM, a non-profit global network of the organic movement, with the mission to “lead, unite and assist the organic movements in its full diversity” (IFOAM 2002).

The increasing demand for healthy food coupled with the growing scare of environmental pollution and damage (Connor 2008; Nemes 2009), often associated with conventional farming, is further pushing the growth of organic farming worldwide (Fig. 2.1). The global total area under organic farming, from a total of 164 countries, was 37.5 million ha at the end of 2012, up from 29 million ha in 2005 (FiBL-IFOAM 2014). The total market values have also seen corresponding growth with US$ 64 billion in 2012, up from about US 29 billion in 2004. This growth is predicted to continue (FiBL-IFOAM 2014) despite a flurry of criticisms from various quarters (Lockeretz 2007).

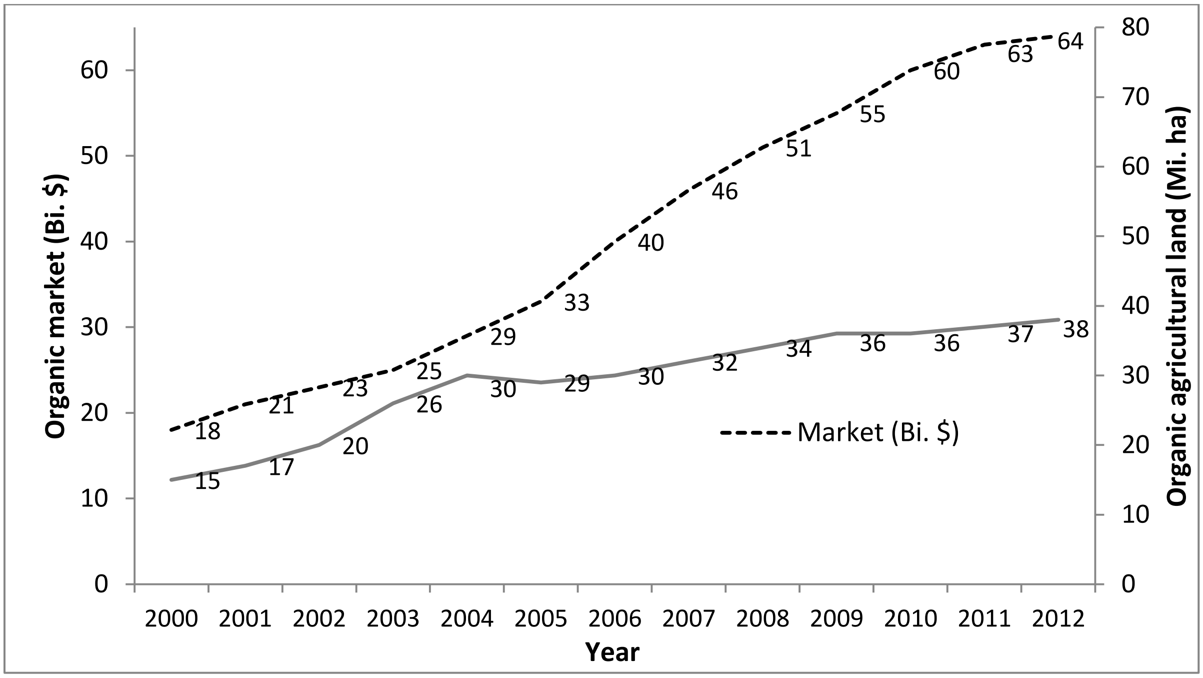

Figure 2.1: Continuing growth of global organic agricultural land and market

Source: FiBL & IFOAM (2000-2014)

2.3 Criticisms of organic farming

Certain variant of organic farming was the primary means of producing food before the advent of SACs and knowledge of plant nutrition and plant physiology (Nemes 2009). It became marginalized as agriculture shifted to industrialization. But as agriculture became more chemical-centric, OA gained momentum. However, the ‘renaissance’ of OA as a presumed way of producing safer food and fiber with less damaging effects on the health of animals and the global ecosystem is hit by a myriad of criticisms (Vos 2000). Critics allege that organic farming is an impractical ideology, a cult and a myth (Kirchmann 1994).

Many academics argue that the yield from organic farming is low (Maeder et al. 2002; IFAD 2005; Murphy et al. 2007; Zundel and Kilcher 2007; Seufert et al. 2012; Stewart et al. 2013) and that the production cost is high (Maeder et al. 2002; Komatsuzaki and Syuaib 2010; Uematsu and Mishra 2012), thus translating into high price for organic products (Trewavas 2001; Connor and Minguez 2012; Surekha 2013).

Because organic farms are comparatively small and because many of them are away from the markets (although not always necessarily), shipment and transportation require substantial energy (Connor and Minguez 2006), thus negating any environmental benefits, if any. Further, organic produce, mainly fruits and vegetables, are alleged to be often unsafe, as they can harbor harmful microbes (Smith-Spangler et al. 2012; Miller 2014) and increased levels of secondary plant metabolites because of the plant's survival responses to pests (Pacanoski 2009).

It is being argued that maintaining soil fertility of organic farms is not feasible, especially in tropical areas, because of the faster rate of organic matter decomposition and generally poor soil-nutrient status (Lal and Kimble 2000). Besides, it is alleged that fertilizers from organic sources are limited, and that farms managed organically lack essential plant nutrients such as phosphorus.

Ultimately, organic farming is interpreted as being grossly inefficient (Leifeld 2012), and its ability to feed the growing global population is being seriously doubted and debated (Kirchmann et al. 208; Seufert et al. 2012). It is argued that in order to feed the world, organic farming, which is seen more as a "luxury production' (Vaarst 2010), leads to cultivation of more land (Connor and Minguez 2012) at the cost of the environment.

These criticisms are counter-argued in detail by IFOAM in its publication titled *Criticisms and Frequent Misconceptions about Organic Farming: The Counter-Arguments* (Fookes 2001; IFOAM 2008). Various other publications and articles in different journals refute all allegations against organic farming (Fookes 2001) and highlights that "organic farming is the best choice we can make for our environment, animals and our own health" (Jahanban and Davari 2013).

Despite all the criticisms, whether founded or not, Bhutan joined the global organic bandwagon without any pressure from within or outside, and with no resistance from farmers or agriculture policy makers.

2.4 Gross National Happiness and Organic farming in Bhutan

Bhutan joined the OA movement with the formal launch of organic farming in 2003. Organic farming, which espouses socio-economic and ecological soundness and sustainability, blends well with the developmental policy objective and philosophy of Bhutan, which in 1972 initiated and embraced the Gross National Happiness (GNH) concept as opposed to the Gross Domestic Production (GDP) as a measure of growth, well-being and prosperity.

The GNH concept, coined by the Fourth King of Bhutan, and institutionalized in 2008 (Powdyel 2004; Braun 2009), is a "multidimensional development approach that seeks to achieve a harmonious balance between material well-being and the spiritual, emotional and cultural needs of the society" (Powdyel 2004). The GNH concept hinges on four pillars, namely good governance, sustainable socio-economic development, cultural preservation and environmental conservation (Tideman 2011; Ura et al. 2012). These four pillars are likened to the four Principles of OA (Tshomo 2014).

The four GNH pillars are classified into nine domains with 33 indicators and 124 sub-indicators to emphasize, understand and measure different aspects of wellbeing, happiness and growth (PPD 2010; Ura et al. 2012). As a measure of well-being, growth and happiness, the GNH index is derived from a robust multidimensional methodology called the Alkire-Foster method[1] (Alkaire and Foster 2008).

However, the measure of GNH is alleged to be imperfect (Bates 2009). Like organic farming, GNH has also attracted a fair share of criticisms (Bates 2009). Nevertheless, Bhutan continues to persevere, endeavoring to embrace all those projects, plans and technologies such as OA, that align with or complement GNH goals. Some examples of these include provisioning of a legal framework through the Bhutanese Constitution (Article 9) to "promote those conditions that will enable the pursuit of GNH", the rechristening of the erstwhile Planning Commission as GNH Commission and the launching of the Green Public Procurement Project in mid-2014. The GNH Commission screens all new development plans and projects through a set of criteria before their implementation. Since 2012, the "Educating for GNH" initiative has started in schools with green activities and value education.

Through the aforementioned initiatives and others, such as mandating through the Constitution (Article 5) the need to maintain at least 60% of the land under forests cover at all

[1] Details about the method can be found here: http://www.ophi.org.uk/research/multidimentional-poverty/alkire-foster-method/

times, as well as being carbon neutral along with various green initiatives, Bhutan has already earned, whether with mockery or all honesty, the nickname Poster Child of Sustainable Development (Vidal and Kelly 2013).

All development plans and programs in Bhutan are screened through the GNH lens, and are required to foster the long-term sustainability and well-being of its citizens. Accordingly, the Economic Development Policy of Bhutan written in 2010 envisages "to promote a green economy and self-reliant economy sustained by an IT-enabled knowledge society guided by the philosophy of GNH" (EDP 2010; RGoB 2012). Two important strategies embedded in this policy document of relevance to OA are "diversifying economic base with minimum ecological footprint" and "promoting and building Bhutan as an Organic Brand" (EDP 2010).

2.5 Strategies for full conversion to an organic agriculture country

Cognizant of the significance of OA in alleviating poverty through reliance on local resources without compromising the environment, which aligns with the four main pillars of the GNH concept, Bhutan has ambitiously proclaimed to convert to a wholly organic country by the year 2020 (PCS 1999; Thinley 2011). Some quarters have expressed skepticism towards meeting this target, but Andre Leu, President, IFOAM, dispels such misgivings, as he argues that the "majority of the agricultural land is already under organic by default" (Leu 2014) and also because the use of SACs is very limited in Bhutan. So making a shift to become fully organic is assumed to be relatively easy.

Towards achieving this goal and as a manifestation of the commitment to go fully organic, the National Framework Organic Farming in Bhutan (NFOFB) was launched in 2007 (NFOFB 2007) and the National Organic Program (NOP) established in 2006 (Tshomo 2014). Further, Gasa district in the north and Samdrup Jongkhar in the south of the country were recognized as organic districts in 2004 and 2010, respectively. Additionally, one of the country's five Renewal Natural Resources Research Development Centres located in Yusipang, Thimphu, was mandated in 2006 to conduct research exclusively on organic farming; but in reality this may not yet be happening on the ground.

The mission and vision for NFOFB and NOP are to develop and promote organic farming and environmentally friendly farming systems as a way of life and to produce high quality and safe food, both for domestic and export markets (NFOFB 2007). The NOP intends to initially promote organic farming through viable alternative methods and inputs with select crops and in selected pockets of the country (NFOFB 2007; Duba et al. 2008). This will be scaled up at an opportune time, and eventually all crops and the whole country will be included.

The NOP is assisted by a technical working group (TWG) comprising 14 specialists from the Ministry of Agriculture and Forests (MoAF) and a representative from the private sector. So far, the group does not have any members from academia. The TWG was established in 2010 and as stipulated by the NFOFB, it is mandated to apprise, decide and review policies and issues that may have national implications (Duba et al. 2008).

Other strategies adopted by the NOP to promote organic farming include training of farmers and field extension workers, field demonstrations as well as facilitation of marketing and the formation of farmers' groups and cooperatives. As of 2013, all agriculture extension workers based in the field have been trained by the NOP (Namgay, pers. comm.).

Besides, the government has proposed a tax holiday of 5-10 years for commercial organic farming and for the processing of organic products (Tshomo 2014), but thus far no one has availed this benefit.

Perhaps one of the most crucial initiatives illustrating the government's commitment to promote the plan of converting to OA and going fully organic is the plan to phase out in its entirety the use of synthetic chemical fertilizers (SCFs) and pesticides (RGOB 2012; Confino 2014; WB 2014). This plan is deemed feasible for two main reasons. First, the use of SACs is not only minimal (Fig. 2.2), both in quantity (23 kg ha^{-1} of cropped land) and types (6:1:1 ratio of NPK) (Dorji 2008), but is also confined to those selected pockets of the country that are accessible by motor roads. And second, all agro-chemicals are imported/ purchased centrally by the government and distributed through specific agriculture commission agents based in different districts (yet a few sporadic illegal imports of such chemicals do occur in places close to India because of the porous nature of the border).

Phasing out SACs could boost the image of Bhutan as intended and expedite the adoption of organic farming even more. When and how the phasing out will happen was yet to be decided at the time of this study.

The host of initiatives and interventions listed above clearly manifest Bhutan's seriousness to commit to integrate OA into its national conscience. It also manifests the strong political affirmation organic farming enjoys in Bhutan (Dosch 2011; Thinley 2011).

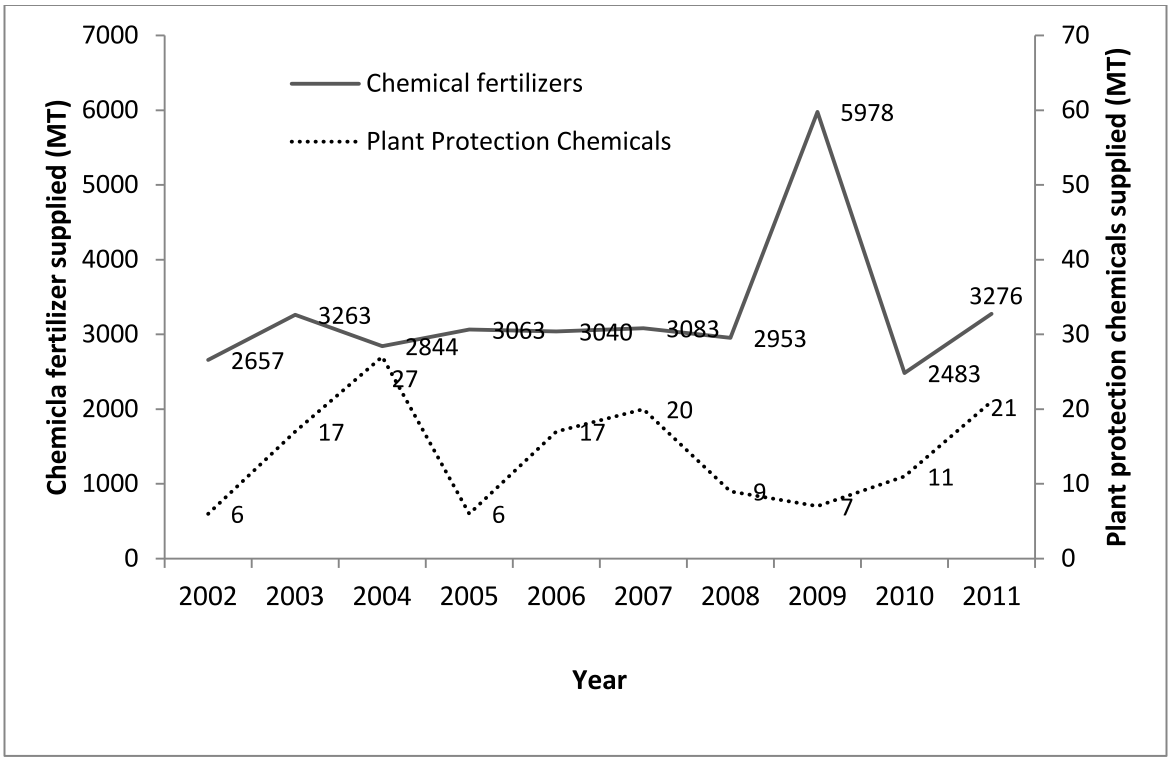

Figure 2.2: Fertilizer and pesticide distribution and use trend 2002 and 2013

Adapted from: Dorji (2008)

2.6 Current scenario of organic agriculture in Bhutan

So far the growth of OA in Bhutan has been very gradual. This could be in part attributed to the lack of technical expertise, as organic farming is knowledge intensive (Lampkin 1990; Thimmaiah 2007) requiring management of the whole ecosystem to produce food in a sustainable manner. Research in OA is at its infancy (Neuhoff et al. 2014), and budgetary support of $ 550,000 for the 10th Five Year Plan, which ended in 2013 can be considered to be relatively low (GNHC 2013).

No official records and statistics of OA until 2012 were maintained to compare and determine the trend of OA activities in the country. Although, by 2013 organic farming had spread across all the 20 districts of the country, the total area under organic management was only about 16,441 ha, or 14% of the total cultivated agricultural area (Tshomo 2014). The remaining cultivated agricultural land is considered either conventional or organic by default (Gurung 2008).

There is no fixed definition for the term “organic-by-default”. However, a farm is generally considered to be organic by default if it is farmed following traditional methods without using SACs, growth regulators or certification (Pretty et al. 2006; Scialabba 2007; Garcia 2013). Taking this definition into account, a large portion of farming in Bhutan can be categorized as organic as organic-by-default (Duba et al. 2008; Dosch 2011; Leu 2014). Having a large portion of the agricultural land managed as organic by default positions Bhutan in a comfortable state to shift to fully organic, as this shift would not compromise yield or require major structural change (Leu 2014).

Apart from agricultural products from organic-by-default farms, the main products from organically managed farms include asparagus, buckwheat, lemon grass oil (collection from wild), ginger, turmeric, medicinal plants (both wild and domesticated), some select vegetables and paddy. Most of these products are exported mainly to India and Bangladesh, while red rice and lemon grass oil are exported, to the US and Europe, respectively.

The organic produces in local markets, except in the capital city Thimphu, do not receive any notable premium price. This could be because the prices of most local produces in the country are already higher than those imported produce.

Unfortunately, the official record of the value of organic products, both for the domestic and export markets, could not be ascertained, as record keeping in Bhutan is still in its infancy.

While organic certification is, to a large part, an integral part of OA, especially for export markets, Bhutan does not have any specific organic certification in place yet. So even those farms recognized and managed organically are not certified. So far the organic products exported are certified by third-country certifiers. At the time of this study, the NOP was in the last stages of finalizing an Internal Control System (ICS) and a Participatory Guarantee System (PGS) in collaboration with the Bhutan Agriculture and Food Regulatory Authority (BAFRA), as a quality assurance mechanism for organic products in lieu of an organic certificate. The National Organic Standard of Bhutan initiated by NOP was at a final draft stage at the time of the present study.

Besides the NOP and the Department of Agricultural and Marketing Cooperatives under the MoAF, five NGOs, two private companies and three farmers' groups and cooperatives are involved in promoting OA in Bhutan. All schools across the country also have some form of school agriculture activities, which are solely organic-based.

2.6.1 Questions and challenges of going fully organic

The initiative to go fully organic has received commendation and support, both from within and outside the country (Garcia 2013). Organic practitioners and specialists, such as Andreu Leu and Vandana Shiva (Alternative Nobel Prize Laureate and Ecologist), have offered to assist. Even so, certain quarters, including several specialists from the MoAF, continue to express a need for caution through formal and informal channels.

Although organic farming has potential to contribute to poverty eradication, to promote gender equality, and to ensure environmental sustainability (Duba et al. 2008), this note of caution stems from some of the important challenges organic farming in Bhutan has to contend with (Duba et al. 2008; Neuhoff et al. 2014). Chief amongst these challenges or constraints are the fear of failing to achieve food self-sufficiency goals, lack of the availability of effective alternatives to synthetic plant protection chemicals, unavailability of organic manure in adequate volumes, and poor research and development culture and establishment (Wynen 2011; Connor and Minquez 2012; Nuehoff et al. 2014).

These challenges, however, are not unique to Bhutan only (Duba et al. 2008), as organic farming is just beginning to be mainstreamed worldwide (Setboonsarng 2006) with increased budget allocation to research in OA. Other challenges and opportunities are listed and discussed in Chapter 7.

2.7 Organic and conventional agriculture – systems comparison

A number of comparative studies between organic and conventional farming systems have been conducted across different parts of the world in terms of, amongst others, soil nutrient contents, yield, economics, biodiversity, environmental impact, greenhouse gas emissions, carbon sequestration, energy use, ground-water pollution and food quality (Lee and Fowler 2002; Jahanban and Davari 2013). However, in keeping with the objectives of this study, this section will focus on systems comparison pertaining to only soil nutrient contents, crop yield and economics (production cost, gross and net returns and benefits-cost ratio).

Further, paddy rice being the subject of this study, the focus of the examples and findings of past comparative studies will relate mainly to this crop. Also, where possible, the findings are selected from Asia, where paddy is predominantly cultivated.

2.7.1 Soil nutrients

Soil is the primary base of agricultural production, although lately hydroponics and aeroponics are steadily gaining momentum as alternative media for producing food. However, as these latter media are expensive, it may be argued that soil as a base for production will continue to dominate food production in the foreseeable future.

Soil as a base of production is fundamental to organic farming, because, more than in conventional agriculture, OA revolves around the concept of 'feeding the soil' (Paull 2006; Stockdale ad Watson 2009; UNEP 2011). OA advocates a closed nutrient cycle (Stockdale and Watson 2009), through promoting and sustaining the biological activity of the soil by optimizing the bio-physico-chemical structure of the soil using appropriate interventions and by relying on local on-farm resources.

The bio-physico-chemical structure of the soil will accordingly alter with the kind, volume and frequency of inputs being applied/ incorporated (Foth and Ellis 1997; Zhang et al. 2012), in addition to the kind and degree of tillage practiced (Schjonning et al. 2002; Madari et al. 2005). Since tillage is not within the purview of this study, this section will mainly focus on inputs and their consequences on the nutrient status in soils.

As a source of plant nutrients, organic farming relies chiefly on organic sources of fertilizers. The health of the soil is fundamental to organic farming (Jahanban and Davari 2013). Synthetic chemical fertilizers, which when used indiscriminately are found to harm the soil and pollute underground water sources through leaching and are strictly restricted or are entirely banned in organic farms. Besides applying organic fertilizers, organic farming also depends on a host of other management tools such as legume planting, crop rotation, green manuring, cover cropping, catch crops, mulching etc., to enrich and feed the soil (Watson et al. 2002: Thimmaiah 2007).

On the other hand, in CA the chief source of plant nutrients is synthetic chemical fertilizers, which feed plants directly after hydrolysis with the moisture present in the soil. The way in which organic amendments and the application of synthetic chemical fertilizers impact the soil-physico-chemical structure of soil remains controversial, as highlighted in some of the selected worldwide studies described below.

The British scientist Lady Eva Balfour was perhaps the first researcher to scientifically compare side-by-side organic and conventional or 'chemical-based farming' (Geier 2007). The results of her long-term study, initiated in Haughley Green, England (the Haughley Experiment) show that soil microorganisms, which abounded in the organic farms trigger a marked fluctuation in mineral phosphate (P), potassium (K) and nitrogen (N) with maximum available levels coinciding with the time of maximum plant growth (Balfour 1977). Balfour's findings described in The Living Soil (1943) and presented in 1977 during the first IFOAM Conference in Switzerland indicate two important features of organic farms: one, soils of organic farms are 'alive' and rich with microbial communities; and two, soil microorganisms are essential in breaking down or mineralizing plant nutrients bound in soils.

In field trials running over 150 years at Rothamsted Experiment Station, UK, it was noted that soil organic matter and N levels, which are the main measures of soil fertility (Yan et al. 2007; Jenkins et al. 2010), increased by 120% in plots receiving organic manure compared to only 20% increase in plots receiving synthetic chemical fertilizers. Similar findings were recorded by Dong et al. (2012) in China. Their study, which involved five different fertilizer treatments in a double paddy cropping system, shows higher contents of soil organic carbon

(SOC), total N, available N and available P in fields treated with organic matter, as compared to fields treated with only synthetic sources of N, P and K.

In another Chinese study conducted by Yan et al. (2007) to determine the long-term effect of fertilization on labile organic matter fractions shows the highest biomass C content and C and N mineralization in paddy fields treated with manure, as compared to fields treated with synthetic chemical fertilizers and combinations of the two. Labile organic fractions have direct impact on plant nutrient supply because, unlike the stable organic matter (OM) fraction, they are readily accessed by microbes.

The study of Tadasse et al. (2012) conducted in north-western Ethiopia to investigate the physico-chemical properties of rice fields treated with different fertilizers and their combinations, shows that fields treated with farm yard manure (FYM) had significantly higher SOM and soil total N contents than paddy fields treated with synthetic chemical fertilizers.

The claims of the benefits of organic farming on soil quality, as highlighted above, are further validated by the work of Surekha (2013) in India, where a five-year field study was conducted to compare organic and conventional paddy production. The results of this study show organic farms to have significant improvement in (i) soil biological properties, such as soil respiration and enzymatic activities, (ii) soil physical properties represented by increased levels of SOC, available N, P and K.

Contrary to the above findings, Jenkins et al. (2010) found no significant difference in SOM between organic and conventional farms. For this study, they paired 16 different farms in England and grouped them based on soil types to study different characteristics, including SOM content. They suggest that the lack of observable differences could stem from farmers applying only 40 t ha^{-1} organic matter instead of the 65 t ha^{-1} typically required in wheat fields.

Although a seven-year study conducted in central Italy found increased levels of total N and available P, along with increased microbial biomass content and enzymatic activity in organically managed farms, it did not observe a consistent increase in total SOC (Marinari et al. 2006). Further, a 21-year study conducted in Therwil, Switzerland, to determine the P budget and its availability in organic and conventional farms did not observe any difference in total P (inorganic, organic and iseyotopic) between the two farming systems (Oehl et al. 2002).

Another contradictory finding was reported by researchers in Thailand. The study conducted by Thuithaisong et al. (2012) in a rice research centre in Surin province, Thailand, found low levels of SOC, N, P and K in all plots, irrespective of the treatments (amendments of OM and synthetic chemical fertilizers).

Soil aggregates are important components of soil fertility as they, amongst other functions, influence the availability of nutrients (Madari et al 2005). Wang et al. (2011) conducted a long-term investigation of water-stable aggregates (WSA) as well as soil C, N and P concentrations of paddy fields in central south Chine subjected to organic and synthetic chemical fertilizers. The authors found that long-term application of organic materials increased the proportion of large WSA, whilst no such results were detected in soils treated with synthetic chemical fertilizers. Large aggregates are important, as they generally contain higher levels of nutrients, are less prone to erosion, and facilitate water infiltration and aeration, which are both important for plant growth (Madari et al. 2005).

As noted above, the findings of these different studies are rather contradictory. These controversies arise primarily because the dynamics of soil nutrients are constantly exposed to, and influenced by biophysical processes, in addition to anthropogenic activities, such as farming practices (Jahanban and Davari 2013).

Despite claims and counter claims regarding the beneficial effects of organic farming on soils, a large majority of the studies still concur that organic farming improves soil quality (Birkhofer et al. 2008). This improvement is brought about by the addition of organic materials, which enhances SOM as a crucial attribute of soil quality and which is essential to enhance physic-chemical and biological properties and processes in the soil (Foth and Ellis 1997; Yan et al 2007).

Besides good management and suitable climatic conditions, good or fertile soil is important for optimal crop growth and yield.

2.7.2 Crop Yield

Crop yield is still one of the many aspects of OA that is being ardently contested (Hazarika et al. 2013; Reganold 2014), with almost equally contradictory verdicts, as in the case of soil properties. As will be described below, the number of studies that claim yields of crops from organic farms to be low approximately equals the number of studies that claim the opposite (Nemes 2009). These contradictory claims present a difficult dilemma to decision making, and perhaps, will fuel a further cycle of comparative studies.

It is worthwhile to note that in reporting the findings, most of these comparative studies provide only broad perfunctory statements, neglecting factors in one or the other detailed specifics of important functions of yield such as, amongst others: (i) the state of soil fertility and edaphic conditions; (ii) the level and degree of management, including types and volumes of inputs; (iii) the impact of pests and diseases; (iv) genotype of the cultivar(s) in question; and (v) biophysical conditions (Dobermann and Cassman 2002; Whitbread et al. 2003). These functions effect yield directly, and hence failing to consider them in yield equations render such studies flawed (Clark et al. 1999; Samui 1999; Zundel and Kilcher 2007; Arthurson and Jaderlund 2011).

Further, because these yield functions are not constant and also because they vary from one location to another, presenting objective study results remain challenging. Moreover, because organic farming is construed to be holistic and embraces the whole ecosystem or the whole farm with its myriad of allied farm components, any comparative study performed on the basis of compartmentalization will invariably fail to paint the whole picture or benefits emanating from the organic method of production.

However, in keeping with the objective of the present study and despite some inherent flaws, a selection of important comparative yield studies on organic and conventional paddy production conducted across the paddy growing regions of the world is presented below.

The results of a six-year study conducted by Li et al. (2010) in China show that paddy fields treated with organic fertilizers had higher rice yield than fields treated with synthetic chemical fertilizers (SCFs). Similar results were obtained by Siavoshi et al. (2011) from their two-year study in Iran. The authors conclude that "organic fertilizers can be a better supplement of inorganic fertilizers to produce better growth and productivity of rice".

The same was the case in The Philippines, where a case study conducted by Mendoza et al. (2001) compared the yield of paddy under organic, conventional and Low External Input Sustainable Agriculture (LEISA) management. The authors report that highest yield with the organic system, followed by LEISE and finally conventional agriculture with yield of 4.37, 3.89 and 2.98 t ha^{-1}, respectively. Another case study in China involving 690 farmers found a significant increase in yield of super[2] rice from fields treated with organic fertilizers (Qing-gen and Lei 2011). These authors did not observe any increase in yield with the increasing use of SCF.

However, similar increases in yield were not obtained in organic fields in a 12-year comparative study on yield and economics conducted by Rasul and Thapa (2004) in Bangladesh. Similarly, a two-year study in four provinces of India by Charyulu and Biswas (2010) found a higher paddy yield of 4.5 t ha^{-1} from conventional fields as compared to only 3.2 t ha^{-1} from organic fields. Similar yields were found in The Philippines. In this study by Rubinos et al. (2007), involving 110 farmers (55 each organic and conventional), yield from conventional fields was 23% higher than yield from organic paddy fields.

Comparative yield studies have also been conducted under other scenarios. For instance, in 'developed' countries, yield of crops generally is argued to be higher in conventional systems (Zundel and Kilcher 2007), while the opposite is reported to be true in 'developing' countries (Halweil 2006; Scialabba 2007; Nemes 2009). Two important contributing factors to yield differences in such scenarios are the scale of production or farm size and the level of mechanization.

Studies on yields of crops other than rice also show similar conflicting claims. Whilst some researchers argue that yields from organic farms in general are between 5% and 54% of those of conventional farms (Ponti et al. 2012; Seufert et al. 2012; Gabriel et al. 2013), others argue that yields from organic fields are up to 40% or higher than yields from conventional farms (Badgley and Perfecto 2007; Scialabba and Muller-Lindenlauf 2010) depending on the level of management interventions employed. These claims are contested and re-contested.

[2] A rice variety is recognized as a super rice if it meets the yield target gap at two pilot sites in two successive years, or if it meets the goal of yield advantages over the control variety in regional yield trials. The criteria of super rice cultivars vary with both production area and subspecies type (Chen et al. 2014)

Yet, a unanimous agreement prevails regarding the high yield found in organic systems under drought conditions. Here yield from organic systems is found to be consistently high (Pimentel et al. 2005), mainly because soils under organic systems capture and retain comparatively more water (Letter et al. 2003).

Another claim that is also less contested, or on which not many comparative studies have been conducted, concerns yield fluctuations. It has been noted that yields from organic fields show lower fluctuations (Rodale 2012). Further, there is also consensus that yields can be low in the initial years of conversion to organic management, especially if the newly transited farms are large and have been under conventional management for long periods (IFAD 2005).

Higher yield is generally associated with higher farm profitability or economic benefits and vice versa. A comparison of the two farming systems in terms of profit and economic benefit is given below.

2.7.3 Economics

"You cannot step in the same river twice."

Heraclitus of Ephesus (535 B.C. – 475 B.C.)

An analysis of the economic viability of a new technology or production system is paramount in an increasingly commercialized world (Offerman and Nieberg 2000). Accordingly, economics of organic and conventional production systems, particularly those relating to production costs and returns have received much attention (Lee and Fowler 2002). However, studies on this front continue to remain inconclusive and report divergent findings.

On one hand some authors like Cacek and Langner (1986), Cobb et al. (1999), Setboonsarng (2006) and Santosa (2012) argue that OA has a definite economic advantage over CA, while others argue to the contrary (Wander et al. 2007).

A study in four states of India show that the unit cost of paddy production was about 19% higher in organic as compared to conventional systems (Charyulu and Biswas 2010). Accordingly, the average net returns from organic farms were lower compared to those from conventional paddy farms (Charyulu and Biswas 2010). These results corroborate the findings of two Thai studies conducted in five districts of Chiang Mai involving 72 organic and conventional paddy growers (Lawanprasert et al. 2007) and in the Pathumthani Rice Research Centre (Pattanapant and Shivakoti 2009).

The experience in The Philippines, however, is the opposite. The study of Mendoza (2004) shows that organic paddy production required only US $ 39 investment per hectare compared to US $ 118 in the conventional system. In Sheikhupura district, Pakistan, the cost of organic paddy production per acre was 21.5% lower than that of conventional paddy production (Mehmood et al. 2011).

Another study in Andra Pradesh, India, by Sudheer (2013) shows 37% higher income from organic paddy as compared to conventional paddy farming. Similarly, Scialabba and Hattam (2002) report that in The Philippines the cost of paddy production is lower for the organic system as compared to the conventional system.

In parts of Africa, Lyons and Burch (2008), report that organic farming significantly increased farm income, and similar results were obtained in Iran by Mansoori et al. (2012).

A comparative analysis of farm profitability in organic and conventional farming systems shows a relatively higher profit with organic system, both in developed and developing countries (Nemes 2009). Nevertheless, others refute these findings (Pattanapant and Shivakoti 2009; Surekha 2013).

Not surprisingly, Zundel and Kilcher (2007) argue that the costs of production depend on farm type and also on many other factors, including labor and input costs (Nemes 2009). For mechanized farms, common in industrialized countries, heavy farm machinery as well as high labor wage add to the production cost (Zundel and Kilcer 2007).

Organic farming is labor intensive, and this high labor cost is particularly unfavorable factor. This could be further exacerbated in countries where labor is scare, such as in Bhutan (due to high rural-urban migration rates). In such situations, recourse to enhance manual labor efficiency and interventions to minimize the need for more labor would be in the best interest of organic farmers in order to reduce production costs and increase profitability.

Reflecting on the diverse nature of comparative studies vis-à-vis the cost of production, it is rather difficult to come to a definite conclusion regarding the profitability of a particular system of production (Lee and Fowler 2002). Generalizing conclusion from such conflicting results could be potentially lamentable as ‘one is not the same as all’ and ‘all is not the same as one’. Nevertheless, there is a certain broad consensus on what determines the costs and profits in both systems. In the organic system, the fundamental elements that push production costs are labor (mainly for weeding) and certification fees, whereas in conventional farms it is the cost of SACs.

It has been noted that higher profitability in organic systems often comes from premiums for organic producers, for instance in Thailand and Nepal (Udmokit and Winnett 20020; Adhikari 2011). However, authenticating organic products through organic certification often comes at significant costs. Fortunately, expensive certification systems have been successfully circumvented by adopting the Internal Control System (ICS) and the Participatory Guarantee System (PGS) in many countries, such as Brazil, Colombia and India (May 2008). Such a system is also being considered and worked at in Bhutan.

2.8 Perils and consensus from comparative systems studies

As described above, the results of the systems comparison studies are contradictory. While some researchers argue that organic farming is inefficient, unproductive and economically and ecologically unsound, others argue to the contrary. Such findings and narratives maybe healthy, but the dichotomy thus generated could pose, if it has not already done so, a dilemma that may potentially forestall progress of the both systems.

Contradictory findings resulting from empirical studies are hard to refute in many instances, providing that the methodologies used for the studies are impeccable and robust. However, the refuge to consolation to overlook the contradictions that the findings of these, even if robust, studies present, stems from the fact that the number of variables found under natural fields conditions is too high to be controlled strictly and uniformly (Hazarika et al. 2013). Emphasizing on this premise, it could be agreed that results of field studies depend on, amongst other factors, biophysical conditions, which change, or could change because of farmers’ interventions, and the management practices per se that farmers employ to grow their crops (Rigby and Caceres 2001; Jahanban and Davari 2013).

Perhaps based on this underlying assumption Bhutan has embraced OA despite criticisms, and this may be also the case with farmers in other countries. The present study could, therefore, generate some of the needed information with regard to the prospects of OA in Bhutan given the country's prevailing conditions and farmers' management practices.

Notwithstanding the opposing results, most comparative studies agree that under extreme climatic conditions organic farms perform better (Lotter et al. 2003) and soils farmed organically generally contain higher levels of soil microbial mass and SOM, which are important indicators of soil health and fertility (Foth and Ellis 1997; Madari et al. 2005; Reddy 2010). There is also consensus that yield depend to a large extent on biophysical conditions and management practices (Badgley et al. 2007; Ponti et al. 2012; Jahanban and Davari 2013).

Verheye (2006) defines management as an "act, art or manner to handle and control things carefully. It stands for technical ability, tactfulness and long-term vision". Therefore, sound management practices along with conducive biophysical conditions or the management skills to work within given biophysical conditions could spell a big difference in the results of systems performance.

2.9 Is middle path possible?

Given that there is no patent consensus between proponents of OA and those opposing it on many fronts, including in the areas of economics, yield and soil nutrient status, the debate and discourse seems to drive the followers to either extremes – organic or conventional. Whilst OA enthusiasts contend that the organic method of food production is more environmentally benign, the detractors argue that conventional farming is economically more efficient and better suited to meet food sufficiency targets. Such dichotomy and polarization of their respective followers and proponents of organic and conventional farming systems should be a cause for concern for many. Rather than either organic or conventional, it has been suggested that these two systems should converge, and in a progressive society, find a common ground to develop a hybrid system representing the best of the both (WWI 2006; Hazarika et al. 2013).

After reviewing the merits and limitations of organic farming vis-à-vis impacts of organic farming on soil health and India's food security, Hazarika et al. (2013) concluded that in order "to achieve sustainable food security we will probably need different alternatives, including organic, conventional and possible 'hybrid' system to produce more food at affordable prices, ensure livelihoods for farmers, and reduce the environmental costs of agriculture".

Finding a right balance, a middle path, a hybrid, between the two systems is suggested to be more practical in meeting the need to safeguard the environment, while at the same time producing enough food and fiber in an economically more efficient manner (WWI 2006). In fact, studies combining both these systems have yielded some promising results (Dorji et al. 2009; Siavoshi et a;. 2011). Further, it has been suggested that the hybrid system would attract more smallholder farmers because currently they cannot afford the expensive and complicated organic certification system, and these farmers will be able to produce two to three times the yields they are currently producing (WWI 2006).

However, because the organic system mandates a holistic approach to farming and extends beyond the farm to embrace life itself, any comparative study between the two systems could argued to be complex and unbiased conclusions hard to arrive at.

The four principles of organic agriculture (see Appendix 1) adopted by IFOAM in 2005 are profound and inspiring. Hence, any reconciliatory endeavor geared to amalgamate these two systems may have to first consider how to treat these fundamental principles. Given that these principles are the essence and cornerstone of OA, it remains to be seen if and how a compromise and a middle path can be reached.

3 PADDY PRODUCTION IN BHUTAN

3.1 Introduction

This chapter provides a brief background of Bhutan, pertaining particularly to agriculture, and highlights paddy production practices and constraints.

3.2 Bhutan background

Bhutan (27.4170^{o} N, 90.4350^{o} E), with a population of 0.7 million (NSB 2014) is sandwiched between China (Tiber) to the north and India to the south, east and west. The country (Fig. 3.1) is landlocked with mostly rugged mountain terrain, ranging in elevation from 130 meters above sea level (m.a.s.l.) in the southern belt to over 7,500 m.a.s.l. in the alpine north.

Figure. 3.1. Map soil the geographical location of Bhutan

* Thimphu, capital city of Bhutan

World map: http://commons.wikimedia.org/wiki/File:Bhutan_in_the_world_%28W3%29.svg

Bhutan map: http://www.worldofmaps.net/en/asia/map-bhutan/map-districts-bhutan.htm

The mountainous terrain and 72% forest cover coupled with 51.4% of the land set aside as protected areas seriously challenge agriculture and accessibility in Bhutan. Yet, agriculture employs 62% of the population (NSB 2013) and contributes about 15.8% of the GDP, making it the fourth largest contributor after hydropower, tourism and construction (RNR 2013).

Agriculture is largely traditional and smallholder-based (average per capita agricultural land is 0.8 ha), and characterized by low yields and low inputs (Tobgay 2005). Further constraints to agriculture are low levels of mechanization, rampant wildlife damage, growing land fragmentation, and rural-urban migration. Ironically, despite possessing one of the highest amounts of annual fresh water per capita in the world with 70,000 m^3 (Jamtsho 2010), agriculture in Bhutan also suffers from inadequate irrigation water because of lack of irrigation infrastructure.

CA was introduced in Bhutan in the 1960s, when the construction of the first road began in 1961. However, the modern or CA that uses SACs, is still confined to only district headquarters and a few other pockets, because many parts of the country are still inaccessible or farmers are too poor to afford the requirements of CA.

CA is mainly practiced for crops such as paddy rice, apples, mandarins, potatoes and vegetables such as cabbage, cauliflower and broccoli. Where CA has not made inroads, the aforementioned crops are still largely farmed using the traditional method with no SACs or organically by intent. Paddy rice is one such crop, which is cultivated following traditional, organic and conventional methods.

3.3 Paddy (*Oryza sativa*) cultivation in Bhutan

Globally paddy rice, *Oryza sativa* L. (Poaceae) is next to maize, *Zea mays* L. (Poaceae) in terms of production, and it is the most important crop in Asia (IRRI 2014). Paddy is also the mainstay of agriculture in Bhutan and is important to Bhutanese culture, tradition, religion and livelihoods. Although a staple of western and southern Bhutan in the past, it is now increasingly consumed in all parts of the country. The annual average per capita consumption of paddy estimated at 144 kg $year^{-1}$ is one of the highest in the world (RNR 2013). The global per capita rice consumption is about 100 kg $year^{-1}$ and that of Asia is about 65 kg $year^{-1}$ (IRRI 2014).

There is no recorded information on the introduction of paddy cultivation in Bhutan, but it could have been more than 500 years (Tshewang, pers. comm.). It is cultivated under varied conditions of soil and climate in all 20 districts by some 30,000 Bhutanese households (Ghimiray et al. 2007).

Samtse district in the south-west has the highest land under paddy cultivation (3,418 ha), whilst Punakha district in mid-centre, with 9,025 MT leads in terms of production (Table 3.1). Land under paddy cultivation represents 24,121 ha or 21% of the total cultivated agricultural land (RNR 2013). The national per capita paddy landholding is approximately 0.8 ha.

The paddy landholding figures are likely to change soon, because lately the Bhutanese government has planned to support irrigation infrastructure to bring more land under paddy cultivation in order to enhance production. The annual rice production and supply amounting to 78,202 MT is 50% lower than the domestic demand (RNR 2013). This huge deficit is met through imports, mainly from India. The latest import data available for 2011, published in 2013, show that the import of rice reached 54,057 MT, up from 52,180 MT in 2008 (Table 3.2). On the other hand, exports, which mainly comprise organic rice, are nominal both in terms of volume and value (RNR 2013).

Although paddy is cultivated in all parts of the country, it is more predominant in the southern part, where the land is relatively flat. Production, however, is mainly for subsistence, although the surplus is sold. The productivity of paddy in Bhutan as compared to regional and world standards is low (Dukpa et al. 2007; Tshewang et al. 2012), with the national average yield fluctuating between 2 and 4 t ha^{-1} (Tables 3.1 and 3.3). The yield in neighboring Bangladesh is 4.4 t ha^{-1} while in Indonesia, Vietnam and Japan it is even higher at 5 t ha^{-1}, 5.6 t ha^{-1} and 6.7 t ha^{-1}, respectively (FAOSTAT 2014). The low productivity in Bhutan is attributed in part to poor seed quality, poor soil fertility, low inputs, poor crop and nutrient management, and inadequate irrigation during critical growth stages of the rice crop (Ghimiray et al. 2005; Tshewang et al. 2012).

Table 3.1: Paddy area, production and yield (2011)

District	Production area (ha)	Production (MT)	Yield (t ha^{-1})
Bumthang	58.6	180	3.07
Chukha	832.8	2,439	2.93
Dagana	2,168.3	6,375	2.94
Gasa	67.9	272	4.00
Haa	46.1	127	2.75
Lhuentse	1,371.1	4,624	3.37
Mongar	689.1	2,328	3.38
Paro	1,846.6	7,976	4.32
Pemagatshel	66.4	183	2.76
Punakha	2,127.0	9,025	4.24
S/Jongkhar	972.4	2,730	2.81
Samtse	3,417.9	8,867	2.59
Sarpang	2,916.2	8,704	2.98
Thimphu	591.6	2,456	4.15
Trashigang	1,541.4	5,419	3.51
T/Yangtse	1,046.9	3,391	3.24
Trongsa	392.5	1,108	2.82
Tsirang	1,594.5	4,469	2.80
Wangdue	1,125.8	3,862	3.43
Zhemgang	1,248.4	3,667	2.94
Total (Bhutan)	**24,121.50**	**78,202**	**3.24 (National ave.)**

Adapted from: RNR (2013); NSB (2013)

Unlike many other countries, where paddy is cultivated two to three times a year, Bhutan cultivates paddy only once a year Although double cropping (or growing of paddy twice a year) was introduced in the warmer west-central region of the Wangdue-Punakha valleys in the late 1990s, it was discontinued after a year or two because of inadequate irrigation water and labor. So a large portion of paddy fields across the country remains fallow for about five to seven months each year after paddy harvest. Where water and labor are available and the risk of wildlife and stray cattle minimal, farmers grow wheat, mustard, chilies, maize, potatoes and other assorted vegetables after paddy harvest.

Table 3.2: Export and import volume and value of paddy rice (2008-2011)

Year	Export (MT)	Import (MT)	Export (mi Nu)	Import (mi. Nu)
2008	90	52,180	7	694
2009	112	53,473	9	722
2010	376	52,010	15	848
2011	116	54,056	9	854

Source: RNR (2013)

Nu= Ngultrum, Bhutanese currency; Nu 100 = € 1.25 as of 16 August 2014

Since 2012, paddy double cropping has been reintroduced on a small scale in the districts of Wangdue (west-centre region) and Samdrup Jongkhar (south-east region) with the government's renewed drive to enhance and commercialize rice production. To further support the commercialization effort, three new commercial rice mill were installed in mid-2014 in three strategic locations of Wangdue, Tsirang and Samdrup Jongkhar districts.

Table 3.3: Paddy area, production and productivity (2005-2011)

Year	Area (ha)	Production (MT)	Yield (t ha^{-1})
2005	25,237	67,858	2.69
2006	26,406	72,513	2.74
2007	27,524	71,982	2.61
2008	20,096	78,659	3.82
2009	23,937	67,245	2.81
2010	22,813	71,615	3.14
2011	22,123	78,730	3.24

Source: RNR (2013)

Another new paddy production technology, the System of Rice Intensification (SRI), which was developed in Madagascar in 1983 (Styger et al. 2011; Roy and Bisht 2012) and is spreading across the paddy producing countries of the world because of its potential to enhance productivity and other benefits (Sinha and Talati 2006; Styger et al. 2011), is also being tried in Bhutan. A few research trials initiated in 2008, both in research stations and in farmers' fields, to revalidate the suitability and alleged benefits of SRI under Bhutan's conditions yielded conflicting results. The findings of the trials in research stations were positive (Lhendup et al. 2009), but the same was not true for farmers' fields, owing to the higher labor required with the new technolody; labor is critically short in Bhutan. Similar mixed results have been reported in Timor Leste by Noltze et al. (2012). However, in 2013, the government went ahead with SRI in one of the geogs (group o villages) in the south-eastern district of Samdrup Jongkhar, but results from this latest venture are yet to be ascertained.

Upland[3] paddy is also cultivated in the country, and is more dominant in the non-irrigated dry lands of the east and east central regions of the country. The acreage and productivity have declined over the years. However, the government has mainstreamed upland paddy production since 2013 by including it in the 11th Five Year Development plan in order to meet rice self-sufficiency (Dorji et al. 2013). The present study covers lowland paddy only, which is more predominant.

3.4 Paddy production constraints

Whether under organic or conventional systems, paddy production in Bhutan faces similar constraints, and these constraints are not unique to paddy production alone. However, only the constraints that directly impinge on paddy productivity such as crop varieties, soil fertility, production management, pest and disease incidence and irrigation are discussed below. Other constraints, although equally important, such as labor shortage, wildlife crop depredation and market are not included in the discussion.

[33] Globally upland and lowland are two main paddy environment; upland paddy is rain-fed, while lowland paddy can be either rain-fed or irrigated.

3.4.1 Paddy varieties

Most farmers grow two to four paddy varieties to meet their varied[4] needs even if their paddy fields are less than 0.5 ha (Ghimiary 2012). These paddy varieties used are often traditional. In fact, Ghimiray and Katwal (2013) reported that about 65% of the total area under paddy cultivation in Bhutan is cropped with traditional varieties.

The traditional varieties found in Bhutan are reported to be > 500 and are conserved in the Gene Bank of the National Biodiversity Centre, Serbithang (Ghimiray et al. 2005). The traditional or local varieties are characterized by low yield and do not respond positively to added inputs such as SCFs, as manifested by lodging and disease (Karma and Ghimiray 2006). However, their advantages are stable yields and grain quality, and higher straw weight (Ghimiray et al. 2005).

Despite numerous promotional programs, the adoption rate of the improved high yielding rice varieties, developed both in and outside the country, is low at 42% (Ghimiray and Katwal 213). As of 2013, about 23 improved rice varieties and over 150 crosses to suit all AEZs have been released (Ghimiray 2012; Ghimiray and Katwal 2013). These improved cultivars were developed using local rice varieties and improved breeding lines and/ or varieties from elsewhere, notably from the International Rice Research Institute, IRRI, (Shrestha et al. 2004). Cross-breeding in Bhutan, which is led and coordinated by RNR RDC Bajo, focuses on the following criteria: (i) adaptability; (ii) medium plant height (about 100 cm); (iii) medium maturity (140-160 days); (iv) resistance to prevailing pests and diseases; and (v) preferred grain quality (Ghimiray 2012).

The yield potential of the improved varieties is up to 11 t ha^{-1} compared to about 5 t ha^{-1} of the traditional varieties (Gorsuch 2001; Shrestha et al. 2004; Ghimiray 2012). Since 2005, as a consequence of the low adoption rate, no new varieties have been developed or released, thereby forgoing better yield.

[4] Rice is processed into different products, which require different varieties; some varieties are aromatic with low (t ha^{-1}) yield , but some farmers still grow these varieties to use on special occasions.

3.4.2 Soil nutrient management

The use of traditional varieties coupled with the generally poor soil fertility status of rice fields (Noru and Floyd 2001) continues to constrict productivity (Chettri et al. 2003).

Norbu and Floyd (2001) report that the current soil fertility management regime is generally inadequate. This combined with low P, K and Ca (SSF-PNM 2001), imbalanced nutrient[5] applications (mainly urea), and inadequate nutrient supplements to replenish nutrients removed by crops are of major concern. A study conducted in farmers' fields shows that on average a ton of rice removes about 20 kg N ha^{-1}, 8.2 kg P_2O_5 ha^{-1}, 25 kg K_2O ha^{-1} and 18 kg Ca ha^{-1} (SSF-PNM 2001). Additionally, on an average a ton of rice straw harvested removes 7 kg N ha^{-1}, 2 kg P_2O_5 ha^{-1}, 15 kg K_2O ha^{-1} (Dobermann and Fairhurst 2002).

For nutrient supply, farmers generally depend on small amounts of animal manure through tethering animals in the field, adding leaf litter collected from nearby forests, or farmyard (mainly cow) manure mixed with paddy straw and leaf litter collected from nearby woods (Dorji 2008; Ghaley et al. 2010).

The average rate of organic manure application in paddy fields is 1 t ha^{-1}, which is not adequate for optimal production (SSF-PNM 2001). Urea (46% N) is the most commonly applied SCF (Ghaley and Christiansen 2011) mainly as a top-dressing, at an average rate of about 23 kg ha^{-1} (SSF-PNM 2001) as opposed to at least 70 kg ha^{-1} for local varieties and about 79 kg ha^{-1} for improved varieties (NSSC 2009). In some instances, small amounts of single super phosphate 16% P_2O_5), muriate of potash (60% K_2O) and suphala (15:15:15, $N:P_2O_5:K_2O$) are also applied. According to Norbu and Floyd (2001), the application rates of organic manures and SCFs as can be seen from the supply details (Table 3.4) are imbalanced, and volumes do not math crop requirements. This results in serious nutrient mining, and hence threatens sustainability. Further, there is no report of the use of micro-nutrients.

Soil testing to analyze nutrient contents and to assess the quantities to be applied is usually not practiced. The application rates of fertilizers are generally based on broad blanket application recommendations provided by the National Service Centre, Semtokha (NSSC 2009),

[5] Nutrients other than nitrogen are rarely applied or are applied in very minute quantities.

which can lead to either over-or under fertilization, if applied in excessive or low quantities, respectively (SSF-PNM 2001).

The recommended fertilizer rate (see Appendix 2) is about 7.5 t ha^{-1} FYM for organic production and 70:40:40 NPK kg ha^{-1} for conventional producers (NSSC 2009). It is recommended that 50% of the total N be applied as a basal dosage (i.e. at the time of transplanting) and the other 50% as a top dressing at the tillering stage. Such recommendations are not complied with at farmers' management conditions.

Table 3.4: Chemical fertilizers supplied to farmers (MT)

Year	Urea	Suphala	SSP	DAP	CAN	Bonemeal	MoP
2002	1,458	704	414	12	20	20	29
2003	1,578	1,022	613	7	3	11	20
2004	1,500	805	467	35	3	11	23
2005	1,611	965	451	8	0	13	15
2006	1,402	810	815	1	4	8	0
2007	1,399	1,042	602	2	0	9	29
2008	1,377	931	614	4	0	7	20
2009	2,856	1,955	1,112	4	0	16	35
2010	1,219	838	412	0	0	4	10
2011	1,462	1,147	636	0	0	11	20

Source: RNR (2013)

SSP= Single Super Phosphate; DAP = Di-Ammonium Phosphate; CAN = Calcium Ammonium Phosphate; MoP = Muriate of Potash

3.4.3 Production management

Production management practices, which are reported to be generally poor for various reasons, are another reason for the low productivity (Norbu and Floyd 2001; Ghimiray et al. 2005; Tshewang et al. 2012). Paddy seedlings are planted in a typical traditional manner without following any uniform planting distance between plants or rows. It has also been observed that the number of seedlings planted in each hill is not uniform resulting in either high low density plants per unit area.

Fertilizer application and weeding are done when time allows, meaning that timely application and weeding is not strictly adhered to, which leads to serious consequences for yields (Ghimiray et al. 2005; Dukpa et al. 2007). This arguably lackadaisical or inefficient approach to production management practices is believed to be partially a result of the University Primary Education thrust of the government and the lures of city life, which have dried up the labor supply needed on farms. This, coupled with physically exhausting day-to-day household chores, typical of a bucolic life of developing countries, leaves farmers with limited time and energy to attend to field work (Yeshey 2012).

Further, plant protection activities are also neglected, either because plant protection chemicals or bio-pesticides are not readily available or these are unaffordable.

3.4.4 Plant protection

Weed incidence

Pond Weed, *Potamogtan distinctus* A. Benn (Potamogetonaceae) is more common in the high AEZ, while in the mid and low AEZs grass-like fimbristylis, *Fimbristylis littoralis* Gaudichaud (Cyperaceae) and knotgrass, *Paspalum distichum* L. (Poaceae), respectively, are common. Barnyard grass, *Echinochloa crus-galli* (L.) Beauv (Poaceae) is a common weed in all three AEZs.

Amongst the various weed management tools available, organic farmers resort mainly to manual weeding, which is not only labor intensive, but also inefficient. Conventional paddy growers use butachlor, a selective herbicide that belongs to the anilide group. However, it has reported that farmers do not strictly follow the recommended dosages and application time because of which there is no effective control of weeds (Pradhan 2011).

Such poor weed management practices coupled with less intensive farming encourages weed growth and results in fairly high weed incidence in both organic and conventional paddy fields.

Pest and disease pressure

A wide diversity of ecological conditions in Bhutan favors prevalence of a diverse range of pests and diseases, many of which cause crop loss at varying degrees.

However, in many instances, unless pests and diseases incidences are widespread, both organic and conventional farmers do not bother much to intervene (Neuhoff et al. 2014). In Indonesia, Suristiyonubowo et al. (2011) found less pest and disease attack in semi- and fully organic fields as compared to conventional paddy fields.

In Bhutan, there are three main reasons for the neglect of pest and disease management in both organic and conventional farms. First, killing of any sentient beings, including insect pests is seen as a sinful act, and such acts carry social stigma. So many farmers deliberately hesitate to spray or manually destroy pests and diseases.

Second, constrained by labor shortage, the majority of the farmers see pests and diseases as a part of nature/ system, and hence neglect them or do not invest in plant protection.

Third, the average paddy landholding is small, scattered and in many cases isolated across or along the valleys, ridges and slopes. Such conditions, coupled with a wide diversity of ecological conditions and low intensive farming may have contributed to less intense pest and disease problems. So far, only two serious pest and disease outbreaks in paddy in Bhutan have ever been recorded.

The first was rice blast (*Magnaporthe grisea* (T.T. Herbt) M.E. Barr, [Magnaporthaceae]) outbreak in 1995 (Uden 2012) and the second was army worm (*Spodoptera furginperda* [J.E. Smith] [Lep.: Noctuidae]) infestation in 2013 (Namgyel 2013). Rice blast, which occurred mostly in paddy fields that lacked free wind circulation caused a loss of 1,099 tons of milled rice (Uden 2012). The armyworm outbreak occurred in 14 of the 20 paddy growing districts in the country (Namgyel 2013). It was caused by unusual weather conditions with a protracted dry spell followed by wet weather. It was reported that between 90 and 99% of the affected plants recovered fully (Wangmo 2013).

3.4.5 Irrigation

Another important constraint that compromises paddy yield both in organic and conventional farms is alleged to be inadequate supply of irrigation water (Karma and Ghimiray 2006). A large proportion of the southern belt as well as some parts of the mid AEZ depend on monsoon rains for paddy cultivation and irrigation. Monsoon rain starts in early June (Karma and Ghimiray 2006), usually tapers by late September, and ends by October (Table 3.5). The end of the monsoon rain coincides with the critical water requirement stage of paddy (i.e. rice panicle formation) mainly in the low and some parts of the mid AEZs. Lack of water at this critical stage seriously impacts the paddy yield in these regions.

Because paddy transplanting starts early in the high and most parts of the mid AEZs, the ending of the monsoon rain does not affect paddy yield in these areas, unlike in the low AEZ (Ghimiray, pers. comm..).

The ideal water requirement for the various growth stages of the paddy crop to achieve optimal yield as recommended by IRRI is presented in Appendix 3 (IRRI 2004).

Table 3.5: Monthly rainfall, average from 2000 to 2012 (mm)

District	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Bumthang	5.3	11.9	28.6	70.3	88.0	101.9	142.2	131.9	83.3	58.6	4.5	0.6	727
Paro	7.5	16.5	14.0	32.3	55.7	80.3	178.5	106.7	82.6	51.5	2.3	0.7	629
Punakha	4.4	8.9	11.2	32.1	88.0	113.8	127.8	131.5	94.1	41.9	5.2	3.6	663
Tsirang	8.6	15.6	36.7	81.7	116.9	317.3	457.4	281.8	194.9	114.8	2.9	3.8	1,632
Mongar	6.0	13.5	31.6	92.2	82.7	132.5	190.5	142.6	101.4	75.0	3.9	2.5	874
Samtse	15.1	25.9	71.8	219.4	403.1	706.5	1,135.1	819.9	661.2	220.0	27.0	15.8	4,321

Source: Dept. of Hydromet Services, MoEA (2014)

3.5 Cost of paddy production

To date no formal empirical study has been conducted in Bhutan to compare the costs of organic and conventional paddy production. However, some isolated and separate economic studies conducted in farmers' fields with field supervision and intervention by researchers show that production costs vary from district to district, owing to differences in labor and other costs. These studies show that production costs of a kilogram of paddy in Bumthang amount to Nu 14 (Dukpa et al. 2007), while in Geylephu it is about 4 Nu ka^{-1} to 11 Nu kg^{-1} (Pradhan 2011), as opposed to 12 Nu kg^{-1} in Gasa district (Pulami 2010).

The cost of paddy production, as with all other agriculture produce, is comparatively higher in Bhutan than elsewhere. This is attributed mainly to comparatively high labor cost, and also as a largely import driven country, about 90% of the goods and services have to be imported, which adds to the cost of production.

The high cost of production has a direct bearing on the market price. The market price for locally produced rice has been increasing at a very steady rate (except in 2005 and 2010), and within just a decade, the price of Bhutanese paddy rice has increased by more than 100% (Fig. 3.2). In 2014, the average price of local rice touched Nu 60 kg^{-1}, and this price is used in this study to calculate the economics of rice production. This price is more than 100% higher than that of many of the Indian paddy rice varieties that are imported and available in the local market. Thus, to be competitive, there is a strong need to find new and innovative ways to reduce production costs for Bhutanese rice farmers.

Despite the high cost of production, agricultural produce in Bhutan, be they conventional or organic, do not receive any premium price. Perhaps, this is because most local produces are generally more expensive compared to imported goods and services. It is for this reason, many farmers sell their own produce and purchase cheap imported rice and other commodities.

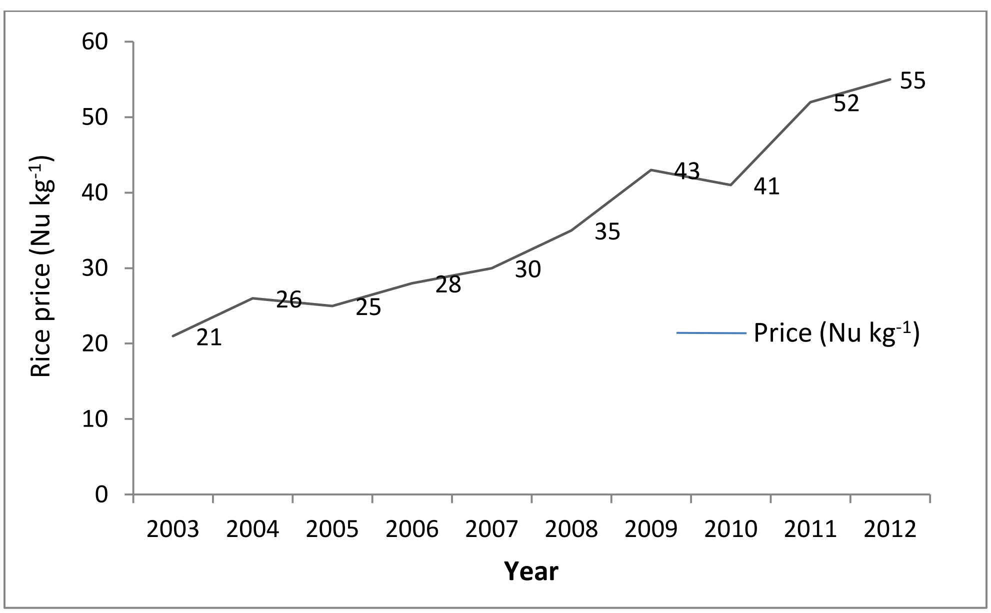

Figure 3.2: Increasing trend of the Bhutanese paddy rice

Source: RNR (2013)

3.6 Paddy production mechanization

Production cost is reported to be reduced with increasing farm mechanization, but the study of Yeshey (2012) conducted in a Bhutanese research centre (Bajo) does not confirm this.

Mechanization of paddy farming in Bhutan started in 1983 with the introduction of power tillers, pumps and threshers. However, this development has been restricted mostly to the western and a part of the west-central region, due to the easy accessibility of these regions and the socio-economic status[6] of these farmers. In these regions, mechanization has taken place in ploughing, puddling and, to some extent, threshing. Transplanting, harvesting, weeding and other management practices are still done manually. Since 2013, the government has introduced combine harvester[7], but their use is yet to pick up.

The information and statistics quantifying the benefits of farm mechanization in Bhutan in terms of yield gained, labor saved and social implications are limited to the basic studies conducted by Yeshey (2012) and Chhogyel et al. (2013). Farm mechanization is still seen as a crucial step towards achieving the government's goal of food self-sufficiency, eliminating drudgery, and attracting the younger generation to farming. However, the rugged topography of the country, with very limited flat land, poses a huge challenge to farm mechanization. Therefore, smaller portable semi-automatic machinery may be more suitable than larger and fully automated ones. Further, the success of paddy farm mechanization will possibly depend on farm machine subsidies and/ or on-farm machinery rentals at nominal rates as currently practiced.

The farm mechanization initiative aimed at achieving food self-sufficiency will have to be complemented and supplemented with other interventions. Moreover, people should be encouraged to change their eating habits so that wheat, potato and maize, which are produced in huge quantities, will be consumed as a substitute for rice, thus reducing rice imports.

[6] This scenario is expected to change soon because the MoAF is striving to mechanize

[7] A special type of machine that combines harvesting, reaping, threshing and winnowing; such machine is also simply known as combine.

4 MATERIALS AND METHODS

4.1 Study sites

The two-year (2012 and 2013) study on soil nutrient content and other properties and yield of organic and conventional paddy under farmers' prevailing management practices was conducted in the three AEZs of Bhutan (Table 4.1). In each of these AEZs, two districts were selected. In the high AEZ (> 2,000 m.a.s.l.), Bumthang and Paro districts, in the mid AEZ (1,000 – 2,000 m.a.sl.), Punakha and Tsirang districts, and in the low AEZ (< 1,000 m.a.s.l.), Samtse and Mongar districts were selected (Fig. 4.1).

For socio-economic information, interviews and group discussions were carried out in all the 20 districts of the country and the capital Thimphu.

4.1.1 Description of study sites for soil sample and crop yield data

The sample districts of Bumthang and Paro, representative of the high AEZ, are located in central and western Bhutan, respectively. Both districts are located in the cool temperate region with elevations ranging from 2,000 m.a.s.l. to above 3,000 m.a.s.l.. In this region, mean annual precipitation ranges from 1,000 to 1,500 mm and the mean annual maximum and minimum temperatures are 22 ^{o}C and -4 ^{o}C, respectively. The prevailing soil texture in Bumthang is sandy clay whereas in Paro it is mostly loam to clay loam.

In Bumthang and Paro districts high-altitude paddy varieties are grown. The total area under paddy cultivation in the former is 58 ha and in the latter 1,846 ha, and annual paddy production and average yield in Bumthang are 180 MT and 3 t ha^{-1}, respectively (RNR 2013). In Paro, values are 7,976 MT and 4.3 t ha^{-1}, respectively (RNR 2013).

The area in Bumthang selected for this study was the two geogs of Choekhor (27^{o} 33' 33"N, 90^{o} 44' 00" E) and Tang (27^{o} 33' 29" N, 90^{o} 48' 16" E). Of the four geogs in the district, paddy is cultivated only in these two. In Paro, the study area was Lyung geog, which is one of the most popular geogs in the district for paddy cultivation.

In the mid AEZ, Punakha and Tsirang districts located in west-central Bhutan were selected. The elevations in this region range from 600 to 1,500 m.a.s.l. and the region has a humid to dry sub-tropical climate. The mean annual maximum and minimum temperatures in these districts are 33 ^{o}C and 3 ^{o}C, respectively, and mean annual precipitation ranges from 1,000 to 2,000 mm. soil textures in Punakha are mostly loam to clay loam, whereas they are mostly sandy loam to loam in Tsirang. In Punakha and Tsirang districts paddy production is widespread (90% of the inhabitants/ farmers cultivate paddy) with about 2,127 and 1,594 ha, respectively, under paddy cultivation (RNR 2013). The annual paddy production in Punakha is 9,025 MT and in Tsirang 4,469 MT. The average yield in the former is 4.2 t ha^{-1} and in the latter 2.8 t ha^{-1} (RNR 2013).

In Punakha district, Kabjisa and Chubu geogs were selected and in Tsirang district the Tsirangtoe geog. Over 90% of the inhabitants in these geogs cultivate paddy.

The two districts selected in the low AEZ were Mongar and Samtse located in the southern and eastern part of the country, respectively. The elevations in this region range from 150 to 1,000 m.a.s.l. and the region is characterized by a wet to dry sub-tropical climate. The mean annual maximum and minimum temperatures are 35 °C and 12 °C, respectively. This region, with a mean annual precipitation range of 2,500 to 5,500 mm, receives the highest rainfall in the country. Soils in Mongar are mostly silty clay loam, loam and clay loam whereas in Samtse they are mostly sandy loam to loam.

Mongar district has a total of 689 ha under paddy cultivation with an average annual production and yield of 2,328 MT and 3.4 t ha^{-1}, respectively. The total paddy area in Samtse district is 3,471 ha with an annual production of 8,867 MT. With 2.6 t ha^{-1} the average yield recorded in this district is one of the lowest in the country.

The geog selected in Mongar was Dremetse and in Samtse it was Yoeseltse. Paddy rice is the mainstay of farming in these geogs besides maize and millet.

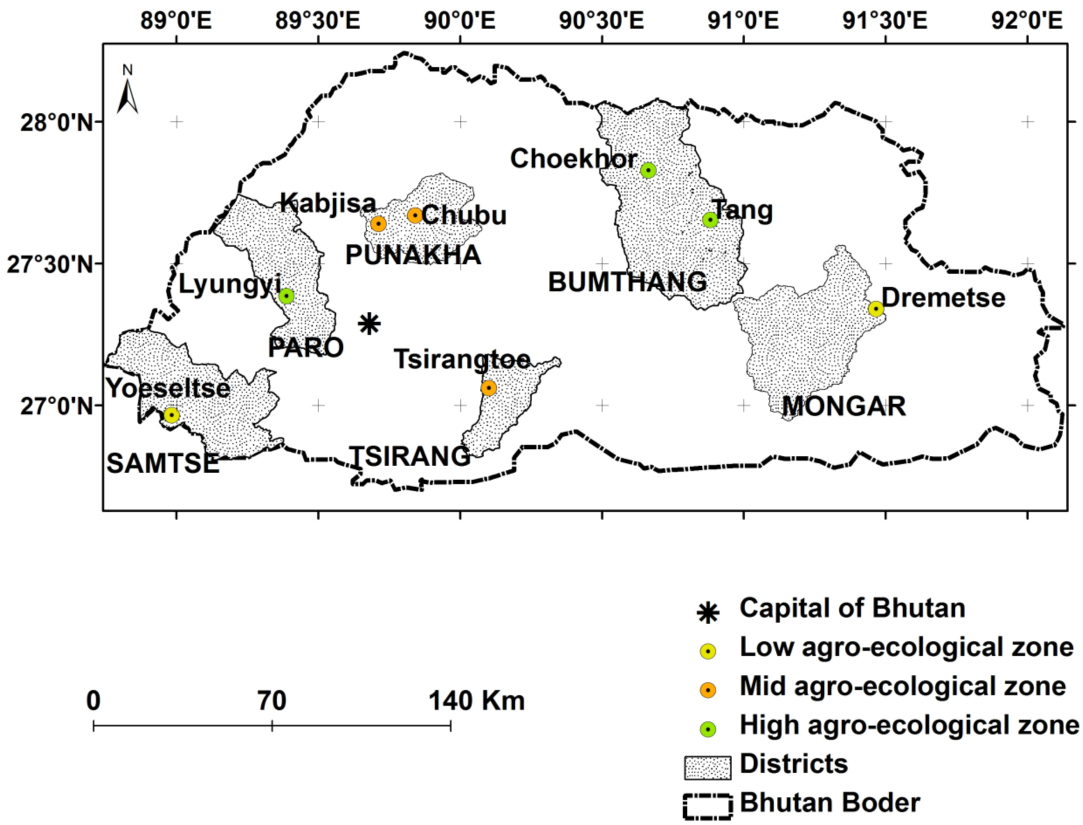

Figure 4.1. Map of Bhutan showing soil sample and yield data collection sites

The above districts were selected for collecting soil samples and crop yield data after discussions with the respective district agriculture officers and preliminary verification (through visit to the fields) of their representativeness. This was done in order to make the sample districts representative of the specific AEZ.

From each of these six districts, 20 paddy fields (10 each of organic and conventional) totaling to 60 organic and 60 conventional paddy fields were selected. All 120 paddy fields ranged from 0.4 to 0.8 ha in size, which is close to the average national per capita paddy land holding of 0.8 ha.

Table 4.1: Main climate parameters in the study areas

Agro-ecological zone	District	Geog	Village	Alti. (masl)	Climate	Temp. (^oC)			Rainfall (mm)
						Max	Min	Mean	
Low	Mongar	Dremetse	Yayung	820	Wet to dry sub-tropical	35	12	24	2,500 – 5,500
	Samtse	Yoeseltse	Khuchudaina	400					
			Kharbandi B	500					
Mid	Punakha	Kabjisa	Sirigang	1,360	Humid to dry sub-tropical	29	3	16	1,000 – 1,200
		Chubu	Chocola	1,260					
	Tsirang	Tsirangtoe	Shentapsa	1,280					
High	Bumthang	Choekhor	Jalekar	2,550	Cool-temperate	22	-4	9	1,000 – 1,500
		Tang	Tang	2,620					
	Paro	Lyungyi	Chimakha	2,500					
			Getana	2,500					

Adapted from: Dorji (1995)

4.1.2 Soil sample collection

Soil samples were collected three to five weeks before paddy transplanting (Mahler and Tindall 1994) for two consecutive cropping seasons (2012 and 2013). Before collecting soil samples, the surface of the soil had been cleared of weeds and other debris. Then an imaginary W-shape was drawn in each paddy field, and seven to nine soil sub-samples were collected from each tip of the W shape using a soil auger. The soil sample was taken from a depth of 0 – 15 cm from the surface (NSSC 2009).

All sub-samples from one field were pooled and thoroughly mixed in a large plastic bucket. From this mixture, four to five composite samples of approximately 1 kg each were collected and packed in plastic bags, which were then labeled appropriately.

All composite soil samples were air-dried before transporting them to the Soil and Plant Analytical Laboratory, Semtokha, Bhutan for analysis.

4.1.3 Soil nutrient content and soil properties analysis

Soil nutrient content analysis was conducted to compare the soil nutrient status and other soil properties between organic and conventional paddy fields under the farmers' prevailing production management practices.

Air-dried composite soil samples were sieved using a 2 mm sieve. Subsequently they were analyzed for the following soil chemical parameters: organic matter (OM %), total nitrogen (N %), available phosphorus (P), exchangeable potassium (K), exchangeable calcium (Ca), cation exchange capacity (CEC), pH, bulk density (BD) and texture. The analysis was restricted to the above parameters, because particularly OM content, total N, available P and exchangeable K are affected by routine application of fertilizers and manures, but remain less prone to "inter-session and spatial variability" (Rahman and Parkinson 2007).

Whilst OM% is an important component of soil fertility measurement as it influences the soil's bio-physico and chemical functions (Wijnhoud et al. 2003; Yan et al. 2007), the three macronutrients such as N, available P and exchangeable K are the main nutrients limiting rice yield (Wijnhoud et al. 2003).

Optimal soil pH is essential for soil microbes and faunal populations, such as earthworms, as well as for chemical nutrient availability (Alam et al. 1999). According to Hazelton and Murphy (2007), CEC is crucial for soil structure stability. It also influences soil pH, nutrient availability and the reaction of soil to fertilizers (Fernandez and Hoeft 2009). Bulk density, which is a measure of soil compaction, influences root penetration and soil microbial activity as well as the amount of water and air the soil can hold (Shierla and Alston 1984; Abdel-Magid et al. 1987).

Total OM was measured using the Walkley-Black method following low temperature oxidation with acidified $K_2Cr_2O_7$ and titration of the excess dichromate (SPAL 2003). Micro-Kjedahl and Bray II methods were used to analyze total N (%) and available P, respectively. The method used to analyze exchangeable K, Ca and CEC was 1 M ammonium acetate extraction at pH 7. Soil pH was measured in a distilled water-soil suspension of 1 M KCl (both 1:2.5) using an automatic pH meter (PHM 83). Bulk density and texture were measured using the core and pipette method, respectively (SPAL 2003).

The various methods used for analysis of the above parameters are standard procedures commonly used for analysis of soils in Bhutan (Appendix 4), the details of which are provided in the Soils and Plants Analytical Laboratory manual (SPAL 2003).

The units of exchangeable K and exchangeable Ca, which were initially calculated in milli equivalent per 100 g soil (me 100 g^{-1}), were later converted to mg kg^{-1} in order to make them consistent with the unit of available P. The following formula was used for the conversion:

$$mg = me \times \frac{AW}{V} \qquad \text{...(4.1)}$$

where, mg is milligram, me is milliequivalent value obtained in the lab analysis, AW is Atomic weight or formula weight of the element in question and V is valence of the element in question.

4.1.4 Paddy yield assessment

Paddy crop cut data was collected to determine and compare yield of organic and conventional paddy under farmers' management practices within their respective prevailing biophysical context.

The sample crop cut is one of the simplest and widely used methods (Dukpa et al. 2007; Chhogyel et al. 2013) to analyze yield of cereals in Bhutan. Three to four crop cut sites in each field were randomly selected, but peripheries of plots were avoided, in order to prevent boundary effects. Crop cut was done at the time of harvest for two consecutive cropping seasons (2012 and 2013) following the farmer's normal practice.

Each crop cut plot area was 6 m^2 (i.e. 2 m × 3 m). All paddy plants within this plot were cut using a harvesting sickle. Three to four crop cuts were done in each of the 60 organic and 60 conventional paddy fields (RNR 2004). The yield data for each field was averaged from these crop cuts.

The harvested plants were manually threshed on either a block of wood or a stone, the way most farmers thresh their paddy. About 15 to 19 threshed grains were placed in a moisture meter (Delmhorst Instruments G-7) to measure the moisture content of the grains at harvest.

Finally, using a weighing balance (Kern Compact Scale EMB), the weight of all threshed grains was recorded.

The yield from each field was calculated using the following formula:

$$GY\ (t\ ha^{-1}) = \frac{WG \times 10{,}000\ m^2 \times MC_{adj}}{Area \times 1{,}000} \quad \text{...}(4.2)$$

$$MC_{adj} = \frac{(100 - MC)}{86} \quad \text{..}(4.3)$$

where, GY is grain yield in ton per hectare, WG is weight of grain from the plot in kg, MC_{adj} is adjusted moisture weight of grains in percentage, MC is standardized moisture weight at 14% in dried condition, Area is the plot size in m^2.

4.1.5 Farm Economics

Cost of production

The cost of production is the sum of all variable costs. Variable costs include farm expenditure on machinery, labor, bullock, seed, fertilizers/organic manure and plant protection chemicals/ bio-pesticides. Production cost or gross production cost was calculated per kg and per hectare. The following formula was used to calculate gross production cost (Plastina 2015):

$$GPC\ (Nu\ ha^{-1}) = \sum M_c + L_c + B_c + S_c + F_c + PP_c \quad \text{..............................}(4.4)$$

where, GPC is gross production cost expressed in Ngultrum per hectare, M_c is machinery cost, L_c is labor cost, B_c is cost for bullock used, S_c is cost for seed, F_c is cost for fertilizers/ organic manure, PP_c is cost for plant protection chemicals/ bio-pesticides.

Gross return

Gross return is the total rate of return obtained before deducting all expenses incurred during production (MAFRI 2013; Plastina 2015). Gross return was calculated for both per kg and per hectare by multiplying the average yield (per hectare) by the selling price or farm-gate price as shown below. The selling price was obtained from the national average price of paddy rice in local market.

$$GR\,(Nu\ ha^{-1}) = Y \times SP \quad (4.5)$$

where, GR is gross return in Ngultrum per hectare, Y is crop yield in ton, and SP is selling price or farm-gate price.

Net return

Net return is the income obtained after deducting all expenses incurred in production (MAFRI 2013; Plastina 2015). It was calculated using the following formula:

$$GR\,(Nu\ ha^{-1}) = GR - GPC \quad (4.6)$$

where, NR is net return in Ngultrum, GR is gross return in Ngultrum, and GPC is gross production cost in Ngultrum.

Benefit-cost ratio

The benefit-cost ratio (BCR) is used as an indicator to assess the worth of an enterprise. If the BCR value is > 1, then the enterprise is economically beneficial and efficient. The following formula was used to calculate BCR (MAFRI 2013):

$$BCR = \frac{GR}{GPC} \quad (4.7)$$

where , BCR is benefit-cost ratio, GR is gross return in Ngultrum, and GPC is gross production cost in Ngultrum.

4.2 Socio-economic survey

4.2.1 Description of study sites and sample size for socio-economic survey

Socio-economic household surveys in all 20 districts of the country involving 411 villages from 122 of the total 205 geogs were conducted to compare the socio-economic status of organic and conventional paddy farmers. In 17 of the 20 districts, 20 organic and 20 conventional paddy farmers each were randomly selected with the help of the respective agriculture field extension officers. The districts of Samdrup Jongkhar and Gasa do not have conventional paddy farmers, hence 20 organic paddy farmers each were exclusively selected in these districts. In Pemagatshel district, only 13 organic and 13 conventional paddy farmers were selected because of the very limited paddy production here. In total 746 paddy farmers (393 organic and 353 conventional) were analyzed in the survey.

The survey was conducted using two sets of structured questionnaires (one each for organic and conventional paddy) farmers (Appendices 5A and 5B), which were submitted to a pre-test with two representative organic and conventional paddy farmers each. The questionnaires included queries on both socio-economic and biophysical aspects of the farms. The questions asked were on demography, education attainment, gender contribution to paddy cultivation, irrigation adequacy, crops grown in paddy fields after paddy harvest and pest, disease and weed pressure. Farmers were also asked whether they were subjectively happy as farmers, and if not, what they would opt for, given a host of other profession options such as a monk/ nun, administrator, doctor, teacher, and so on.

The responses from the farmers were mainly provided based on recall and perception. To prevent subjectivity or bias emanating from such methods, agriculture field extension agents based in the specific village blocks were involved in the survey. Further, each of the study sites was regularly visited as a means of verification, as well as to record various paddy production management practices.

Table 4.2: Characteristics of socio-economic study sites

Dzongkhag	Population density (people km^{-2})	Farming population (age 15-64)	Area (km^2)	Wetland (ha)	Ave. cultivated agri. Land (ha)
Bumthang	5.3	3,913	2,668	25	1.20
Chukha	46.3	9,445	1,879	1,799	1.20
Dagana	14.7	12,513	1,723	1,493	2.00
Gasa	1.1	1,689	3,075	144	0.80
Haa	6.8	3,185	1,865	89	1.20
Lhuentse	5.8	6,011	2,809	1,576	2.00
Mongar	21.2	14,246	1,945	432	2.00
Paro	35.3	9,727	1,251	1,753	0.80
Pemagatshel	25.1	7,961	1,023	302	1.20
Punakha	23.5	5,890	1,110	5,074	1.20
S/Jongkhar	19.5	11,010	1,878	1,148	1.20
Samtse	50.8	18,427	1,305	5,683	2.00
Sarpang	26.7	14,135	1,666	2,088	1.20
Thimphu	60.7	6,488	1,749	458	0.80
Trashigang	21.2	19,408	2,204	1,449	0.80
T/Yangtse	9.7	7,619	1,449	949	0.80
Trongsa	9.7	5,308	1,822	1,082	0.12
Tsirang	38.0	11,926	639	1,572	1.60
Wangdue	10.3	8,429	3,920	4,202	1.20
Zhemgang	8.6	6,367	2,416	640	1.60

Adapted from: RNR (2013); NSB (2013)

4.2.2 Expert group discussion

An expert group workshop and personal interviews were held among 35-member experts comprising policy makers, organic farmers and agriculture specialists, academia and private sector and cooperative representatives (see Appendix 6). This event held in Thimphu, the capital city of Bhutan, covered topics and questions related to organic farming policies, research, challenges and future prospects, amongst others. The participants were also given a set of questionnaires in which they had to rank various statements in a SWOT (Strength, Weakness, Opportunity and Threat) analysis for organic farming in Bhutan. The various parameters for strengths, weaknesses and opportunities used by the experts group are given in Appendix 7.

It has been acknowledged that the SWOT analysis is an important tool usually used at the first planning stage in order to assess and identify both the internal and external factors that are favorable or unfavorable towards achieving the goals of a venture or project in question. Such exercise helps to develop a strategic plan or solution to a problem (Nair and Prasad 2004).

The summarized overview of the various methods used in this study is presented in Appendix 8.

4.3 Data analysis

All data were analyzed using the Statistical Package for Social Science SPSS® version 21 for Windows (Landau and Everitt 2004). The datasets were checked for outliers, followed by Shapiro Wilk's and Levene's tests for normality and homogeneity of variance, respectively. When the data were not normally distributed or homogenous, they were log transformed to fulfill the assumptions of ANOVA. However, untransformed means are reported for easy comprehension.

Before conducting individual ANOVA test, it was important to check whether there were any significant differences in any of the correlated variables. This was done through a multivariate analysis or MANOVA. The MANOVA model used was:

$$\left(\frac{Yield}{Bulk\ density}\right) = \left(\frac{\mu_i}{\mu_{15}}\right) + Farm\ type + AEZ + Farm\ type * AEZ \quad \text{............(4.8)}$$

where, μ_i is different yield components and soil property parameters and AEZ is agro-ecological zone.

The results for 2012 and 2013 were: $p = 0.0018$ and 0.017 for the farm type, $P = 0.000$ and 0.000 for AEZ and $P = 0.950$ and 0.990 for the interaction between farm type and EAZ. After conducting this test, the significance for each of the variables using standard ANOVA model was conducted. The processed data were analyzed at two stages. In the first stage, analyses were carried out within the high, mid and low AEZ to detect differences in soil and plant characteristics between organic and conventional farms. In the second stage, analyses were carried out to compare between three AEZs, the soil characteristics and yield of organic and conventional farms. P values ≤ 0.05 were considered significant in all the analyses.

For three factorial analysis of the interactions between AEZ, farm types and years, a linear model was corrected for repeated measurement with fixed factors (soil nutrients/ properties, year and AEZs).

Except for demographic background of the respondents, a major part of the social data were collected using a typical five-level Likert scale, and because of controversies surrounding the presentation of results thus derived in statistical significance model, they are presented and interpreted as proportions/ percentages only. The demographic information were tested using t-test and chi-squared test.

5 RESULTS

5.1 Soil analysis

5.1.1 Soil nutrient levels and other soil properties in organic and conventional paddy fields in three AEZs

Three-factorial ANOVA conducted over two years indicated that there were no significant interactions between the experimental factors, namely farm type (Organic, ORG and Conventional, CON), AEZ (low, mid and high AEZ) and year (2012 and 2013). Significant effects of the farm type were only noted for soil P-content and bulk density (Tab. 5.1). In contrast, the factor AEZ significantly affected several soil parameters including SOM, available P, exchangeable K and CEC. A comprehensive overview of all results is additionally provided in Appendices 10, 11 and 12.

Table 5.1: P-values of different soil parameters following a three factorial analysis on year, farm types and AEZs

Soil parameters	Yr.	FT	Yr*FT	AEZ	Yr*AEZ	FT*AEZ	Yr*FT*AEZ
pH	0.5233	0.6097	0.5068	0.9277	0.6793	0.9376	0.8497
OM (%)	0.1736	0.1646	0.9655	**0.000**	0.6889	0.8345	0.9987
Total N (%)	0.9777	0.7991	0.9554	0.8271	0.9805	0.9697	0.9933
Avail. P (mg kg^{-1})	0.5788	**0.0342**	0.2092	**0.0445**	0.4960	0.2899	0.1637
Ex. K (mg kg^{-1})	0.5226	0.7587	0.9272	**0.0246**	0.9054	0.9532	0.9845
Ex. Ca (mg kg^{-1})	0.9892	0.8944	0.9612	0.7435	0.9864	0.9952	0.9961
ECE (me 100^{-1})	0.4120	0.1881	0.7588	**0.0014**	0.7920	0.5604	0.9988
BD (g cm^{-3})	0.6248	**0.0172**	0.5028	0.5689	0.9825	0.8140	0.9942

Yr. = Year   FT = Farm type   AEZ = Agro-ecological Zone   * = Interaction

Avail = Available   Ex. = Exchange   BD = Bulk Density

CEC = Cation Exchange Capacity

Though not significantly different, the absolute mean values of other soil nutrients such as total N and exchangeable Ca, as well as soil pH of ORG and CON showed some minor variations over two cropping seasons (Table 5.2). However, these parameters were not significantly affected by AEZ or by year. The minimum total N in ORG and CON was identical at 0.13% while the maximum in the former was 0.147% and in the latter 0.143%. The exchangeable calcium in ORG ranged from 720 mg kg^{-1} to 739 mg kg^{-1} while in CON it ranged from 715 mg kg^{-1} to 734 mg kg^{-1}. The pH of ORG in all three AEZs in both years ranged from 5.83 to 5.87 while for CON it ranged from 5.82 to 5.85.

Table 5.2: Soil properties between organic and conventional paddy fields in the high, mid and low agro-ecological zones 2012 and 2013

	2012		**2013**	
AEZ/Soil parameters	**Organic soil**	**Conventional soil**	**Organic soil**	**Conventional soil**
High AEZ				
pH	5.87 ± 0.05	5.84 ± 0.05	5.87 ± 0.04	5.83 ± 0.04
Total N (%)	0.147 ± 0.03	0.143 ± 0.01	0.140 ± 0.01	0.143 ± 0.01
Ex. Ca (mg kg^{-1})	738.38 ± 24.17	734 ± 22.04	736.65 ± 29.61	734.55 ± 22.47
Mid AEZ				
pH	5.84 ± 0.03	5.85 ± 0.03	5.85 ± 0.03	5.84 ± 0.02
Total N (%)	0.130 ± 0.01	0.138 ± 0.01	0.135 ± 0.01	0.130 ± 0.01
Ex. Ca (mg kg^{-1})	720.7 ± 31.64	716.20 ± 26.73	720.68 ± 31.35	715.45 ±
Low AEZ				
pH	5.83 ± 0.06	5.82 ± 0.06	5.86 ± 0.04	5.84 ± 0.03
Total N (%)	0.142 ± 0.01	0.130 ± 0.01	0.140 ± 0.01	0.138 ± 0.01
Ex. Ca (mg kg^{-1})	721 ± 25.81	720.70 ± 25.48	722.20 ± 34.48	722.70 ± 28.02

*P≤0.05, mean ± values standard error

In both 2012 and 2013, SOM was significantly higher in the high AEZ as compared to the mid and low AEZs, which were not significantly different from each other (Figure 5.1). It was also observed that the SOM tended to be consistently higher in ORG (1.71% to 2.63%) in all three AEZs compared to CON (1.7% to 2.42%) in both years.

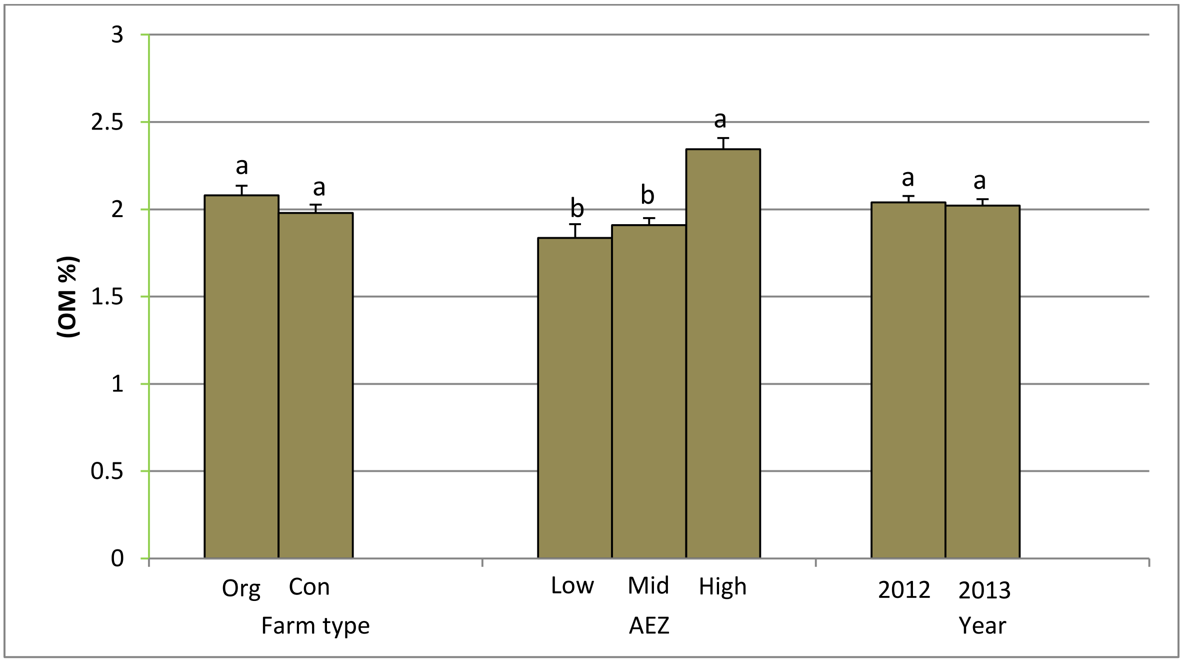

Figure 5.1: Organic matter as affected by AEZs and farm types averaged for years 2012 and 2013

Both AEZ and farm type had significant effect on available P content (Figure 5.2). ORG had significantly higher available P content than CON and it was significantly higher in the low and high AEZ compared to the mid AEZ. The affect of year on available P was negligible.

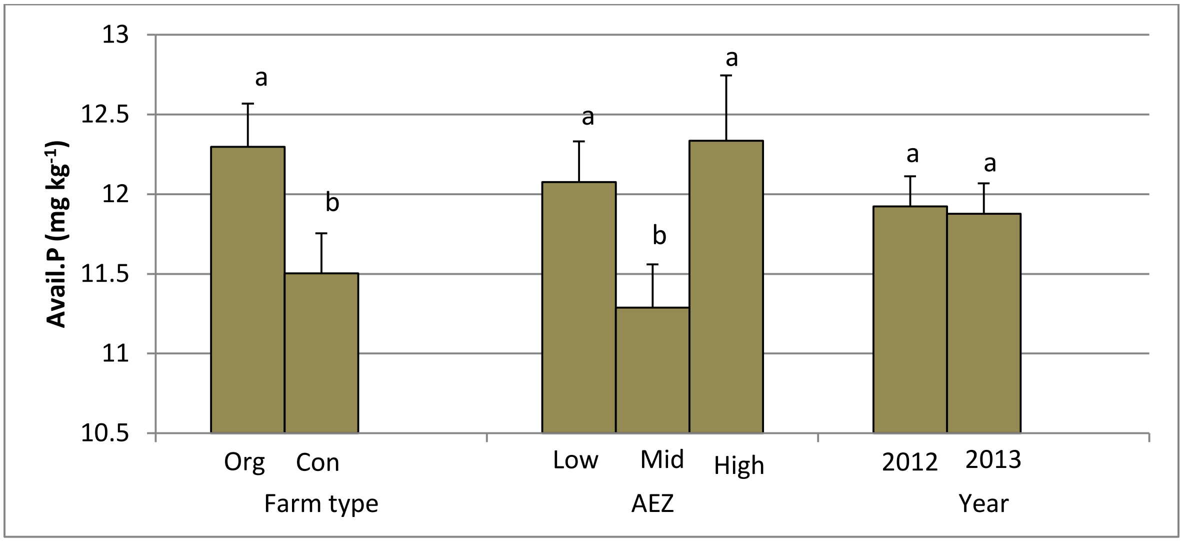

Figure 5.2: Available P as affected by farm types and AEZs averaged over two years (2012 and 2013)

The exchangeable K content of the soil was significantly higher in the high AEZ as compared to the mid and low AEZs, which were not significantly different from each other (Figure 5. 3). The organic production system had higher K content, although it was not significantly different from conventional production system. The K content tended to decrease in the second year, though it was not significant.

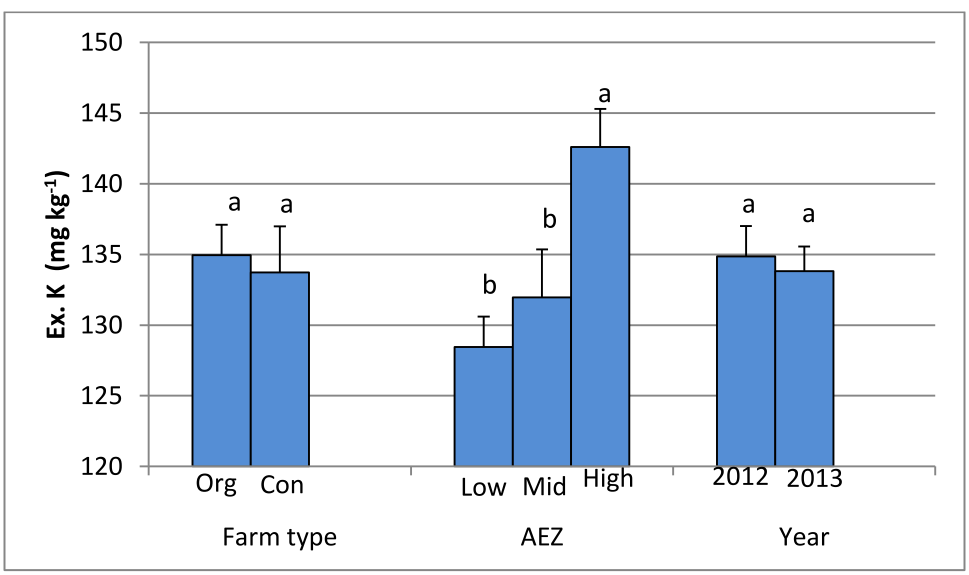

Figure 5.3: Exchangeable K as affected by AEZs and farm types averaged over two years (2012 and 2013)

The CEC was significantly higher in the high AEZ than in the other two AEZs (Figure 5.4). The farm type and year did not have any significant effect on CEC, though ORG tended to have higher CEC than CON. The CEC increased marginally in second year.

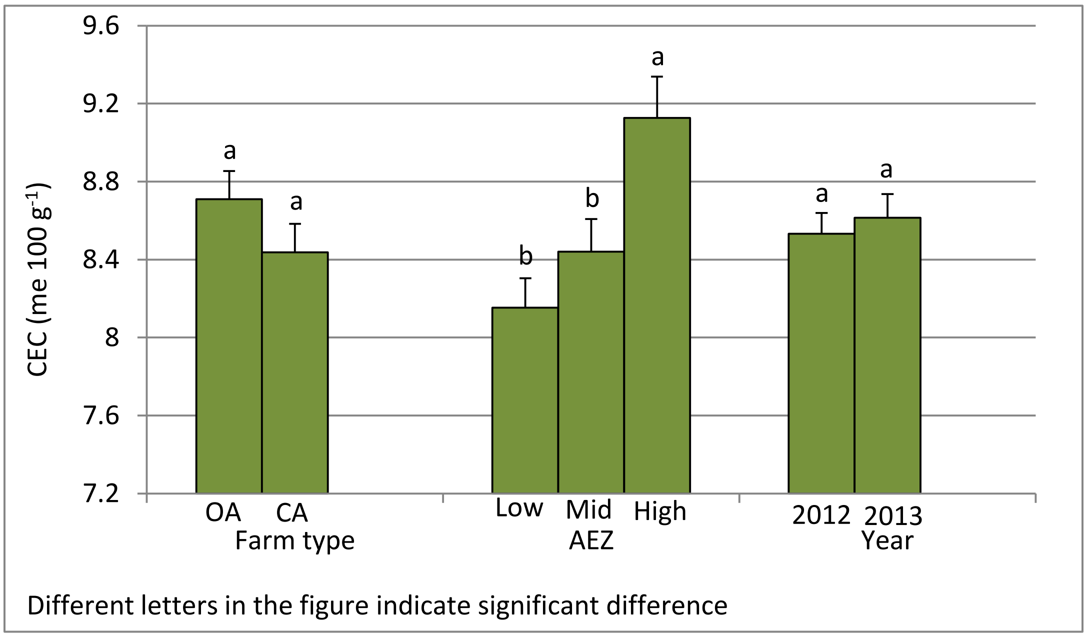

Figure 5.4: Cation exchange capacity as affected by AEZs and farm types averaged over two years (2012 and 2013)

The farm type had significant effect on the bulk density (BD) of the soil. The illustration in Figure 5.5 shows that BD was significantly higher in CON than in ORG. The AEZ and year did not significantly effect the BD. The mid and the high AEZs had the highest and the lowest BD, respectively. The BD tended to increase marginally in second year.

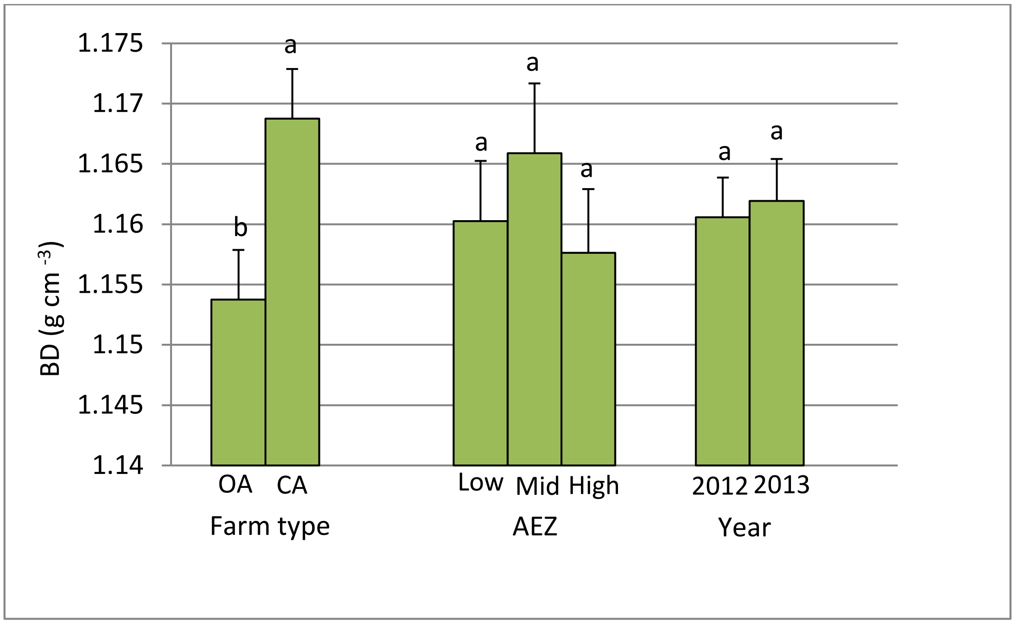

Figure 5.5: Bulk density as affected by farm types and AEZs averaged over two years (2012 and 2013)

Soil analysis was also conducted to compare the three major soil nutrients N,P and K against the set standard (very high, high, medium, low and very low) provided by the National Soil Service Centre (NSSC 2009) (see Appendix 9). In general only 2% of the ORG and CON soil samples showed a high N and K content respectively, whereas over 98% of both ORG and CON samples had either low or very low N content (Table 5.3). Similarly the P content was also either very low or low (ORG 84% and CON 97%). For K, a large proportion of ORG (97%) and CON (94%) samples tended to have moderate amount.

Table 5.3: Proportion of organic and conventional fields with different levels of N, P and K in 2012 and 2013

2012	**V. high (%)**		**High (%)**		**Moderate (%)**		**Low (%)**		**Very low (%)**	
Soil nutrients	**OA**	**CA**	**OA**	**CA**	**OA**	**CA**	**OA**	**CA**	**OA**	**CA**
Total N%	0	0	2	0	0	5	85	90	14	5
Avail. P (mg kg^{-1})	0	0	0	0	8	5	92	95	0	0
Ex. K (mg kg^{-1})	0	0	0	2	97	84	4	13	0	0

2013										
Total N%	0	0	1	0	9	2	73	95	17	3
Avail. P (mg kg^{-1})	0	0	0	0	11	3	84	97	5	0
Ex. K (mg kg^{-1})	0	0	0	2	97	94	4	4	0	0

5.2 Paddy yield comparison between production systems

5.2.1 Organic and conventional paddy yields in three AEZs

The yield of organic and conventional paddy, like the analysis of soil was conducted in two ways. The first analysis involved comparison of yield between ORG and CON within each AEZ. This first analysis did not show statistically significant differences between ORG and CON paddy in both cropping seasons (Figure 5.6). However, the absolute mean values of CON paddy at 3.2 t ha^{-1} was slightly higher than ORG paddy (2.9 t ha^{-1}) in the high AEZ in 2012, but in 2013, the CON paddy yield at 3 t ha^{-1} was marginally lower than ORG paddy at 3.1 t ha^{-1}. In the mid AEZ yield of CON paddy in both years was marginally higher than ORG paddy and the opposite was true for ORG in the low AEZ in both years.

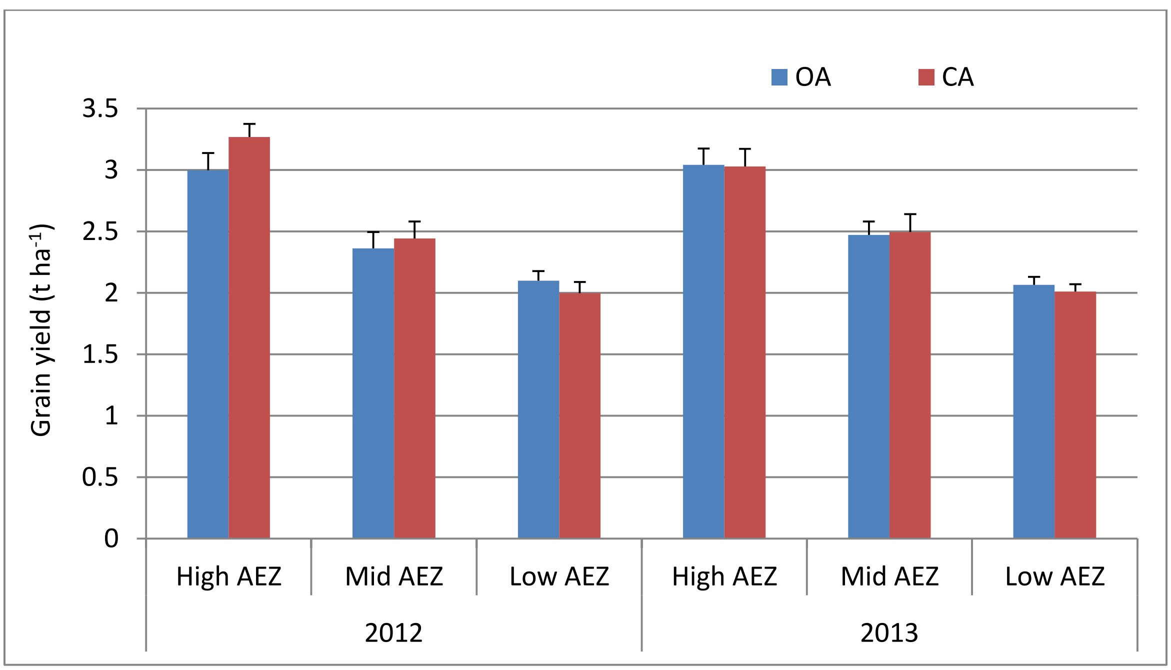

Figure 5.6: Comparison of yield between organic and conventional paddy within each agro-ecological zones in 2012 and 2013

The second analysis of ORG and CON paddy yield involving interaction between the three factors, namely farm types (ORG and CON), AEZs (low, mid and high) and years (2012 and 2013), revealed significant interaction effect of AEZ at P = 0.000 (Fig. 5.7).

The significant difference in yield followed a gradient from high AEZ > mid AEZ > low AEZ (Fig. 5.7). The factors farm type and year at P values = 0.64 and 0.87, respectively did not have significant interaction effects.

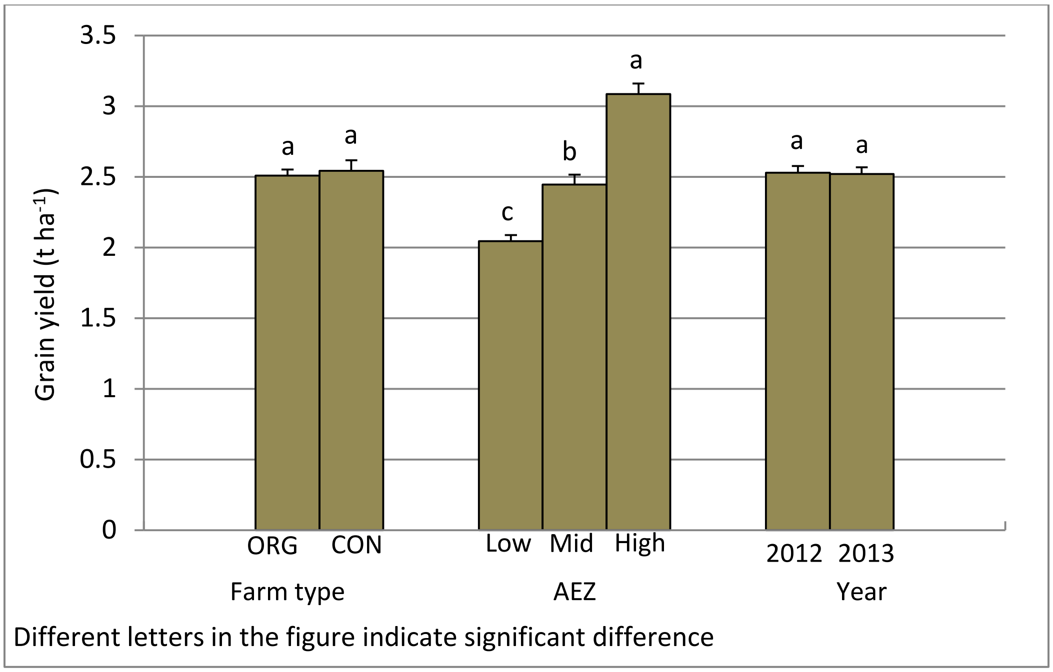

Figure 5.7: Paddy yield as affected by AEZs and farm types averaged over two years (2012 and 2013)

5.3 Socio-economic and production related study analyses

5.3.1 Background of the respondents

The chi-squared test (Fisher's exact test) revealed no significant difference in the proportion of gender, age group and education level of organic and conventional farmers. Gender and demographic age groups between organic (n=393) and conventional (n = 353) farmers were almost similar with only 1 to 3% difference (Table 5.7). The proportion of males (62 - 63%) in both production systems was almost double that of female (37 - 38%). In both systems the majority of farmers (68 - 70%) were in the age group of 31 - 50 years followed by age group representing ≥ 51 years.

With regard to education attainment, in both farming systems, more than 50% of the farmers did not have any formal education, while less than 2% attended high school.

The t-tests on paddy landholding and household members between OA and CA households showed no significant differences. The average paddy landholdings of organic and conventional farmers were comparable at 0.65 and 0.67 ha, respectively (Table 5.4). Likewise, the mean household size of organic and conventional farmers' households was the same at 6.3.

Table 5.4: Socio-economic background of the respondent farmers

Farm type	Gender (%)		Age group (%)			Education (%)				Ave. paddy landholding (ha)	Ave. HH members
	M	**F**	**20-30**	**31-50**	**>51**	**N**	**NFE**	**PE**	**HS**		
OA (n=383)	63	37	6	68	26	52	24	22	2.0	0.65	6.31
CA (n=353)	62	38	7	70	23	53	21	25	1.0	0.67	6.31
	X^2 (Fisher's exact test)									**t-test**	
P=	0.706		0.525			0.673				0.591	0.971

*= significant; ns = non-significant; N = None; NFE = Non Formal Education; PE = Primary Education; HS = High School; HH = Household

5.3.2 Gender involvement in organic and conventional paddy production

The engagement of women in farming activities, particularly paddy cultivation, has not been quantified. The results of this study show that women are substantially involved in both organic and conventional paddy cultivation. The participation of women in various paddy cultivation activities in both organic and conventional systems was comparable (Fig. 5.8).

As compared to men, the major contribution of women in both production systems was related to paddy transplanting (ca. 99%), followed by winnowing (ca. 91%), weeding (ca. 89%) and harvesting (79%). In both systems, while women are not at all involved in fertilizing, they are also very nominally (1-3%) involved in ploughing, puddling and irrigation.

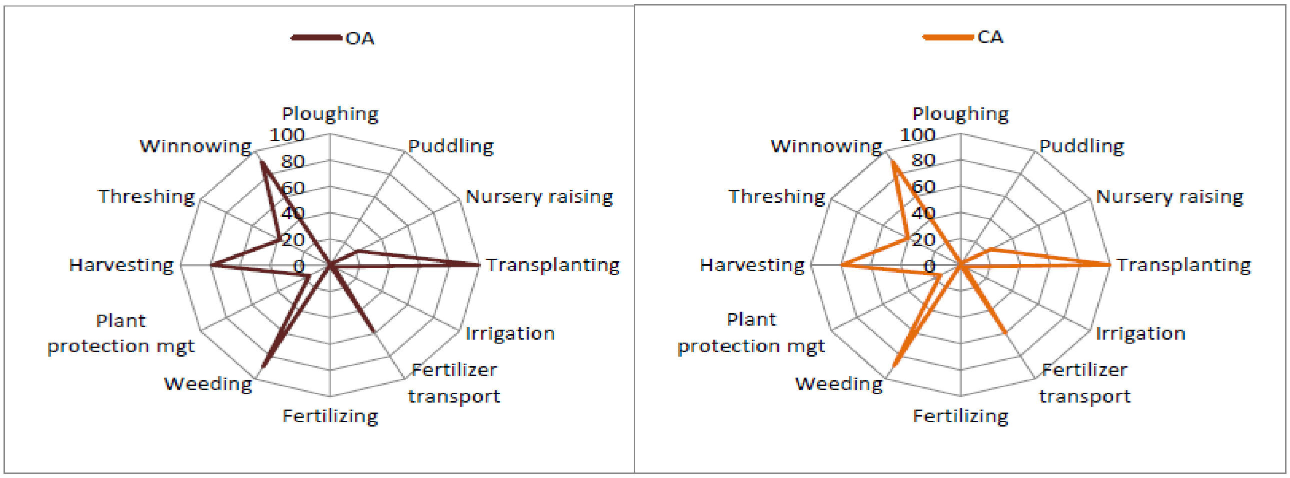

Figure 5.8: Women's contribution (in %) in OA and CA paddy production

5.3.3 Happiness among organic and conventional farmers

Making a living as a farmer is not often easy especially in the developing world with very little or no mechanization. Does that make farmers any unhappier? If so, who is more unhappy - organic and conventional farmers? The results (Fig. 5.9) showed that in general, a higher percentage (84%) of organic farmers felt that they were subjectively happy or very happy as compared to conventional farmers at 77%. The percentage of conventional farmers who felt subjectively unhappy or very unhappy was almost double at 20% as compared to organic farmers at 11%.

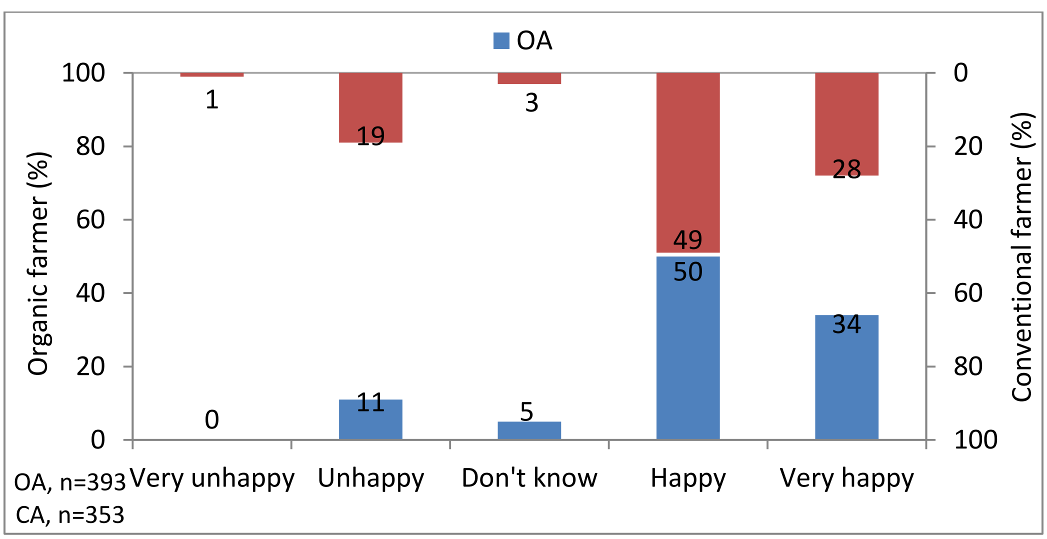

Figure 5.9: Happiness status of OA and CA farmers

5.3.4 Career and livelihood alternatives of organic and conventional farmers

Irrespective of happiness, given a choice, what would organic and conventional farmers opt to do in order to make a living, or how would they like to spend their time? The majority of organic (34%) and conventional farmers (32%) wanted to continue living as farmers (Fig. 5.10). The next best alternative was to pursue a career as a doctor with 20% of the organic and 18% of the conventional farmers opting for it. The proportion (18% each) of organic and conventional farmers opting for monk was also higher than those preferring to be a teacher or a businessman. The occupation soldier was the least preferred by both organic and conventional farmers at 2% each.

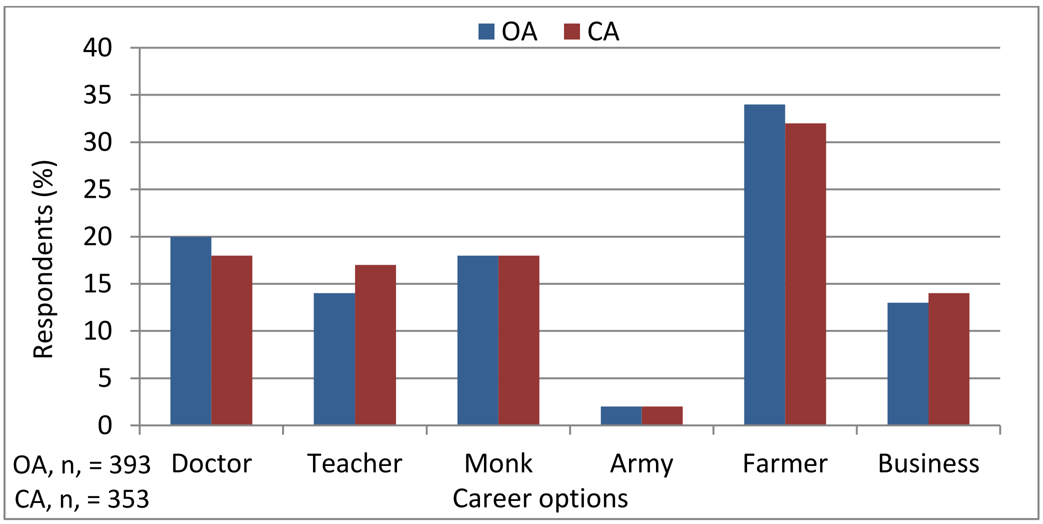

Figure 5.10: Preferred career and livelihood choice of OA and CA farmers

5.4 Economic aspects of organic and conventional paddy production

5.4.1 Variable costs in organic and conventional paddy production

Among the input costs, the cost of plant protection chemicals (908 ± 13 Nu ha^{-1}) was significantly higher in conventional compared to organic paddy production (Table 5.5).

Among various labor costs, the costs of manuring (1,529 ± 32 Nu ha^{-1}) and weeding (7,277 ± 169 Nu ha^{-1}) were significantly higher in organic compared to conventional paddy production (Table 5.5). The remaining labor and variable costs were not significantly different between the two production systems.

Table 5.5: Cost involved in organic and conventional paddy production

Variable cost	Organic paddy[×] (Nu ha^{-1})	Conventional paddy[+] (Nu ha^{-1})	P-values
Inputs costs			
Seeds	2.093 ± 14	2,108 ± 15	0.461
Fertilizers/manure	4,564 ± 109	4,710 ± 10,000	0.315
Plant protection chemicals/botanicals[8]	**131 ± 10**	**908 ± 13**	**0.000*** **
Meals served to laborers[9]	3,897 ± 34	3,942 ± 92	0.721
Total	**10,685**	**11,672**	
Labor costs			
Ploughing	13,060 ± 165	13,539 ± 187	0.065
Puddling	7,198 ± 121	7,360 ± 131	0.367
Bunding	1,500 ± 32	1,565 ± 39	0.206
Nursery raising	840 ± 7	870 ± 6	0.076
Transplanting	6,996 ± 84	7,223 ± 90	0.067
Fertilizing/manuring	**1,667 ± 32**	**1,529 ± 34**	**0.046***
Weeding	**7,277 ± 169**	**2,099 ± 152**	**0.000*** **
Pest/disease management	499 ± 20	584 ± 19	0.088
Irrigation	1,160 ± 26	1,262 ± 24	0.066
Harvesting	5,871 ± 87	1,107 ± 91	0.062
Threshing	2,640 ± 39	2,588 ± 38	0.351
Winnowing	774 ± 9	819 ± 7	0.061
Total	**49,483**	**45,547**	
Capital cost			
Farm equipment	1,664 ± 110	1,153 ± 113	0.471
Land rent	59 ± 00	59 ± 00	NA
Total	**1,723**	**1,609**	

[×]n = 383; [+]n = 353; *P ≤0.05

Nu.= Ngultrum (Bhutanese currency); 100 Nu = 1.25 as of 16 August 2014

NA = Not applicable because standard deviation is zero

5.4.2 Comparison of costs and returns in organic and conventional paddy

The yield of organic paddy at 2,792 kg ha^{-1} and conventional paddy at 2,772 kg ha^{-1} was comparable with no significant difference between them (Table 5.6).

Amongst the various production cost and return factors, benefit-cost ratio, input costs, household labor, total labor cost and gross production cost were significantly different between

[8] Mainly neem (Azadirachta indica) oil is used as bio-pesticides.
[9] In addition to wage, it is customary in Bhutan for the host to serve the laborers with one to two decent meals, tea and snacks, beverages and copious amount of alcoholic drinks.

organic and conventional paddy production. While the latter three parameters were significantly higher in organic, the first two were significantly higher in conventional paddy production.

In other cost and benefit parameters, such as gross and net returns, there were no significant differences between the two production systems. However, in general, notwithstanding the lack of significant difference, the cost of producing a kilogram of conventional paddy at Nu 21 was lower by Nu 1 compared to the cost of producing a kilogram of organic paddy.

The calculation of returns and benefit-cost ratio in this study does not include any premium price for organic rice, unlike in many other studies conducted elsewhere.

Table 5.6: Costs and returns of organic and conventional paddy production

Parameters	**Organic**	**Conventional**	**P-values**
Yield (kg ha^{-1})	2,792 ± 0.15	2,772 ± 0.16	0.389
Price (Nu kg^{-1})	60 ± 0.00	60 ± 0.00	NA
Capital cost (Nu ha^{-1})	1,723 ± 110	1,609 ± 113	0.471
Input cost (Nu ha^{-1})	**10,686 ± 157**	**11,600 ± 156**	**0.000*** **
Hired cost (Nu ha^{-1})	16,025 ± 216	15,811 ± 211	0.481
Household labor (Nu ha^{-1})	**33,457 ± 405**	**29,736 ± 378**	**0.000*** **
Total labor (Nu ha^{-1})	**49,483 ± 533**	**45,547 ± 484**	**0.000*** **
Gross production cost (Nu ha^{-1})	**61,891 ± 647**	**58,756 ± 585**	**0.021** **
Gross production cost (Nu kg^{-1})	22 ± 0.22	21 ± 0.21	0.113
Gross return (Nu ha^{-1})	167,502 ± 944	166,308 ± 1,105	0.389
Net return (Nu ha^{-1})	105,611 ± 928	107,522 ± 998	0.223
Net return (Nu kg^{-1})	37 ± 0.22	38 ± 0.21	0.067
Benefit-cost ratio	**2.7 ± 0.03**	**2.8 ± 0.03**	**0.024***

*P≤0.05

NA = Not applicable because the standard deviation is zero

5.4.3 Irrigation adequacy and cropping in paddy fields and on the levees

About 75% of both organic and conventional paddy farmers do not have adequate irrigation facilities. The results on adequacy or inadequacy of irrigation water show no significant difference between organic and conventional paddy fields (Fig. 5.11).

In the absence of adequate irrigation water, an almost equal proportion of organic (73%) and conventional (75%) paddy farmers leave their paddy fields fallow after harvest. There is no significant difference in the proportion of organic and conventional farmers, who grow crops in their paddy fields after paddy harvest.

Paddy levees constitute a good chunk of land and could be used to grow crops, especially vegetables and legumes. This study shows that only about 10% or less than 10% of organic and conventional farmers, respectively, grow crops on paddy levees.

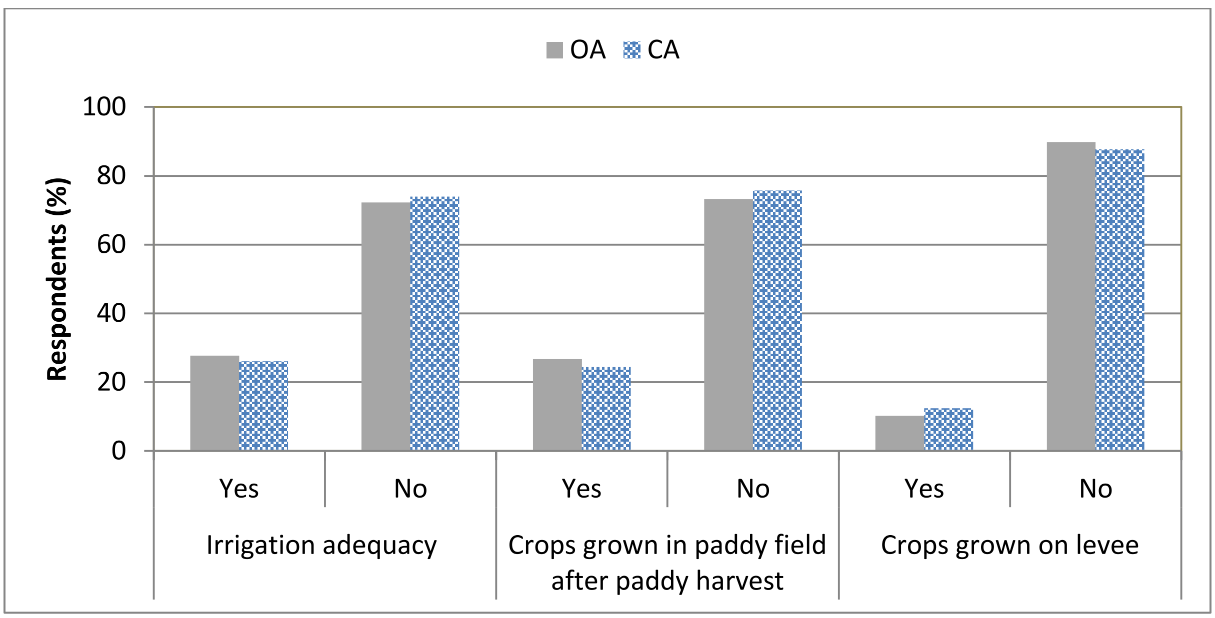

Figure 5.11: Irrigation adequacy and cropping in paddy fields and levees

5.4.4 Weed, pest and disease pressure

Weed pressure in both organic and conventional paddy fields was comparable (Table 5.7). The large majority of both organic (88%) and conventional (87%) paddy fields experienced moderate to high weed pressure.

Similarly, the proportion of organic and conventional paddy fields that face low to moderate pest pressure is almost similar at 88% and 89%, respectively. While none of the fields face very high pest and disease pressure, almost double the proportion of conventional fields faced high disease pressure at 31% than organic ones.

Table 5.7: Weed, pest and disease pressure in organic and conventional paddy fields

Farm type					
Weed pressure (%)	**Very low**	**Low**	**Moderate**	**High**	**Very high**
***OA**	0	1.5	50.9	37.2	10.4
+CA	0	2.5	48.2	38.5	10.8
Pest pressure (%)					
***OA**	6.3	53.6	34.9	5.2	0
+CA	2.3	31.8	58.9	7.0	0
Disease pressure (%)					
***OA**	0	33.5	50.6	15.9	0
+CA	0	21.3	47.3	31.4	0

*n=383; +n = 353

OA = Organic agriculture, CA = Conventional agriculture

5.5 Organic farming SWOT analysis by experts group

5.5.1 Strengths and Weaknesses

Findings on the strengths and weaknesses of promoting OA in Bhutan are mixed. The proportion of the experts who agree or strongly agree on the strengths of promoting OA in Bhutan at 85% is five percentage points higher than the proportion of the experts who agree or strongly agree on the weaknesses at 80% (Table 5.11). While no experts disagree or strongly disagree on the strengths, about 3% of them disagree of any weaknesses in promoting OA in Bhutan.

5.5.2 Opportunities and threats

The proportion of experts who agree on the opportunities (44%) and threats (43%) is comparable (Table 5.8). While no experts strongly disagree on the opportunities and threats, 28% of the experts strongly agree on the opportunities as opposed to 25% of the experts who strongly agree on threats.

Overall, the proportion of experts who agree or strongly agree on having opportunities at 72% is four percentage points higher than the proportion of experts who agree or strongly agree on the threats.

Table 5.8: SWOT analysis of promoting OA in Bhutan (n=35)

SWOT	Strongly disagree (%)	Disagree (%)	Don't know (%)	Agree (%)	Strongly agree (%)
Strengths	0	0	15	63	22
Weaknesses	0	3	17	34	46
Opportunities	0	6	22	44	28
Threats	0	6	26	43	25

5.5.3 Promotion of OA and transitioning to fully OA

Although 100% of the experts did not say that Bhutan should promote OA, at least a large majority (94%) did say so (Table 5.12).

On the question of whether or not "Bhutan can convert to a fully organic country", only 36% of the experts were sure. The remaining majority (64%) did not agree (Table 5.12).

With regard to phasing out all SACs from the country as planned by the government, only about one-thirds (30%) of the experts were in favor of this move. The other two-third (70%) of the experts were either not in favor or were not sure (Table 5.9).

Table 5.9: Questions about converting to a fully organic country (n=35)

Questions on converting to a fully organic country …	Yes (%)	No (%)	Not sure (%)
Should Bhutan promote organic farming?	94	0	6
Will it be possible for Bhutan to convert to a fully organic country?	36	24	40
Should Bhutan phase our synthetic agro-chemicals in its entirety?	30	38	32

6 DISCUSSION

6.1 Soil chemical analysis

6.1.1 Soil nutrient levels and other soil properties in organic and conventional fields in three AEZs

The soil nutrient levels and other properties between organic and conventional paddy fields within each AEZ did not differ significantly (Appendices 10, 11 and 12) primarily because soil nutrient management in Bhutan in terms of fertilizer type, quantities applied, application time and application methods, be it in an organic or a conventional system, is generally poor (Norbu and Floyd 2001; SSF-PNM 2001) and almost comparable to each other in management regimes barring the use of synthetic agro-chemicals in organic farms (Tobgay 2006; Pradhan et al. 2012). Whilst organic farmers make their own FYM and often combine this with animal dung and/ or leaf litter (Fig. 6.1a) collected from nearby forests or use crop residues and slashed weeds (Norbu and Floyd 2001; Roder et al. 2003; Ghaley and Christiansen 2011), conventional farmers use small quantities (<40:20:20 kg ha^{-1} N:P:K) of SCFs, mainly urea with either home-made organic fertilizers such as FYM, poultry or other manure supplements (SSF-PNM 2001; Ghaley et al. 2010).

Field verifications and rough estimates of the dominant macronutrients (NPK) applied in organic and conventional fields through organic manures and SCF in combination with organic manures (in the case of conventional paddy growers) is comparable at an average application rate of about 38:18:15 kg ha^{-1} N:P:K (SSF-PNM2001; NSSC 2009). This quantity is 50% or more lower than the standard recommendation (Appendix 2) provided by the National Soil Service Centre, Bhutan (NSSC 2009).

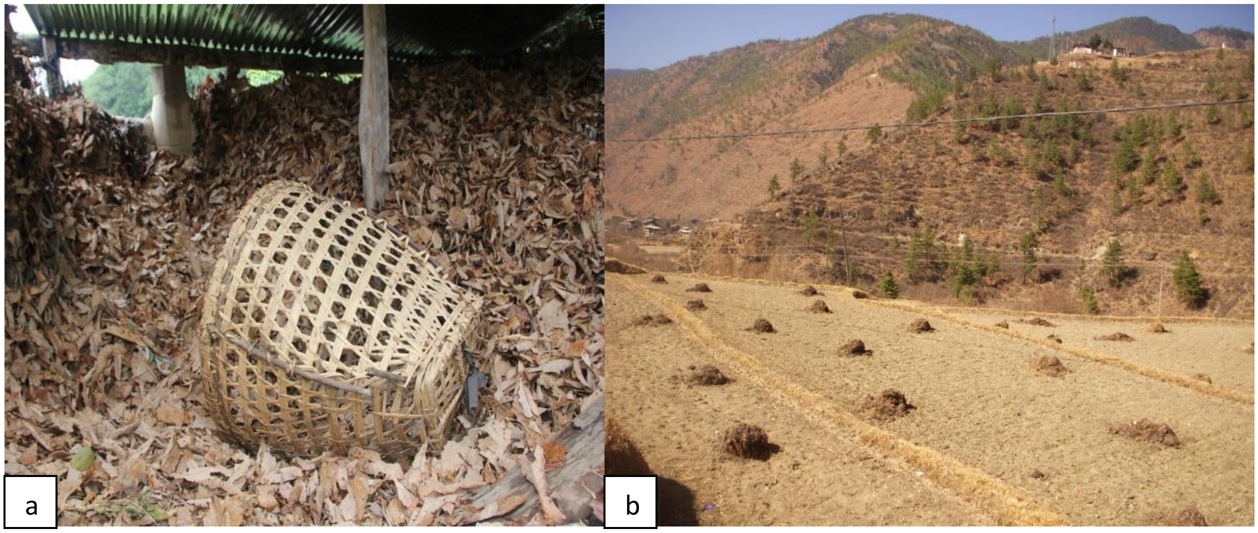

Figure 6.1a: Leaf litter collected from forest to make FYM
b: Organic manure heaped in paddy fields

Another reason for the lack of significant difference and generally low nutrient content (Dorji 2008) could be the method of fertilizer/ manure application as “nutrients can be lost if applied inappropriately” (Foth and Ellis 1997; Boman and Obreza 2002; Pennington et al. 2012). Farmers in Bhutan generally broadcast SCF rather than incorporate them in the soils, and in the case of organic manures, these are often heaped in the fields for several weeks prior to application. According to Bouldin et al. (1984), excessive loss of N through ammonia volatilization occurs if manure or FYM is broadcasted or left in the field. Research has shown that solid raw manure will lose about 21% of its N to the atmosphere if spread and left for four days (Bellow 2000; Van Kessel and Reeves 2002). Prompt soil incorporation reduces that loss by half (Kuepper 2000). Manure application far in excess of crop needs greatly increases the potential of nutrient loss, especially in high-rainfall areas (Bouldin et al. 1984; Van Kessel and Reeves 2002).

Besides the methods, rate and timing of application, soil type/ texture, temperature, soil microbial community and pH several other factors such as soil moisture, previous cropping and so on influence soil nutrient levels, but this study did not consider them (Foth and Ellis 1997; Fageria et al. 2003; Arthurson and Jäderlund 2011). Yet for instance sandy soils hold lower amounts of soil nutrients compared to loam or clay loam, and extremely low or high temperatures and pH will limit soil nutrient availability (Havlin et al. 2005; Fernandez and Hoeft 2009; Pennington et al. 2012).

The three factorial analysis for several soil parameters revealed significant effect modifications between AEZs, farm types and years (Tables 5.1 and 5.2). The results show the high AEZ to have significantly higher SOM, available P, exchangeable K and CEC and significantly lower bulk density. This result corroborate the findings of many earlier studies (Condron et al. 2000; Yan et al. 2007; Dong et al. 2012; Tadesse et al. 2012), and are consistent with the findings of a few studies that reported higher nutrient content in organic soils (Maeder et al. 2002; Zhang et al. 2006; Ma et al. 2011) This demonstrates better soil fertility of fields in the high AEZs under organic management as reported by some authors (Carpenter Boggs et al. 2000; Melero et al. 2008).

The higher level of SOM, P, K and CEC can be attributed to lower decomposition rates in higher elevations and also to the fact that Bhutanese farmers use FYM, which mainly constitutes cattle dung and bedding materials such as rice straw and oak leaves. Besides cow dung being relatively high in N (Adegunloye et al. 2007), it supplies potassium, phosphorous and calcium to the soil (Farid et al. 2011; Tanimu et al. 2012). Organic manure is known to support microbial activity and results in release of nutrients into the soil (Carpenter-Boggs et al. 2000), which may explain the higher nutrient content of fields under organic management.

The additional advantages of applying animal manure are increases in organic matter content and enhancement of soil structure, which in turn improves the nutrient and water holding capacities and reduces soil erosion (Sutton et al. 2001).

Similar to the findings of this study, numerous previous studies have found the bulk density (which is the indicator of soil compaction) of soils from organic field to be lower than conventional fields, mainly because of comparatively high organic matter content in organically managed field (Shierla and Alston 1984; Abdel-Magid et al. 1987). Soils with a low bulk density (see Appendix 9 B) are desirable for the optimal movement of water and air through the soil (Hunt and Gilkes 1992; Arshad et al. 1996) as this facilitates easier root penetration and nutrient uptake.

When availability/ adequacy of the three major plant nutrients N,P and K between organic and conventional fields was analyzed (Table 5.3), K was moderate in both ORG and CON while the other two were either low or very low in both ORG and CON. This is partly because soil parent material is generally rich in K (Baillie et al. 2004; Dorji 2008) and because Bhutanese farmers return up to 70% of paddy straw in paddy fields in the form of bedding materials or FYM (Norbu and Floyd 2001). Paddy straw retain up to 85% K (Dobermann and Fairhurst 2002; Byous et al. 2004) and hence returning it to the soil increases K content of the soil.

Low or very low N and P indicate low application of fertilizers and manures rich in these nutrients as well as lack of or inadequate interventions such as green manuring or legume rotation. As explained previously, input supply in Bhutanese paddy rice is lower than what is normally recommended and hence year-on-year the nutrients removed by the harvested crops cannot be replaced leading to depletion and nutrient mining. This is a serious issue confronting the country's agriculture.

6.2 Paddy yield comparison between production systems

6.2.1 Organic and conventional paddy yields in three AEZs

This study did not find any significant difference between organic and conventional paddy yields within each AEZ in both cropping seasons (Fig. 5.7). The yield of organic paddy found in this study is similar to the organic paddy yield obtained in Gasa district by Pulami (2010). And the yield of conventional paddy is similar to the conventional paddy yield obtained in Bumthang district by Dukpa et al. (2007) and in Wangdue district by Tshewang et al. (2012). Although these yields, especially from the mid and high AEZs are similar to the national average yield, they are lower than those obtained in other major rice producers in Asia such as in Bangladesh (4.4 t ha^{-1}), Indonesia (5 t ha^{-1}) and Vietnam (5.6 t ha^{-1}) (FAOSTAT 2014).

Three main reasons can be cited for the similarity of yields in organic and conventional systems as well as for the generally low yield level. First, not only is the applied amount of fertilizer/ organic manure low (Neuhoff et al. 2014), the application method (mostly broadcasting on the surface or heaping for extended period on field surface) and timing (applying all at once, rather than splitting into at least doses) followed are also inappropriate

(Norbu and Floyd 2001; SSF-PNM 2001). The low nutrient supply, particularly N, as well as the inappropriate method of application can directly contribute to lower yield levels because of lower availability and uptake of nutrients by the crop (Pennington et al. 2012).

The second reason is that other production management practices such as weed and plant protection activities are poor in general (Shrestha et al. 2004; Tashi 2007; Tshewang et al. 2012). Weeding is labor intensive and restrictively expensive weed control inputs usually lead to widespread weeds in both organic and conventional crop fields in Bhutan, as illustrated in Figure 6.2. Many researchers have found that weeds, if not managed timely, can cause grain yield loss between to 40 - 80% (Smith 1983; Ramzan 2003; Wood et al. 2006; Hussain et al. 2008), as weeds compete for water, nutrients, light and space besides harboring pests and diseases (Vakili 2000; Pasha et al. 2012).

The third reason is that 80-90% of the paddy growers (both organic and conventional) do not have adequate irrigation water supply (Fig. 5.1) or irrigation infrastructure to ensure steady supply of water (Karma and Ghimiray 2006; Jamtsho 2010). Lack of irrigation water has been noted to be one of the biggest obstacles to agriculture development in Bhutan (Pradhan et al. 2012). Lack of irrigation has not only constricted production but has also rendered several hundred hectares of land fallow or uncultivable. In many cases such lands are abandoned. Other than attributing yield contraction to lack of water no empirical study has been undertaken to assess the impact or yield loss caused by inadequate irrigation water supply. A study conducted in the Philippines by the International Rice Research Institute attributes between 17% - 45% yield reduction to inadequate irrigation water (IRRI 2004).

Figure 6.2: Weeds growing wild in paddy field

In sum, the comparable values and lack of difference between organic and conventional yields found in this study are contrary to the findings of many other researchers, who found significantly higher yield of organic paddy (Mendoza et al. 2001; Syaukat 2008; Qing-gen and Lei 2011) or of conventional paddy (Rasul and Thapa 2004; Rubinos et al. 2007). The findings of the current study can be explained by the fact that management practices in Bhutanese paddy rice irrespective of an organic or conventional productive system are similar to a large extent (Tobgay 2006; Pradhan et al. 2012). According to Badgley et al. (2007), besides other factors, crop production management practices can greatly influence yield, because management practices involve careful synchronization of production activities with appropriate seasons.

Furthermore, Zundel and Kilcher (2007) argue that yield can be influenced by cultural, social and economic dynamics, which are of relevance to this study because this study was conducted under farmers' prevailing production management practices and these factors were almost similar.

Across the AEZs, paddy yield differed significantly, with the high AEZ having the highest yield in both production systems in both study years (Fig. 5.8). This implies that the difference in grain yield is caused by difference in elevations and the underlying differences in climatic conditions. The findings correspond with the observation of Samui (1999) that rice yields differ in different agro-climatic regions and that weather influences and controls the yield. Studies report variations in the management of paddy production at different elevations in Bhutan (Pulami 2010), which could be another reason for the yield differences.

Differences in yields have been attributed to variations in management systems under different climatic regimes (Marinari et al. 2006; Vakali et al. 2011). The higher yields of both systems in the high AEZ can be for three reasons. First, the high AEZ has a temperate climate, and the low temperature regimes limit rice cropping to only one season. Second, lower disease incidence at higher altitudes has been reported (Ghini et al. 2008), for example in rice blast, besides lower incidences of pests (Luo et al. 1998). Third, Nguyen (2013) states that respiration is low during the low night temperatures in high altitudes, and during the grain development phases of rice plants this favors grain development and filling, leading to higher yields

6.3 Socio-economic and production related study analyses

6.3.1 Background of the respondents

The analyses of the socio-economic background of the respondents reveal that the samples were comparable in many attributes (Table 5.7). However, a few of these parameters, such as the average paddy landholding (0.65 - 0.67 ha) were lower than the national average paddy landholding of 0.8 ha, and the average household size of 6.3 was higher than the national average household size of 5 (NSB 2007).

Comparable household and landholding size of organic and conventional farming households could to a large extent mean that the average household expenditure and household support, as well as other household or farming requirements, were similar in both farming systems.

6.3.2 Gender involvement in organic and conventional paddy production

Traditionally the role of women in farming is often underestimated and not credited (IFOAM 2007). Organic farming is labor intensive (Morison et al. 2005; Shreck et al. 2006), and the additional work load is often filled up by women (Farnworth and Hutchings 2009) as indeed corroborated by the findings (Fig. 5.2) of this study.

This study found that women, in both organic and conventional paddy production, contribute substantially to labor, corroborating the FAO report which stated that women workforce engaged in agricultural work in developing economies constituted two-thirds of the labor force (FAO 2006). The present study also found that there is clear gender division of labor in both farming systems based on various factors, which were not primarily related to physical labor. This is because even in physically less demanding tasks such as plant protection, fertilizing and irrigation, the involvement of women in both systems is nominal. The complex gendered division of labor could perhaps result from the ideological orientation of farmers, culture and labor processes linked to different farm types, as explained by Hall and Mogyorody (2007) in their study on Organic Farming, Gender and the Labor Process.

In Bhutan, particularly in the western region where agriculture is more advanced, the prevailing culture restricts men from carrying fertilizing manure. Thus it falls on women folks to carry manure from stores and cowsheds to the fields. Although this is a repetitive and tiresome task (Roder 1990), more women (59-60%) than men, especially in the western region, perform this chore. It has been observed that those male farmers from the east and south, who are settled in the west participate in carrying manure because the regions they come from do not have such tradition.

6.3.3 Happy as organic or conventional farmers?

Who are happier: organic or conventional farmers? So far no studies have been conducted to address this question directly, other than a recent study by Mzoughi (2014). The scarcity of the knowledge base on this topic is hard to explain other than merely speculating that the words happy and happiness are subjective and vary from time to time depending on circumstances. This study made a modest attempt to compare the subjective happiness of organic versus conventional farmers.

To a large extent, happy and happiness can be argued to be a state of mind with a dose of pleasure and contentment or satisfaction. In fact, Acacia Parks, psychologist at Herim

College, Ohio, USA, argues in her essay, *What is Happiness, Anyway?* that happiness is a combination of the level of satisfaction with life in terms of finding meaning in one's work and how good one feels on a day-to-day basis (Parks 2014).

Taking work satisfaction as one of the primary bases to measure the state of happiness, organic and conventional farmers in Bhutan were asked whether or not they were subjectively happy with their life as farmers. The finding (Fig. 5.3) that over 84% of the organic farmers were subjectively happy or very happy compared to 77% of the conventional farmers who felt the same is consistent with the findings of Mzoughi (2014). The study, which involved French organic and conventional farmers as well as recently converted farmers in the region Provence-Alpes-Côte d'Azur also found that subjective well-being was positively associated with income, satisfaction at work and good health, amongst others. However, a similar correlational factor involving income, etc., was not included in the current study.

Nevertheless, the reasons for being happy or very happy as a farmer (organic or conventional alike) presented here in this study were related more to good crop yield and being able to send children to school. The happiness of the farmers was also influenced by factors such as temple visits or participation in religious activity and good health. None of the respondents concurred that any particular way of farming (organic or conventional) interfered in being happy or unhappy contrary to popular speculations that the use of pesticides in conventional farming made conventional farmers comparatively less happy.

6.3.4 Career and livelihood preferences of organic and conventional farmers

It is not surprising that a large majority of both organic and conventional farmers are subjectively happy or very happy being farmers, because comparatively higher proportion of organic (34%) and conventional farmers (32%) said they would prefer to live and earn their livelihood as farmers, even if various other occupational options were available to choose from at will (Fig. 5.4). Despite the drudgery of farm work and farming in general, what most attracted the farmers to continue their livelihoods in farming was the sense of food security and "simple" life that farming and a farm accorded them. Farming also provided them the opportunity to stay physically healthy.

Although a doctor's life is comparatively more comfortable than that of a farmer's, it was opted for as the second best option after farmer by both organic farmers (20%) and conventional farmers (18%). This may indicate that the farmers are not entirely obsessed with or care so much about comfort in life or a sense of nobility because often a doctor's profession in the less industrialized orient is associated with these among other privileges and benefits. Alternately, it can also be speculated that humble farmers cannot "imagine" to become a doctor, which is seen as a noble profession. Furthermore, this result could be explained by the primacy for agriculture-based livelihood in rural Bhutan, as opposed to other forms of earning livelihood such as petty trading, herding, fishing and so on.

The least preferred option for both organic and conventional farmers (reported at 2% each) was being a soldier. To lay farmers in Bhutan, life of soldering often implies killing and violence, which are sinful acts to all Buddhists. Since over 70% of the respondent farmers were Buddhist, this result is not unexpected. Many farmers in Bhutan do not work on auspicious days in order to avoid committing sins, because working on farms results in killing insects and other forms of life. Unfortunately no past studies on this subject could be found to compare and contrast the results.

6.4 Economic aspects of organic and conventional paddy production

6.4.1 Comparison of variable costs of organic and conventional paddy production

The costs of plant protection chemicals is significantly higher in conventional than organic farms (939 Nu ha^{-1}), because plant protection chemicals are imported and are thus expensive. A similar difference was noted in the case of rice farmers in The Philippines (Mendoza et al. 2001; Setboonsarng 2006; Scialabba and Müller-Lindenlauf 2010), but not in India (Charyulu and Biswas 2010), Cambodia (Kennvidy 2011) and Pakistan (Mehmood et al. 2011). The other factor which contributes to this significant difference is the fact that most organic farmers generally do not use bio-pesticides such as neem oil, or other products because they are not readily available.

Despite the significant difference in plant protection inputs, the absolute mean values for both organic and conventional plant protection activities are relatively small mainly because plant protection activity is generally not a high priority of Bhutanese farmers (Shrestha et al. 2004). This is even truer for organic farmers. Both organic and conventional farmers are “comfortable”, as long as there is some yield and the whole crop land is not destroyed or damaged by pests and diseases. Despite the presence of pests, diseases and weeds most farmers remain rather indifferent, because paddy is not the only crop they depend on for their livelihood.

The other component of variable costs is the cost of labor. As expected, the costs of weeding (7,277 Nu ha^{-1}) and manuring (1,667 Nu ha^{-1}) are significantly higher in organic paddy, as compared to conventional production. A similar finding was obtained in Nepal (Adhikari 2011), Cambodia (Kennvidy 2011) and in Thailand (Pattanapant and Shivakoti 2009). This seems to be universally true in organic farms across the world (Morison et al. 2005; Nemes 2009). In order to supply plant nutrients in organic farms, a substantial volume of manure has to be applied, which comes at a cost.

In organic farms, the higher costs of weeding are mainly due to hiring additional laborers to weed organic fields. Weed control is frequently a problem in organic farms, where the farmer is limited to manual weed control, because paddy fields are on wetlands, where mechanical weed control is usually less effective (Pimentel et al. 2005).

Among other labor costs (though not significant, but true for both organic and conventional fields), harvesting contributes most to labor costs followed by ploughing, and hence future interventions towards farm mechanization should focus to reduce costs of these management practices in addition to plant protection, particularly weed management.

6.4.2 Comparison of costs and returns between organic and conventional paddy

There is no significant difference in gross and net returns between organic and conventional paddy (Table 5.10), corroborating findings from several previous studies (Pulami 2010; Pradhan 2011; Neuhoff et al. 2014). However, Mendoza et al. (2001) in The Philippines, Kennvidy (2011) in Cambodia and Adhikari (2011) in Nepal found significantly higher net returns from organic paddy.

The combined input costs (seeds, fertilizers, plant protection chemicals and laborers' meals) were significantly higher in conventional compared to organic paddy, mainly because, as previously mentioned, organic farmers do not invest in imported expensive plant protection chemicals and SCFs.

Costs of household labor and the total labor cost are significantly higher in organic paddy than in conventional production, because of significantly more laborers required for weeding and manuring. This in turn results in significantly higher gross production costs in organic compared to conventional paddy. Indeed, organic farming is known to be very labor intensive (Morison et al. 2005), and this is not different in Bhutan. Moreover, compared to other countries in the region, labor costs in Bhutan are high due to the shortage of manpower. The high labor cost adds substantially to the gross production costs. Furthermore, the comparatively higher costs witnessed inorganic cultivation have also been reported by several other authors (Lawanprasert et al. 2007; Rubinos et al. 2007; Pattanapant and Shivakoti 2009; Charyulu and Biswas 2010).

Although the mean costs of producing one kilogram of organic paddy are only marginally higher than producing one kilogram of conventional paddy, the benefit-cost ratio of conventional paddy (BCR 2.8) is significantly higher when a premium price for organic rice is not considered. This corroborates the findings of Lawanprasert et al. (2007), Adhikari (2011) and Charyulu and Biswas (2010), but contradicts the findings of Mansoori et al. (2012) and Mehmood et al. (2011) who found significantly higher benefit-cost ratio for organic paddy when a premium price is included.

A five-year comparative study by Surekha (2013) conducted in India found the benefit-cost ratio of organic paddy to be lower in the initial years, but surpassed conventional production in the fifth year. In the current study, a premium price for organic paddy rice was not used to calculate the economics of production because there is no recognized premium price for organic produce in Bhutan as yet. Elsewhere organic produce commands premium price. For instance, certified Chinese organic products attract about 12% premium price while Australian ones command up to 17% (Paull 2008). The lack of a standard premium price for organic produce in Bhutan could be because the price of local produce is already higher than most imported produce and products, which overwhelmingly stem from conventional production. Other reasons could be the lack of certification and awareness, though lately the latter is increasing.

6.4.3 Irrigation adequacy and additional cropping in paddy fields and on the levees

Farming in Bhutan is largely rain-dependent. In the past this made sense because farming was less intensive, owing to lack of or limited markets, as well as post-harvest processing. Putting in place irrigation infrastructure across the country therefore was not a priority. Wherever irrigation facilities exist, the water is shared between the organic and conventional farmers without any discrimination through traditional water sharing mechanisms. This explains why there is lack of significant difference with regard to adequacy or inadequacy of irrigation water between organic and conventional paddy fields (Fig. 5.1).

Without adequate irrigation facilities and water, a large proportion of both organic and conventional paddy fields are left fallow (Fig. 5.1) after paddy harvest. Other reasons noted for fallowing agricultural lands include wildlife depredation, stray animals (as there is little fodder available during the winter in Bhutan) and the shortage of farm labor (Pradhan et al. 2012). For whatever reason leaving productive lands fallow for up to seven months a year (drier months from December to June) is paradoxical given that annually substantial volumes of food, including vegetables and rice have to be imported.

In light of this paradox, during the rainy season, which also coincides with paddy cultivation, it makes sense from an economic and food security perspective to use paddy field levees for growing crops (Yamaguchi and Umemoto 2009), particularly legumes such as lentils, dwarf beans and chick peas, as commonly practiced by a handful of farmers in the southern part of the country (see Fig. 6.3). The soils in which leguminous crops are grown would be enriched with nitrogen, which is often required in bulk and is limiting. Besides these benefits, such practices may also help control erosion (Fukamachi et al. 2005). However, this study found that less than 10% of the organic and conventional farmers had adopted this practice and all of them are located in the southern region. Farmers in east, west and central Bhutan do not have this tradition, despite the multiple benefits of such a practice.

Figure 6.3: Legumes grown on paddy field levees

6.4.4 Weed, pest and disease pressure

Weed pressure

Weeds are a major problem in Bhutan and weed infestation and pressure are comparable in both organic and conventional paddy fields (Table 5.8), although elsewhere (Korea, Japan and Pakistan), Son and Rutto (2002) reported organic paddy fields to have significantly higher weed infestation levels. Other researchers also concur with these findings mainly on account of the use of various herbicides in conventional paddy fields (Vakili 2000; Pasha et al. 2012).

The only herbicide available for paddy farmers in Bhutan is butachlor, a selective herbicide that belongs to the anilide group. Thus several different non-specific weed species are spared. Recently Bhutanese media also carried several reports of this herbicide being of low quality and ineffective in controlling weeds in paddy fields (Dema 2014; Wángdi 2014). Moreover, because all herbicides and other SACs are centrally purchased and supplied, in many parts of the country these are often not available on time or in adequate quantities.

It has also been reported that instead of applying the herbicide within 2-3 days after transplanting as recommended, it is applied several weeks after transplanting, and the quantity applied is lower than the recommended 25 kg ha^{-1} (Pradhan 2011). Therefore, it is not surprising that weed pressure in both organic and conventional systems remains high and comparable.

Amongst the various weed management tools available, organic farmers resort mainly to manual weeding, which is not only labor intensive, but also inefficient. Where water is available farmers also resort to flooding as a means of controlling weeds. Other innovative and often effective organic weed management interventions such as the simultaneous rearing of ducks, tadpole-shrimps, carps, etc. as practiced in Nepal, Bangladesh, Japan, Philippines and other rice growing regions (Moody 1991; Son and Rutto 2002) are not yet introduced/practiced in Bhutan. Cover cropping, mulching and land cultivation/tillage are some of the other cultural and mechanical practices that could be employed on organic farms to manage weeds (Lundkvist and Verwijst 2011).

Pest and disease pressure

Pest pressure, like many other attributes, is comparable between organic and conventional paddy fields in Bhutan (Table 5.8). This finding contradicts those of Sukristiyonubowo et al. (2011), whose research in Indonesia found significantly lower pest and disease levels in semi- and fully organic fields, as compared to conventional paddy fields. Many other researchers also report comparatively low pest pressure in organic fields vis-à-vis conventional fields because in the latter as a consequence of high pesticide use the population of beneficial organisms, which maintain pest-predator balance gets disrupted (Norton et al. 2009; Luo et al. 2014).

The prevalence of low to moderate pest pressure that was comparable between organic and conventional fields found in this study is difficult to explain. However, as stated before, management practices between organic and conventional fields are almost similar in Bhutan, leading to similar level of problems with pests and diseases in organic and conventional paddy fields.

Likewise, the low to moderate pest pressure could perhaps be because rice is mainly grown once a year with long dry fallow period between harvest and the following cropping. It could also be linked to small landholdings, and diverse farming systems. Moreover, less intensive farming that is typical of Bhutanese agriculture and scattered and partially isolated farms could be another contributing factors to this.

This study shows that conventional paddy fields face higher disease pressure than organic paddy fields (Table 5.8). It is again hard to provide any concrete justification(s) for such findings given that most production management practices between organic and conventional farmers are similar. Literature on this subject provide mixed findings, some reporting organic fields to face significantly higher disease pressure, particularly potato late blight and onion downy mildew in humid climates (Piorr and Hindorf 1986; van Bruggen 1995), while others claim the opposite (van Bruggen 1995; Altieri and Nicholls 2003; Chau and Heong 2005).

Reasons for higher disease pressure in organic fields are reported to be the lack of improved varieties, unavailability of effective bio-pesticides when required, and to some extent poorer plant health. In the case of conventional fields, the reasons argued include pesticide resistance, year-round cultivation of the same land with the same crop varieties (leading to comparatively less complex ecosystem to maintain a balance) and increased application of nitrogen fertilizer to high-yielding varieties (Norton et al. 2010). Some of these reasons are relevant to Bhutan’s context and to the findings of this study.

6.5 Organic farm SWOT analyses by experts’ group

6.5.1 Strengths and Weaknesses

Strengths and weaknesses in the SWOT analysis are reported to be internal factors that need to be used (in the case of strengths) and contained (in the case of weaknesses) (Westhues et al. 2001; Nair and Prasad 2004).

A large majority of experts (about 63%; Table 5.11) agree that Bhutan has many strengths to promote OA, mainly because Bhutan’s developmental philosophy of GNH and the principles and philosophies of OA share the same values of sustaining not only the economy, but also the social and environmental aspects of well-being. A largely intact and pristine environment, in addition to the remarkably stable political system and a strong political support add to the strengths of promoting OA in Bhutan.

A large majority of farmers practicing organic-by-default can also be considered as a strength, as this places Bhutan in a vantage and unique position to convert to a fully organically farming country. Studies done in many parts of Africa and India have shown that smallholder organic-by-default farmers can easily convert to OA without compromising yield or other associated benefits (Scialabba 2007; Nemes 2009; FAO 2013).

In addition to strengths, Bhutan also has a number of weaknesses. The large majority (47%) of experts strongly agree on the presence of weaknesses primarily because OA practices based on scientific knowledge are fairly new in Bhutan. As it is a new farming practice, weaknesses could arise from lack of awareness of the potential benefits of OA as well as lack of technical expertise at all levels. Developing competencies and technologies remain elusive because of a lack of research culture as pointed out by Neuhoff et al. (2014). This adds further weakness in that viable alternatives to synthetic plant protection chemicals such as effective bio-pesticides are presently not produced within the country.

The weaknesses highlighted above need time and investment, especially in research and development of appropriate and viable alternatives, such as labor saving devices to overcome labor shortage and reduce production costs, and provisioning of quality planting materials and other inputs at affordable prices, as these are some of the weaknesses that experts fear. However, these weaknesses are true for conventional farms too, as such the promotion or the practice of either organic or conventional system will require addressing these weaknesses.

6.5.2 Opportunities and Threats

Similar to strengths Bhutan has many opportunities (Table 5.11), primarily because of growing interest in and awareness of OA and an increasing regional and global organic market. Most experts believe in the opportunity to boost sustainable use of natural resources and curb dependence on food and input imports.

However, some experts pointed out that as a small country with limited resources and agricultural land, coupled with other limitations, surplus production in Bhutan to achieve food self-sufficiency will not be possible, let alone the capture of regional or global markets.

Bhutan faces a number of threats vis-à-vis opportunities in promoting OA. The two important threats that most experts (43%) unanimously agree on are variability in climate and yield reduction, thus compromising food self-sufficiency. The experts believed that the increasing variability in climate pattern, coupled with the lack of viable alternatives in plant protection under OA, will seriously reduce yield and may stall the government's goal of achieving food self-sufficiency.

Other threats that led to mixed feelings from the experts include global competition and impending membership in the World Trade Organization (WTO). Most experts feel that with a very small economy constituting a GDP of just US $ 1.6 bi (Wangdi 2015) and an equally small agricultural base, global competition will not have a strong effect on Bhutan (Dorji 2008). However, such a stand may not be entirely true in the wake of increasing globalization and the penetration of foreign direct investments such as the Mountain Hazelnut project (Karchung et al. 2012).

With regard to introduction of genetically modified organisms (GMOs) as a threat, the issue is still being debated, and the experts' opinions were divided. GMOs are argued to be not only high yielding, but also drought, salinity and pest and disease tolerant. However, at the same time GMOs are also alleged to result in the upsurge of more virulent pests and diseases (Shiva 2013). Besides, GMOs could erode traditional varieties and create dependency, which could become an expensive affair (Parrott and Marsden 2002).

In essence if the goal of the GMO is to enhance production through superior traits then Bhutan, or for that matter the world, does not need GMOs. The world does not lack production technologies to produce adequate and quality food. Every year tons of food are wasted or destroyed or the lands that could have been used to produce food are mandated to keep fallow so that world food price can be stabilized. Given this fact the emphasis should be on restructuring food distribution channels and networks and concurrently upping the purchasing power of the people so that they can access adequate and nutritious food at all times.

6.5.3 Promotion of OA and transitioning to a fully organically farming country

A large majority of the experts support promoting OA in Bhutan (Table 5.12). The support stems primarily from the growing awareness of the harmful effects of SACs on soil, water, environment and human and animal health. Indeed, the excessive use of SACs could upset the fragile ecosystem that Bhutan has managed to protect and preserve so far.

Further, promoting OA would also be in line with the country's GNH philosophy, as one of the experts expressed "it would be a living contradiction, if Bhutan did not promote organic farming, while waving the flag of GNH". Bhutan also has the "right conditions" for the promotion of OA because a large majority of the farmers are organic-by-default and farming is chiefly traditional, characterized by small landholding and subsistence farming.

However, not all experts support promoting OA in Bhutan (Table 5.12). Those experts (6%) who were not sure, if Bhutan should promote OA may have feared that the prevailing food deficit could further exacerbate, because OA is still seen as low yielding and expensive. Upholding such attitudes may challenge and potentially slow the promotion of OA. Thus such outlook merits a healthy and transparent dialogue across stakeholders.

Such intervention is even more pertinent given that approximately two-thirds of the experts feel that it will not be possible or are not sure if it would be possible for Bhutan to convert to a fully organic country (Table 5.12). Before rushing to convert to a fully organic country, experts suggest that necessary structures, sound policy support, human capital and exigency plans be put in place in the event if converting to fully organic production flounders.

By far the most feared reasons for harboring reservations against converting to a fully organic country are the expected reduction in yield and the rise in pest and disease levels. This line of thinking suggests, either rightly or wrongly, that there are no effective organic alternatives to enhancing yield and warding off pest and disease. Perhaps based on this understanding or belief, more than double the proportion of the experts (Table 5.12) do not favor, or are not sure if the country should entirely phase out SACs.

Although the experts admit that SACs are inherently toxic and harmful they still cannot wean off from the benefits, even if short-term, that these SACs generate. Rather than eliminate

SACs in their entirety, some experts suggest regulating use, and more importantly encouraging the mixed use of organic and synthetic inputs and interventions.

In summary, despite a large majority of the experts supporting the promotion of OA in Bhutan, inexplicably many of them still feel the task of converting to a fully organic country will not be possible or do not support phasing out SACs entirely, which otherwise could be one of the shortest and fastest ways to converting to a fully organic country.

7 PROSPECTS OF ORGANIC FARMING IN BHUTAN – SOME FINAL PERSPECTIVES

"To be interested in food but not in food production is clearly absurd."

Wendell Berry

7.1 Introduction

This chapter reflects on some of the benefits of OA and provides critical perspectives and analyses of its prospects in Bhutan based on a comparative study and SWOT analysis obtained from experts' group discussion and interviews. Some important interventions as a way forward for converting to a fully organic agriculture country are also explored.

7.2 Prospects analysis

The findings of the comparative study, literature review and experts' group discussion and interviews indicate rather mixed prospects for organic farming in Bhutan. The comparative study results broadly show no significant differences between organic and conventional paddy in terms of soil properties, yield, economics (except cost-benefit ratio being in favor of conventional system when a premium price for organic is not included), and other management and social indicators such as subjective happiness between organic and conventional farmers and livelihood options, and hence one system is not better than the other or both could, as of now, be as good as the other.

Further, the findings from different literature sources and the experts' group discussion also lend inconsistent or mixed reactions on many fronts except when it comes to extreme climate regimes that all literatures unequivocally agree that OA performs better and that in the long run OA has better potential to enhance not only the soil organic matter but also biodiversity and ecosystem services. Perhaps, cognizant of these "larger" benefits, Bhutanese experts almost unanimously support promoting OA in Bhutan, but ironically do less so in phasing out SACs and have even less confidence in the ability to convert to a fully organic country.

What is behind the experts' paradoxical reactions is hard to comprehend and explain, but as a country that embraces the GNH growth paradigm of socio-economic and ecological soundness and sustainability overtures, it may be that Bhutan and the Bhutanese experts recall the unambiguous stand of different literatures on some of the crucial benefits of OA as highlighted in the preceding paragraphs of Chapter 6. These benefits are in consonance with some of the aspirations of the GNH paradigm and could thus be used as a useful reminder in the drive to promote OA in Bhutan.

To further give credence to the prospects of OA in Bhutan, it may be pertinent to turn to a more credible source such as the Rodale Institute, USA, for the ultimate confirmation on the benefits of OA. From their 31 years' parallel comparative study of organic and conventional farming methods, the institute underscored the following benefits (Rodale 2012):

> Organic farming is sustainable because its methods build rather than deplete soil OM [Organic matter]. Soil health increases in OF [organic farming], but it remained unchanged in CF [conventional farming]. Organic farming yields matched or surpassed conventional yields. In years of drought, organic yields outperformed conventional ones. In fact, organic corn yields were 31 percent higher than conventional ones during droughts. Organic farming was nearly three times more profitable than conventional farming. Between 2008 and 2010 the economic data collected showed that an average net return per acre per year for organic systems of $558 [premium price is not mentioned] compared to $190 for conventional ones. OF uses 45% less energy compared to CF. CF produces 40% more GHG [Greenhouse gas].

The findings above summarize wide-ranging benefits of OA – from soil and economy to environment. Social benefits such as job opportunities, community vitality and the facilitation of gender equality are also associated with OA (D'Amario et al. 2005; MacRae et al. 2007; Scialabba 2007; FAO 2013). And since OA is supposed to work with nature and within the framework of its four principles, it is reported to be socio-economically and environmentally sustainable (Kilcher 2007; Scialabba 2007; FAO 2013).

Sustainable and holistic growth is the aspiration of all countries and the new development paradigm advocated by the United Nations post Millennium Development Goals. As a small resource-poor and donor-dependent country, Bhutan acknowledges the importance of balanced sustainable development, including environment preservation. The manifestation of Bhutan's commitment to pursue sustainable development is reflected in its endeavor to institutionalize the GNH philosophy.

But the very foundation of sustainability remains at risk if agriculture, which is alleged to be one of the biggest environmental polluters in the world (Allen 2009), remains unrefined or maintains its business as usual modus operandi. Agriculture, particularly industrial agriculture, is a complex activity that is today acknowledged to cause widespread pollution and degradation of land, environment and eco-systems (WB 1992; Ongley 1994; Wu 2004; IPCC 2007). In this light, OA provides Bhutan with a good platform to practice its sustainable development philosophy of GNH. The parallels that exist between the principles of OA and the philosophies of GNH create good synergy for Bhutan to practice OA. This synergy, however, does not mean that promotion and legitimization of OA will be all smooth sailing. Strengths and opportunities exist, as well as weaknesses and challenges, which are described below.

7.3 Strengths and opportunities

7.3.1 Biophysical conditions

Bhutan is endowed with a wide range of climatic conditions from humid and dry subtropics in the low and mid altitudes to warm and cool temperate climate in high altitudes to perpetual snow in the northern alpine highlands. These variations in climate and altitude (from 130 to 7600 m.a.s.l.) provide corresponding opportunities to grow and supply different crops and food throughout the year. Moreover, the intact and pristine environment that Bhutan boasts, owing to negligible pollution and contamination together with substantial water reserves (Jamtsho 2010) and other natural resources (Pradhan et al. 2012), provides favorable preconditions for the production of a wide range of food and fiber (Tobgay 2006).

Ample anecdotal evidences suggest that both agricultural and non-agricultural soils, and water resources in Bhutan are still not excessively exposed to SACs, unlike in many industrialized countries (Katwal 2013). In the event of going fully organic, such "under-exposed" soils could be a good asset, as arguably, ameliorating or (nutrient) enriching such soils will be fairly easy and less expensive.

Taken together, clean water, soil and intact natural resources make a pristine environment that generates positive externalities to build and sell the image of Bhutan as a brand (Thinley 2011; Tshomo 2014). The presence of these rich and unspoiled resources also foster a compelling and moral reason and strength to embrace food production practices that are less or non-damaging, thus preserving their intactness and continually deriving from them the associated benefits.

7.3.2 Sound political system and rich natural resources

In addition to these favorable biophysical preconditions for growing a wide range of agricultural produce, the politics and political system nurtured under the guidance of the much-revered foresighted successive Bhutanese Monarchs is also acknowledged to be sound and stable. Bhutan is one of the few countries in Southeast Asia that was never colonized. It is one of the more peaceful countries in the world. Political unrest and demonstrations, which are often violent, common and frequent in many parts of the world, are unheard of in Bhutan (except for minor anti-national[10] sentiments expressed by some ethnic Hindu minorities in the early 1990s), thus enabling resource savings and smooth functioning of day-to-day activities and life.

The Monarchs have always emphasized preservation and conservation of natural resources. This has resulted in maintaining a large part of the country under wildlife sanctuaries, national parks and biological corridors besides keeping intact 72% of the land under forests, most of which are primary forests.

Bhutan is one of the few carbon-neutral or carbon negative countries in the world (Noord van 2010). Besides, Bhutan is also ranked among the globally most bio-diverse countries

[10] Some Bhutanese Nepalese obviously "not happy" of the Government of Bhutan's thrust to update citizenship and also promote One Nation One People identity opposed the initiative through a few sporadic short demonstrations along the southern border where this community abound.

(NBC 2009), and is recognized as being one of the top 10 biological hotspots with 5,400 vascular plant species, 200 species of mammals (including the Royal Bengal Tiger, *Panthera tigris* L. [Felidae], and Takin, *Budorcas taxicolor* Hodgson [Bovidae] and 678 bird species, 14 of which are globally threatened and ten fall within the restricted range (BTF 2011; Mittermeier et al. 2011).

This rich biodiversity coupled with a large number of wetlands, glaciers and lakes provides a wide spectrum of ecosystem services from pristine environment to safe freshwater to numerous wild food and ready fodder for farm animals (RGOB 2012). Such precious resources could be at high risk if CA is to take precedent over OA, especially if the alleged ill effects of CA are to be true. Among others, these natural resources formed an important source of farm manure for most of the 82% of the population, who depended on agriculture for their livelihood until the start of modern development in the early 1960s. The farming population, which has since then shrunk to 69%, continues to be contingent in one way or the other on these natural resources for a part of their farm manure and feed for farm animals.

7.3.3 Smallholder farms and organic-by-default

Most farms in Bhutan are integrated with a few heads of cattle or goats or poultry (Roder et al. 2003; Pradhan et al. 2012). These animals play many roles, from draught power to supplying farm manure and nutritional needs such as eggs, milk and meat.

Most farms are smallholder family farms with an average per capita landholding of < 1 ha. Even if farms are small, farmers grow from four to as many as 13 different crops. This traditional multiple cropping practice provides multiple benefits. Although not documented and studied empirically, it could be speculated that one of the reasons for not experiencing widespread pest and disease epidemics (except in the cases of monocropping of a few crop varieties such as apple, citrus, cardamom, potato and paddy) is due to the traditional practice of multiple cropping.

Farming is largely traditional, characterized by the use of low inputs and low yields. The use of external inputs, including SACs is negligible and restricted to areas that are accessible by motor roads and where farmers are comparatively affluent. So a large majority of the farms are organic-by-default. This places Bhutan in an advantageous position to convert to a fully organic country. Transitioning to a fully OA from organic-by-default would entail less dramatic changes both in terms of practice and farm outputs, if any.

The other strength in conversion comes from the virtue of being smallholder farms. Smallholders are easier to convert and they prove more resilient given that it is possible to give more attention and care.

Even in the past, as an evidence of their resilience and productive capacity, despite being small, these farms were food self-sufficient before the advent of modern development, and before the influence of CA made inroads in the 1960s. While the citizens lament the loss of food self-sufficiency, no formal studies have been conducted to ascertain the cause(s) for this loss. It is speculated that population growth and urbanization could have contributed to this.

The existence of food self-sufficiency is evidenced by the existence of barter systems, in which farmers exchanged dried chilies with dairy products or buckwheat flour with maize or ground maize with rice or radish with some other food products (Pradhan et al. 2012; RGOB 2013). Arguably to a large extent a barter system in food only exists and succeeds if there is surplus food to barter.

7.3.4 Growing market and awareness

The barter system has been overtaken by a monetized market economy, with the introduction of Bhutanese currency in 1974. The food market in the monetized economy is expanding not only on the domestic front, but also regionally and internationally. Global markets, especially of organic food, are growing exponentially and demand far exceeds supply. This is good news and represents an opportunity for organic growers across the world.

The trigger for the increasing worldwide demand and market for organic food is attributed to the growing awareness of the wide ranging benefits of OA, and this awareness amongst the primary consumers and producers is gradually growing in Bhutan and other less-industrialized countries too. More awareness could catalyze more demand and this in turn could fuel more conversion and production. In this regard, it could benefit more those who seized the opportunity to establish earlier.

7.3.5 Synergy of favorable conditions and support

The growing awareness, coupled with favorable biophysical conditions and a strong GNH-based sustainable development paradigm offers a good opportunity and social support to promote and adopt OA in Bhutan. Furthermore, by virtue of being largely organic-by-default and farming typically being integrated and faring well lend technical and management strengths in themselves that place Bhutan in a rather comfortable position in its endeavor to convert to a fully OA country. The stable political system, and the strong political-institutional will and support OA enjoys in Bhutan rounds off all the needed support and crucial opportunities to succeed in the conversion endeavor.

7.4 Threats and challenges

7.4.1 Food self-sufficiency and security scare

Notwithstanding the support in all sphere, favorable conditions and opportunities, as expected of a new initiative such as OA, there are several threats and challenges that could constraint or slow a full conversion.

As a resource-poor country, and being the smallest economy in the world (RGOB 2013), food self-sufficiency and security is an important concern for Bhutan. Food self-sufficiency defined in Bhutan's context is the capacity to meet the food requirements from the country's own production rather than from external purchase. Food security as defined by the FAO is the physical and economic access to sufficient, safe and nutritious food that meets a person's dietary needs and food preferences for an active and healthy life (FAO 2013).

The definitions of food self-sufficiency and food security make clear distinction between the two terms. While the focus of the former is on "own production" the latter is concerned more with "access", whether through domestic production or through import. Both are important, but which is more realistic given the host of constraints that agriculture in Bhutan faces? Can Bhutan produce enough food at all times? If not should Bhutan focus on high value low volume production so that the revenue generated from export can be used to meet the deficit through imports?

But what will be the long-term implications of dependence on import, especially of food? Not only quality even price of imported food will be hard to predict because too many actors influence global food markets and supplies. Natural calamities and conflicts are other factors that add to the risk of over-dependence on import more so for a poor landlocked country like Bhutan. The risk further increases if the total debt of the country, which is ironically above its GDP by 8% (NSB 2013), is to be factored in. So eventually to ensure reliability in supply, quality and price domestic production would be the best option. Moreover as a largely agrarian nation with a small population and with pristine environment, adequate water resource and varied agro-ecological zones, Bhutan has many favorable prerequisites for food production and hence could opt for more domestic production, particularly organic production.

However, there is a general fear amongst experts that switching to OA could compromise food self-sufficiency and the food security goal of the country, because OA in Bhutan like elsewhere is largely seen to lower crop productivity. Leu, as cited by Barclay (2012), also noted that some senior agriculturists in the Ministry of Agriculture and Forests are skeptical about converting to OA. But the present two-year comparative study conducted as part of this research shows no significant difference between the yields of organic and conventional paddy. Moreover, because to a large extent the production management and cultural practices of both OA and CA in Bhutan are very similar, yield differences between OA and CA in other crops may also be negligible, unless if intervened.

However, (low) yield alone is not the cause of lack of food self-sufficiency and security (Jahanban and Davari 2013). A UNDP report states that besides low productivity, household food security in Bhutan is influenced by and linked to several factors such as “limited access to land and other productive assets, extensive crop destruction by wildlife, lack of alternative rural employment, farm labor shortage, poor food utilization and weak access to road and transport infrastructure” (UNDP 2008).

This study cannot exhaustively explore the food self-sufficiency issue because, as alluded to above, it is dependent on several factors and actors and detailing each of these may dilute the focus of this study. Thus the narrative on this complex issue in this study is kept broad and generic.

Generally the debate on food self-sufficiency should first underscore the need to ascertain the landholding of individual farming households or their access to production assets such as productive agricultural land. Bhutan has only 2.9% of the total available land under agriculture, which works out to be 0.16 ha per capita landholding, that is, if the total agricultural land of 112,550 ha is to be divided amongst its population of about 700,000. This already meager agricultural landholding of 0.16 ha or a little of quarter of an acre is getting fragmented further due to the strong traditional land inheritance practice. Such small parcels of land may not be adequate and economically viable vis-à-vis rapidly rising cost of living and remoteness of many of these farms.

The landholding issue has a direct bearing on food self-sufficiency concerns of the government. Small parcels of land that farmers possess contribute lower amount to the overall food basket of a family or the country. Besides the drudgery of farming life, the small landholding size could also partly explain the unabated rural-urban migration trend.

In addition to smaller fragmented parcels of land, other factors working against food self-sufficiency goals include labor and dearth of irrigation facilities, rampant wildlife crop depredation and mountainous terrain. Inaccessibility of many of the farms and excessive postharvest losses of up to 30% or more in maize (Katwal 2013) and other crops (Pradhan et al. 2012) are other contributing factors in the complex matrix of food self-sufficiency.

Therefore, based on the UNDP report, it may be concluded that focusing on productivity alone to measure and achieve the food self-sufficiency goal may be parochial and misleading. The other factors as described above have to be factored in and addressed in tandem while addressing food security concerns (IFAD 2005; UNDP 2008).

The food self-sufficiency figures in Bhutan are sketchy, and the latest figure is of 2011, which is maintained by the Ministry of Agriculture and Forests (RNR 2013) and the National Statistical Bureau (NSB 2013). The figures maintained by these institutions (Table 7.1) were calculated on the basis of SSR %[11] (Self-Sufficiency Rate) and IDR %[12] (Import Dependency Rate). As of 2011, overall SSR of Bhutan is 85% against 25% of IDR, which is a good indication. But this

[11] SSR = (Production/Production + Imports - Exports) x 100

[12] IDR = (Import/Production + Imports – Exports) x 100

figure is due to the high contribution from vegetables and fruits SSRs of 112% and 230%, respectively against only 64% from cereals. The SSR of cereals such as rice and wheat are 53% and 69%, respectively (RNR 2013). IDR is the highest for cereals at 36% followed by livestock products at 15% (Table 7.1).

The deficit is met from imports, mainly from India, and most, if not all of the imported food, is conventionally produced. This presents a paradoxical dilemma in that while domestically produced organic food is exported, most if not all imported food comes from conventional production. This mismatch of inorganic food import and organic food export has to be balanced. How this dilemma can be addressed needs a separate study and a separate debate.

Table 7.1: Food Self-Sufficiency Rate (SSR) and Import Dependency Rate (IDR)

SSR (%)						IDR (%)				
Year	**Cereals**	**Vegs.**	**Fruits**	**Livestock products**	**Total**	**Cereals**	**Vegs.**	**Fruits**	**Livestock products**	**Total**
2008	66	103	254	71	85	35	11	3	29	28
2009	61	116	205	59	83	39	11	2	41	34
2010	63	110	150	76	85	37	12	2	24	28
2011	64	112	130	85	85	36	11	1	15	25
2012*	69	118	122	85	86	31	11	1	15	23

Source: RNR (2013)

*Forecast

The experience on OA gathered from around the world, particularly from developing countries, and smallholder family farms with which Bhutan share many commonalities suggest that OA would be in a better position to achieve food self-sufficiency and security. This is because OA is diversified, robust and low cost because of the exclusion of external inputs and energy (Lyons and Burch 2008; Nemes 2009; Leu 2011b), and they are easy to manage and care.

Whether or not the yields of OA will be comparable to those of CA merits concern, but at least in paddy rice and under the existing farmers' management practices as evidenced by this study, there is no significant difference. Yield to a large extent, keeping other factors constant, depends on farming practices adopted by the farmers (Badgley and Perfecto 2007). Good management practices can not only enhance yield, but can also avert much of the pest and disease incidences, which are of growing concern owing particularly to the lack of viable plant protection interventions in Bhutan. This is discussed below.

7.4.2 Weeds, pests and diseases incidences

Weed pressure, pest attack and disease outbreaks are important constraints and a constant challenge for both organic and conventional farmers. A severe weed, pest and disease (WPD) problem can significantly compromise yield and quality. Some allege that this problem will be heightened in OA, which is not necessarily true.

The mere presence of WPD is not likely to be damaging because these are natural components of agricultural fields (Rivera 2004; Norton et al. 2010). Arguably, they cannot be completely controlled (in other words eradicated), and hence the term control in WPD is replaced by management.

Unlike in diversified fields as encouraged by OA, monocropping typically practiced in CA encourages the build-up of a wide range of WPD (Crowder et al. 2010; Katwal 2013). In traditional monocropping such as paddy, organic farmers can resort to resistant varieties, clean culture[13] and timely management practices to reduce WPD pressure. In diversified fields, it is argued that most WPD can be self-regulated or "kept in check by natural forces". These forces may be predators and allelo-chemicals among others (Thimmaiah 2007). Sound management regimes and cultural methods as practiced in OA can also help to suppress WPD (Ramet et al. 2002). Management and cultural practices include mixed species cropping, trap cropping (such as in the push-pull approach), crop rotation, use of resistant/ tolerant varieties, clean culture, hilling up, deep-plowing, flooding, mulching and timely planting, amongst others (Bàrberi 2002;

[13] Practice of growing crops by keeping soil free of competing plants through the use of mulches or growing crops on raised beds such that raindrops do not bounce back from the soil to the crop, thus limiting the spread of soil-borne pathogens

Altieri and Nicholls 2003). These management practices can be used in isolation or in combination depending on the situation, because WPD can be unique and location specific.

Organic agriculture also employs biological control to manage WPD. This method uses beneficial organisms to manage WPD (Wyss 2011). For weed management, insects and pathogens are used. For pest management, predators (lady beetles and lacewings), parasitoids (of many wasp species, and some flies) and arthropod pathogens are used. For disease management, antagonists are used (Hoffman and Fordsham 1993).

Other options to manage WPD in OA are the use of botanicals (plant extracts) and bio-pesticides such as the concoction of canola oil and baking soda that have pesticidal effects. The most commonly used botanicals in Bhutan are neem (*Azadirachta indica* A. Juss [Meliaceae]) oil, jeevatu (introduced from Nepal) and various blends of chili powder with garlic or prickly-ash (*Zanthoxylum americanum* Mill. [Rutaceae]). Artemisia (*Artemisia* spp. [Asteraceae]) is also widely used. All these plants are locally available in abundance.

The major WPD problems in Bhutan, as expected, are associated mainly with mono-cropping or those crops cultivated alone on fairly large scales. These crops include paddy (weeds and rice blast), potato (weeds and late blight, *Phytophthora infestans* [Mont.] De Bary [Phytiaceae]), maize (grey leaf spot, *Cercospora zeae-maydis* Tehon & E.Y. Daniels [Mycosphaerellaceae]), cardamom (wilt), apple (scab and rust), citrus (citrus greening) and chili (blight and fruit borer) (Dorji 1999; Katwal 2013). The problems associated with these crops continue to exist despite the availability of synthetic chemical pesticides and the development of tolerant varieties in the case of rice blast and maize grey leaf spot. As pointed out in Chapter 3, this is because of poor management practices and low rate of adoption of improved varieties. Further research is needed to identify and address the cause(s) of low adoption rates as well as to further improve WPD management practices under OA.

7.4.3 Limited sources of organic fertilizers

In the group discussion on the constraints of OA, a few of the experts pointed out that limited sources of organic fertilizers could constrain the success of OA in Bhutan, as organic farming requires huge quantities of biomass. In reality, this assumption may be misguided. As pointed out earlier, most farms are integrated and hence possess a few heads of farm animals. Other than dung, cattle urine is not commonly used in Bhutanese farms. Urine is rich in plant nutrients with about 6.8 to 21.1 g N L^{-1} (Singh et al. 2014). There are special techniques developed to collect and store urine for various uses (Thimmaiah 2007).

Forests, which are all located near to the farms, form a rich source of biomass and have continued to play an important role in supplying crop manure (Roder et al. 2003; Chhetri et al. 2012). Plant and crop waste that is currently lost in huge quantities instead of being composted and returned to the farms could be another alternative source. However, in this context labor, which is in short supply, remains a challenge to be addressed first.

Further, sound crop rotation with legumes or green manuring as practiced in isolated pockets of the country where water and labor are available, can also supply appreciable amounts of plant nutrients, especially N. There is a vast corpus of literature documenting the success of incorporating adequate N through the use of legumes, and other cropping practices and green manuring (Tilman 1998; Sullivan 2003; O'Dea et al. 2013).

Instead of depending only on cow manure or crop rotation combining these with cow urine, poultry manure and crop residues and practices such as mulching and green manuring would greatly help ease the burden of organic fertilizer needs or excessive reliance on only one plant nutrient source or practice. Multiplicity of resources and approaches, as highlighted above, are available to substitute or combine in meeting organic fertilizer needs.

It is anticipated that OA promotion could open up opportunities in not only meaningfully reusing local biomass waste and natural resources in a sustainable manner, but may also help in developing local organic manure production and supply enterprises. Vermicomposting (using earthworms), which started in the southern district of Samtse in late 2013, could lead the way in this regard. The initiative piloted by the National Organic Program was to explore the feasibility of production as well as to gauge the reaction and interest of farmers in producing and using vermicompost before venturing into commercialization (Tshomo 2014).

7.4.4 Lack of clarity in policy

One final issue raised by the experts' group was the ambiguity of the policy framework in promoting OA vis-à-vis CA. However, a deeper analysis reveals that important tools to promote OA have already been instituted. These include the establishment of the National Organic Program and the Technical Working Group, while standards for OA and an Internal Control System are in the last stages of finalization at the time of this research.

Equally important, many other policies that favor OA have already been put in place. These include: (i) The Forests and Nature Conservation Act of Bhutan (1995); (ii) The Biodiversity Act (2004); (iii) The Pesticide Act of Bhutan (2000); (iv) The Water Act of Bhutan (2011); (v) The Community Based Natural Resources Management Framework of Bhutan (2002); (vi) The Cooperatives Act of Bhutan (2001); (vii) The Non-governmental Organization Act of Bhutan (2001); and (viii) The Food Act of Bhutan (2005). The main goals of these acts are to achieve sustainability, equity, safety, empowerment and self-reliance, all of which are in line with the goals of OA.

What is crucially missing, perhaps, is proper coordination between concerned agencies and implementers regarding consensus building on roles and rights, resource sharing and ultimate aspirations of the respective agencies. The acts and policies by nature are constrained to dwell on the specifics and details on how a goal has to or should be achieved. Therefore, it can be argued that the commitment lies with the concerned institutions to proactively arm themselves with their respective acts and statutes to formulate practical approaches and plans to implement the aspirations expected of them.

Put differently, new policies need not always emanate from the government. Based on the ground realities and emerging needs, these can be promoted by those implementing institutions for the government's endorsement. It helps that OA in Bhutan enjoys a strong and open political support. It has a privileged stature albeit given certain quarters that view it with some degree of skepticism. This quandary is discussed below.

7.5 Missing link in debate on promotion of organic agriculture

Most experts (94%) expressed that Bhutan should promote OA, but only 36% remained optimistic that Bhutan can successfully transit to a fully organic country.

The focus of debate on the promotion of OA in Bhutan seems to be more on the weaknesses and threats than on opportunities and prospects. Whilst such a focus has certain advantages, it could also potentially depict a negative image that could cloud the prospects and thereby deter the effort to go fully organic.

From the weaknesses and threats perspectives, the arguments are focused more on short-term gains, such as achieving food self-sufficiency and security through reliance on SACs. Notwithstanding all these SACs are imported, the arguments assume that these tend to be the only key to growth in crop productivity, as well as an antidote to all plant protection problems. In other words, the arguments myopically assume that if SACs are shunned, crop productivity will automatically slump and pests and diseases will go rampant. Thus food security will be compromised.

Although the debate acknowledges that SACs are inherently toxic (Caspari et al. 2004), what is missing in this line of argument is the future sustainability of agriculture itself, and the fact that it leads to the creation of long-term dependence on agricultural imports. The debate also implicitly takes for granted ecosystem integrity and ecosystem services. The pristine environment and the rich biodiversity that Bhutan enjoys today could be in large part linked to the negligible import and use of SACs, combined with the traditional practices of small farms. The impacts of SACs on ecosystems in Bhutan have not been studied, but those small groups of farmers who have been using SACs complain of their soils getting harder and more parch each year. They also report that paddy straws from conventional farms are lighter than those from organic farms.

There are several other similar anecdotal accounts of the unexpected effects attributed to the use of SACs. Behind these anecdotal evidences it is important to recall that conventional farmers in Bhutan use comparatively less SACs both in type and quantity because either these are not available or are not affordable, besides farming being less intensive, the need for SACs is not very substantial unlike elsewhere.

The import and heavy reliance on SACs could not only damage environment but also make farming more expensive, which could beholden and imprison farmers in a continuous vicious cycle of debt and repayment as happened and is happening in many parts of the world. The widely publicized suicides of CA farmers in India are a grim reminder of farming challenge and expose fragilities of modern farming.

Therefore, the debate on whether or not Bhutan should convert to a fully OA country merits a careful and holistic perspective hinged on sustainability dimensions of socio-economic and environmental factors as these are the cornerstone of the GNH paradigm. Stereotyping OA as a crude passé practice that yield less with more investment and more pests and diseases acutely falls short of understanding OA and its working and thus this debate should engage in revisiting and internalizing the whole concept and philosophies of OA.

The other important fact missing from the debate is that organic amendments not only supply plant nutrients, but they also prevent certain pests and diseases (Littericka et al. 2004). Besides, they enhance microbial activities and soil structure formation, which is important for a number of essential soil functions such as water holding capacity and better aeration.

7.6 Suggested interventions and way forward

The Royal Government of Bhutan wants to promote OA and aspires to convert to a fully organic country. However, some agriculture experts remain skeptic, reflecting the fact that they were trained in CA. Although these experts acknowledge the benefits of OA, they remain pessimistic about Bhutan's ability to phase out CA. Notwithstanding the pervading pessimism and its dissenting voices, this study shows that the performance of OA and CA is comparable thus presenting good prospects for Bhutan in its quest to convert its entire agriculture to fully organic.

The conversion process is already taking place on the ground, albeit gradually. The experience from this ongoing process, which is also highlighted in this study, show that much of the challenges that OA is confronted with are similar to those ailing CA. Therefore, whilst there is no one magic bullet solution to successfully implement an entirely organic system of production, it can be argued that first these challenges must be addressed. This intervention must be simultaneously complemented by multiple initiatives, because farming per se is a conglomerate of activities, players and stakeholders that operate and sway under the influence(s) of their respective forces.

Simply put, farming is unarguably a cross-cutting sector that is dependent on several factors, many of which are beyond its control. These myriad of external factors that directly or indirectly impinge on the outcome and success of farming must be considered in strategizing interventions. But the caveat here is the complexity in harmonizing and synchronizing these various externalities.

Therefore, the solution or the roadmap to successfully achieving conversion to full organic production is not straightforward, and it cannot be encapsulated in a few paragraphs' narrative. Even so a few critical interventions are simplified and suggested below, which should be integrated with some of the elements highlighted under the strengths/ opportunities and threats/ challenges sections in this chapter.

7.6.1 Training and creation of more awareness

Organic agriculture is knowledge-intensive and takes into account the whole farm (Giovannucci 2007). Therefore, capacities of farmers and those engaged in organic farming activities have to be built through comprehensive training. Training and capacity building processes should focus on a diversified production system from soil nutrient management to plant protection and allied specialized production and intercultural practices. Emphasis should be on hands-on training and competencies and skills development in day-to-day farm operations based on specific requirements. Whole-packaged training as followed in the Renewal Natural Resources Research Development Centre (RNR RDC) Wengkhar, Mongar and follow-up training and mentoring instead of one-off training yield more tangible benefits.

Academic institutions should also play a more proactive role and assess training needs and accordingly conduct tailor-made trainings for specific target groups. The academic institutions should also partner with regional and global organic institutions to update on new developments as well as to share and learn from each other's experiences.

Developing appropriate training manuals and extension guides on relevant issues and making these available to needy groups is important. Besides providing knowledge such guides can also serve as a reminder of the lessons.

Although farmers and consumers are gradually becoming aware of the benefits of OA, the campaign and education to raise more awareness should be continued and stepped up. Visits of students to organic farms should be encouraged, facilitated and better organized so that the students gain better insight into the workings and benefits of OA. Organic Fairs and an Organic Day could also be institutionalized to flag off the importance and contribution of OA to rural livelihoods and sustainable resource utilization. Again, such education, awareness and sensitization activities should not be one-off activities, but should rather be sustained in more innovative ways and involve more members.

In this regard, the School Agriculture Program (SAP) that is instituted in various schools across the country is in the right direction. The SAP which is primarily organic farming based is expected to open up avenues for youths to learn, understand and appreciate OA better and also arm them with the necessary skills and knowledge to pursue a career in OA should some of them wish to do so.

7.6.2 Strengthen the organic market

A domestic organic market exists only in the capital city, Thimphu, and since mid-2014 in Bumthang (Central Bhutan, Fig. 7.1). However, these markets are rudimentary with limited items on sale.

Despite the domestic market opportunities, farmers find it difficult to market their produce. This is attributed to the low volume produced by the farmers, who are mainly smallholders, and many of whom are distantly located. It also does not help that local produce is comparatively expensive resulting from high labor wages and absence of economies of scale.

This then calls for improving accessibility or improving producer-consumer linkages in tandem with farmers' group and cooperative formation so that volumes can be increased to meet market demand, as well as to cover the expenses incurred in accessing the market.

The farmers’ group and cooperative formation spearheaded by the Department of Agricultural Marketing and Cooperatives under the MoAF should be continued. The initiative seems to be doing very well.

Figure 7.1: Organic market in Bumthang

Market infrastructures need to be enhanced. Building these at strategic locations at both local and national level could facilitate easier and direct meeting of producers and consumers. Such infrastructures could be built at cheaper rate if they are kept simple and local materials are used.

Market infrastructure has to be complemented with quick and reliable market information. The ongoing market information transmission through radio and the web has to be further augmented through the use of mobile phone applications as widely practiced in many parts of Africa, India and Bangladesh.

Market research, especially for export-import, is crucial to not only boost domestic production but also to lessen burden through availing products that are comparatively cheaper and are of assured quality. Thus research should extend beyond market workings as discussed below.

7.6.3 Research and Development

The experts agreed that the research culture in Bhutan is weak and limited. This has also been pointed out by Neuhoff et al. (2014). Recognizing that research is crucial for innovation and problem-solving commensurate priority should be accorded to investing in research. Despite the prevailing funding constraints, research should be prioritized. The priority areas of research in organic farming for Bhutan include (i) crop breeding for robustness in order to strengthen resilience of organic farming systems, (ii) soil fertility improvement and maintenance, (iii) cultural and biological practices to manage weeds, pests and diseases, and (iv) the development of plant protection agents such as bio-pesticides.

Globally organic plant breeding is in its nascent stage while in Bhutan it is yet to be initiated. As and when breeding starts, the focus of organic crop breeding in the Bhutanese context should be on genotypes that can adapt better to low inputs as well as other traits related to disease resistance/ tolerance against major pathogens such as rice blast, and potato blight. The breeding of traits that can tolerate climate change related issues such as drought or flooding would also be important. Other equally important traits in breeding that will be required include optimal productivity, weed suppression and pest resistance/ tolerance.

Besides seeds, soil and soil health is particularly important for OA, and hence it requires due consideration with regards to its improvement. The crucial research areas in soils for OA in Bhutan include (i) identifying suitable rotation crops in the different AEZs, (ii) developing practical means to conserve soil, (iii) identifying right mixes of organic amendments for various crops and soil types, (iv) improving organic manure production techniques, and (v) developing appropriate reduced or conservation tillage strategies technique(s).

Several studies in the above fields have been conducted outside the country. Therefore, to save the meager research funds, Bhutan could pick the relevant results obtained elsewhere and initiate validation and adaptive research so that appropriate technologies can be generated to suit Bhutan's own needs with shorter turn-over time and lower investment. However, in such studies, the scientists should engage other stakeholders such as farmers, NGOs, community-based organizations and extension agents, instead of working in isolation. Such a participatory and transdisciplinary approach could create ownership amongst the stakeholders and thereby increase the probability of adopting the successful technologies generated.

The research restricted to and within the country and among the country's researchers and scientists only would limit scope and output. Exploring, fostering and linking up with relevant regional and international institutions and scientists may help source the necessary research funds as well as help to bring about global implication.

7.7 Other interventions

Other interventions to boost agriculture production whether under OA or CA include irrigation infrastructure improvement and construction, farm mechanization, protection against wildlife depredation and road connectivity. These are all equally important but their priorities in different districts might differ. Some districts may already have good road connectivity but may lack irrigation infrastructure and so on. So assessing each district's specific needs and delivering on these needs based on prioritization of the more important ones would help to reap productive results from the limited resources available in the country.

It is beyond the scope of this study to detail each of the above listed infrastructures and facility development. Suffice to report here that these infrastructure and services are included in the current 11th Five Year Plan (2013-2018), and some progress in delivering these needs has been already made. It has been reported that 160 centers across the country have been established to hire powertillers at an affordable price (Pokhrel 2015). So far 200 km of electric fencing to ward off wild animals have also been put in place (Tshedup 2015).

In addition to providing above facilities, as suggested by Uematsu and Mishra (2012), exploring the feasibility of providing incentives to organic farmers in the initial years may contribute to hastening the adoption rate of organic farming. Incentives may be in the form of free farm equipment, farm animals, planting materials or subsidized transportation of inputs as practiced currently. The way forward is challenging as it often involves additional resources and has to consider all elements that shape farming policy and plans. As such, it is important to prioritize goals and activities and chalk out implementation plans that are aligned to be complementary with those plans that follow sequentially.

8 CONCLUSIONS

Across the developing countries, OA is promoted to enhance income, improve livelihoods and to make sustainable use of local resources. It is also seen as a viable alternative to CA, because it is seen as less damaging to human and animal health as well as to the health of ecosystems.

Growing awareness of the various benefits of OA and its sustainability principles prompted Bhutan to officially adopt OA in 2003. And because the principles of OA and the GNH philosophies institutionalized by Bhutan to measure its growth share much in common, in 2008, the Government of Bhutan declared its intension to shift to a fully organic country by 2020.

But there are many critics of OA who argue that OA is inefficient and does not yield as many benefits as CA in terms of yield and profit among others. However, this study, shows that under farmers' management practices there is no significant difference between paddy yields and the various soil properties of organic and conventional paddy rice fields. Similarly, except for the total labor costs, benefit-cost ratio, inputs cost and gross production cost, there is no significant difference between the economics (gross and net returns) of organic and conventional paddy production, even without a premium price for organic rice. Therefore, based on these findings, adopting OA in paddy rice production in Bhutan will reduce neither yield nor farm profit as widely cited in different literatures. If premium price for organic produce is factored in as practiced in the export or specialized markets then returns from organic rice would be much higher than returns from conventional rice.

Furthermore, experts agree that Bhutan possesses a considerable array of opportunities and strengths in promoting OA. However, they also concur that there are several threats and weaknesses, the majority of which are essentially not unique to OA alone. As such, most interventions to address challenges in CA will also benefit OA and vice-versa.

Therefore, on the basis of the results of this study which also include the findings from a detailed literature review, it can be concluded that under Bhutan's conditions with prevailing management conditions OA is as good as CA or one is not any better than the other. Performances of OA and CA in many aspects of social, economic and soil chemical show comparable results, and experts' views on promoting OA remain divided.

This finding further lends credence to the fact that adopting OA, as feared, may not necessarily, in the case of paddy rice, compromise the goal of food self-sufficiency and security. This could partly be extrapolated to other crops too, primarily because management practices and resource use in both OA and CA are almost similar. Food self-sufficiency does not depend on crop productivity alone. Other factors such as access to productive assets and labor force availability, access to road and employment opportunities equally affect food self-sufficiency goals, and hence these factors also need to be simultaneously investigated and addressed.

Because this study was conducted under farmers' management conditions, future research should investigate the outcome of comparative studies resulting from interventions of researchers, and broaden the scope to include the entire farm system together with environmental dimensions such as ground water pollution and biodiversity richness.

Moreover, how factors such as soil type, temperature and pH influence soil nutrient levels under Bhutan's conditions also require further investigation given the low nutrient contents of Bhutanese soils. Such nutrient replenishment plans suitable for Bhutanese farmers, together with sound management practices, will have to be developed to enhance crop productivity.

Finally in line with enhancing and maintaining optimal crop productivity objective plant protection as well as inadequacy of organic fertilizers issues being recurrent in this study may need prioritizing in the national research agenda so as to address Bhutan's aspiration to become a fully OA country. Additionally, efforts to enhance access to productive land, farm mechanization, irrigation infrastructure construction in potential areas and wildlife crop damage protection interventions should be given equal emphasis in order to enhance crop production and achieve food self-sufficiency and security, be it through OA or CA.

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10 APPENDICES

10.1 Appendix 1 : Four principles of organic farming

1. Principle of Health	Organic agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.
2. Principle of Ecology	Organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.
3. Principle of Fairness	Organic agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.
4. Principle of Care	Organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

Source: IFOAM, Principles of Organic Agriculture (http://www.ifoam.org/en/organic-landmarks/principles-organic-agriculture)

10.2 Appendix 2: Fertilizer recommendation for paddy in selected region (kg ha^{-1})

Local variety			
Location	N	P	K
Gelephu	79	49	20
Paro	69	40	40
Punakha	69	40	35
Thimphu	74	40	30
Trongsa	59	35	20
Tsirang	89	40	20
Wangdue	59	35	35
High-yielding variety			
	N	P	K
Gelephu	79	49	30
Paro	79	49	20
Punakha	79	40	20
Thimphu	79	49	20
Tsirang	89	59	30
Wangdue	79	49	20

Source: NSSC (2009)

10.3 Appendix 3: Water depth for different growth stages of paddy crop

Stage	Sub-stage	Water level
Vegetative	Germination	Moist
	Seedling	Moist or 2-3 cm
	Tillering	2 -5 cm
	Stem elongation	3 -5 cm
Reproductive	Panicle initiation to booting	5 cm
	Heading	5 cm
	Flowering	5 cm
Ripening	Milk	2- 3 cm
	Dough	1 – 2 cm
	Mature	Drain water

Source: IRRI (2004)

10.4 Appendix 4: Methods used for the analysis of various soil parameters

Soil parameters	Methods
Total carbon (%)	Walkley and Black Wet Oxidation
Organic matter (%)	Walkley and Black Wet Oxidation
Total (N%)	Micro-Kjeldahl
Available P (mg kg^{-1})	Bray II
Exchangeable K (mg kg^{-1})	1 M Ammonium acetate extraction at pH 7
Exchangeable Ca (mg kg^{-1})	1 M Ammonium acetate extraction at pH 7
CEC (me 100 g^{-1})	1 M Ammonium acetate extraction at pH 7
pH	pH (1:2.5 soil:water)
Bulk density	Core method
Texture	Pipette method

10.5 Appendix 5A: Questionnaire form number – One (A) – Organic Farming

Section One -General characteristics of sample farmer

1. Farmer's background

Interviewee's name (Optional):	**Age :** (Tick) ☐ ≤ 30 ☐ 31-50 ☐ ≥51
Gender: (Tick) ☐ Male☐ Female	**Education :** (Tick) ☐ NFE ☐ Primary Education ☐ High School ☐ College ☐ None
Religion: (Tick) ☐ Buddhist ☐ Hindu ☐ Muslim ☐ Christian ☐ Others............	**Relation to the head of household:** (Tick) ☐ Wife ☐ Husband ☐ Father ☐ Mother ☐ Brother ☐ Sister ☐ Others
Age of household head : (Tick) ☐ ≤ 40 ☐ 41-60 ☐ ≥61	**No. of people living in the house:** ...
Education level of the household head: (Tick) ☐ NFE ☐ Primary Education ☐ High School ☐ College ☐ None	
No. of non-family* members living in the house:	**No. of household members above 18 years of age:**
No. of permanent farm labor :	**No. of casual farm labor:** ....

No. of family labor available :	**Male =**	**Female =**	**Children (age)**	
			13 -18 =	**≤12 =**

** Family = grandparents+parents+children+brother/sister-in-laws*

Section Two – Farm characteristics

2. Location

Village:	**No. of households in the village:**	**Geog:**
Dzongkhag:	**Altitude (masl):**	
Mean annual temperature (^{O}C):	**Mean annual rainfall (mm):**	

2.1. Operational holding under farming

Total farm size (Langdo):		**Average distance from field to home (km):**		
Land use type	**No. of fields**	**Area (Langdo)**	**Soil types**	**Crops grown**
Chuzhing				
Khamshing				
Others				

2.2. Land rental fee (Nu/Langdo/year)

For Chuzhing:	**For Khamshing:**	**For other type of land: Nu.**

2.3. Land ownership (Tick the appropriate response; tick more than one, if applicable)

□**Self-purchased**	□**Inherited**	□**Lease (rental)**	□**Share-cropping**	□**Others:**

2.4. Land inheritance and future

Will you distribute some part of your current farm land to your family members (as a separated household)?
Yes□ No □
If Yes, to whom will you distribute your land? (choose from the choice below)
□ 1st Son How much land?: ..... langdo, or ....% of the current farm size. When?
□ 2nd Son How much land?: ..... langdo, or ....% of the current farm size. When?
□ 3rd Son How much land?: ...... langdo, or ....% of the current farm size. When?
□ 1st Daughter How much land?: ..... langdo, or ....% of the current farm size. When?
□ 2nd Daughter How much land?: ...... langdo, or ....% of the current farm size. When?
□ 3rd Daughter How much land?: ...... langdo, or ....% of the current farm size. When?
□ Others: How much land?: ...... langdo, or ....% of the current farm size. When?

2.5. Fallow land

❖ **Do you leave any land fallow?** □Yes □No	
❖ **If Yes, how long have you been leaving your land fallow? (number of years):**	
❖ **If Yes, how much of the different land use type do you leave fallow? (Langdo)**	
Chuzhing: ....langdo OR .... % of your Chuzhing	Khamshing: ...... langdo OR ..... % of your Khamshing
Others: .... langdo OR ....% of current landholding	
For how many months a year do you leave your farmland fallow?	
Start and end of fallow period (Month): Start: ....;	**End :** ....
Reasons for leaving land fallow (Tick more than one, if applicable; "1" for Not Very Important, and "5" for Very Important).	

Reasons	**Rating of importance**				
Labor shortage	1	2	3	4	5
Water shortage	□	□	□	□	□
Inadequate resources	□	□	□	□	□
Scattered plots	□	□	□	□	□
Wild life threat	□	□	□	□	□
Already have adequate other sources of income	□	□	□	□	□
Lack of market	□	□	□	□	□
Unsuitable climatic condition	□	□	□	□	□

Allowing land to rest	☐	☐	☐	☐	☐
Others: …………………………………………………	☐	☐	☐	☐	☐
How much farmland in your village/community is left fallow? (Langdo):					

Section Three – Paddy production management practices and economics

3. Variety used

Rice variety	**Source** (Tick)	**Price (Nukg^{-1})**	**Total area under each variety (langdo)**	**Reason for preferring a given variety** (Tick more than one, if applicable)
	☐NSC ☐Alpine Bhutan ☐Self-saved ☐Neighbor ☐Others ………			☐High yield ☐Disease tolerant ☐Less pest attack ☐Faster growth ☐Good taste ☐ Easily available ☐Others ………………
	☐NSC ☐Alpine Bhutan ☐Self-saved ☐Neighbor ☐Others ………			☐High yield ☐Disease tolerant ☐Less pest attack ☐Faster growth ☐Good taste ☐ Easily available ☐Others ………………
	☐NSC ☐Alpine Bhutan ☐Self-saved ☐Neighbor ☐Others …….			☐High yield ☐Disease tolerant ☐Less pest attack ☐Faster growth ☐Good taste ☐ Easily available ☐Others ………………

3.1. Land preparation

Land preparation method	**Date**	**Area (langdo)**	**No. of man hours required**
☐Irrigate land (land soaking)			
☐Manual tilling			
☐Bullock tilling			Bullock use hr.:
☐Manual + bullock tilling			
☐Power tiller tilling			PTiller use hr.:
☐Others			
If bullock and power tiller are used, then what is the cost per day?			
For bullock (Nuday^{-1}) :	For power tiller (Nuday^{-1}). :		

3.2. Nursery raising

Method of raising nursery (Tick more than one, if applicable)	**Date**	**No. of man hours required**
☐Inside green house		
☐In open field		
☐Raised seed bed		
☐No raised seed bed		
☐Others:		
Nursery plot size (m^2):		**Seed quantity used (kg) :**
If green house (GH) is used, what is the total cost of green house? Nu.		
How old is your greenhouse? (Year):		

3.3. Transplanting

Method of transplanting (Tick)	**Date of transplanting**	**Area (Langdo)**	**No. of man hours required**
☐Direct sowing/broadcasting			
☐Line sowing			
☐Random sowing			
☐Machine sowing			
☐Others:			
Seedling age (days) :	**Seedling rate per hill:**	**Spacing (p-p, r-r) (cm):**	
Transplanting depth (cm) :			

3.4. Fertilizing

Fertilizer type	**Date**	**Area (langdo)**	**Qty. (Kg)**	**Methods of application** (Tick)			**No. of man hour required**
				Broadcast	**Drill**	**Incorporate**	
Manure*				☐	☐	☐	
FYM				☐	☐	☐	
Compost				☐	☐	☐	
Leaf litter				☐	☐	☐	
Others				☐	☐	☐	

**Animal dung; Please specify which animal it is:*

3.5. Plant protection

3.5.1. Disease

What disease infested your paddy?	**% infestation**	**Control measures**	**No. of man hour required to control**
Rice blast			
Sheath blight			
Brown spot			
Bacterial leaf blight			
Seedling damping off			
Others			

3.5.2. Pests

Pest name	% occurrence	Control measures	No. of man hour required to control
Stem borer			
Army worm			
Case worm			
Whorl maggot			
Rice bugs			
White-backed hopper			
Brown plant hopper			
Others			

3.5.3. Weeds

Weed name	% infestation	Control measures	No. of man hour required
Sochum (*Potamogeton distinctus*)			
Total number of weedings from transplanting to harvest:			

3.6. Irrigation

Irrigation method (Tick relevant method)	**Date**	**Duration during each irrigation (hr.)**	**No. of man hour required**
□Flooding			
□Basin			
□Rainfall			
□Other …………………….			

3.7. Harvesting

Method of harvesting (Tick relevant method)	**Date**	**No. of man hour required**
□Manual		
□Machine		

3.8. Threshing

Method of threshing(Tick relevant method)	**Date**	**No. of man hour required**
□Manual threshing		
□Animal threshing		
□Animal + manual threshing		
□Machine threshing		
Do you thresh all your harvest in one go? □ Yes □ No		

3.9. Yield and Production

Paddy area this season (acre):	**Paddy area last season (acre):**
Total production this season (t) :	**Total production this season (t):**
Yield this season (tacre^{-1}): …………….	**Yield last season (tacre^{-1})**: ……………..

3.10. Price

Price in different markets (NuKg^{-1}*)				
Farm gate	**Local market**	**Weekend market**	**Distant market ****	**Export** (to be filled by interviewer)
Sell: ………..	Sell: ………..	Sell: ………..	Sell: ………..	
Buy: …………	Buy: …………	Buy:………….	Buy: ………….	

** Put affix (u) for un-pilled rice grains, and (p) for pilled rice grains*
***distant market refers to markets beyond 40 km*

3.11. Seed saving

Do you save your own seeds : ☐ Yes ☐ No	
Reasons for saving seeds:	**Reasons for NOT saving seeds:**
Are the saved seeds enough? ☐ Yes ☐ No	

Section Four – Organic farming

4. When did you first hear about OF? (Year) : ……………….

4.1. From whom did you first hear about organic farming? (Tick appropriate response; tick only one)

☐Radio	☐Govt. officials	☐Neighbors	☐TV	☐Newspapers
☐NGOs	☐Others (Please specify):			

4.2. Since when did you first start organic farming? (Year) ……………………

4.3. Briefly describe your understanding of organic farming:…………………………………………….

4.4. Reason(s) for adopting or switching to OF (Tick more than one answer, if relevant; "1" for Not Very Important: and "5" for Very Important).

Reasons	**1**	**2**	**3**	**4**	**5**
Push from govt.	☐	☐	☐	☐	☐
For health benefits	☐	☐	☐	☐	☐
Because of premium price	☐	☐	☐	☐	☐
Concern for environment	☐	☐	☐	☐	☐
Just following the trend	☐	☐	☐	☐	☐
Push from NGO	☐	☐	☐	☐	☐
Ease of farming	☐	☐	☐	☐	☐
Yield is consistent	☐	☐	☐	☐	☐
More support available readily	☐	☐	☐	☐	☐
Concern for sustainability	☐	☐	☐	☐	☐
Inherited practice from elders	☐	☐	☐	☐	☐
OF is low cost	☐	☐	☐	☐	☐
Others	☐	☐	☐	☐	☐

4.5. What do you like most about OF? ……………………………………………………………………………

4.5.1. What do you dislike most about OF?……………………………………………………………………

4.6. In general, how do you maintain the health and the fertility of soil?………………………

4.7. Training details

Did you receive any training on OF? ☐ Yes ☐ No	
If Yes, How many trainings did you attend so far? …………	
How long was each training? (Days) ………………..	
Where was the training conducted? ……………………….. ; ………………………..; ………………………	
Who provided the training? …………………………………………………………………………………………	

4.7.1. What areas of OF do you think you lack knowledge on?…………………………………………

4.8. What constraints you and your community face while practicing OF?

Categories	Constraints
☐**Production**	
☐**Marketing**	
☐**Postharvest**	
☐**Others**	

4.9. Support services

4.9.1. Did you get any support for adopting/switching to OF?☐ Yes ☐ No
If Yes, tick one or more from the options provided below, if relevant.

☐Training	☐Soft loan	☐Free inputs	☐Free equipment	☐Technical backstop
☐Others:				

4.9.2. If No, what support would be most beneficial? (Tick one or more, if relevant, "1" for Not Very Important and "5" Very Important)

Support	**1**	**2**	**3**	**4**	**5**
Training	☐	☐	☐	☐	☐
Soft loan	☐	☐	☐	☐	☐
Free inputs	☐	☐	☐	☐	☐
Free equipment	☐	☐	☐	☐	☐
Technical backstop	☐	☐	☐	☐	☐
Others (please specify)	☐	☐	☐	☐	☐

4.10. Perceptions about organic farming

4.10.1. Do you think OF really has a good future in Bhutan?☐ Yes ☐ No

4.10.2. If Yes, what are the most promising aspects of OF?……………………………

4.10.3. If No, what are the killing constraints of OF?…………………………………………………

4.11. Certification

4.11.1. Do you have organic certificate? ☐ Yes ☐ No

4.11.2. If Yes, provide the following information:

Year of certification	Certifying agency	Certification fee

4.11.3. If No, do you intend to apply for certificate in the future?☐ Yes ☐ No

4.12. Have you registered as organic grower? : ☐ Yes ☐ No

4.12. 1. If No, what is(are) the reason(s)? (Tick more than one reason, if relevant)

☐Lack awareness	☐Can't follow the registration procedure	☐Registration facility not readily accessible	☐Happy without registration
☐Registration may make any difference	☐Wait for sometime	☐Others (Please specify)	

Section Five – Women's contribution to paddy production

5.1. Is there a difference between the wages of men and women?	☐ Yes ☐No
If, Yes, how much is the difference: Nu ………..	
If Yes, what is reasons for the difference? …………….	

5.2. Women's contribution to paddy production as compared to men (in %)					
Ploughing		**Puddling**		**Nursery raising**	
Transplanting		**Irrigation**		**Fertilizer transport**	
Weeding		**Plant protection**		**Harvesting**	
Threshing		**Winnowing**		**Others**	

Section Six – Cropping practice and Livestock

5. Crop rotation

1st year		2nd year		3rd year	
1st crop	2nd crop	1st crop	2nd crop	1st crop	2nd crop

5.1. Cropping sequence in the field used for this study

		Reasons for choosing these crops
Crops grown last season in the field under study :		
Crops grown before last season in the field under study :		
Crops that will be grown after this harvest :		

5.2. Crop diversification

		Reasons for choosing these crops
Crops grown under multiple cropping :		
Crops grown in intercropping :		

5.3. Livestock

Animal species	Number of breeds	
	Improved	Local

5.4. Reasons for keeping livestock (Rank "1" for Not Important and "5" Very Important

Reasons	Ranking importance				
	1	2	3	4	5
Draught purposes	☐	☐	☐	☐	☐
Manure	☐	☐	☐	☐	☐
Porter	☐	☐	☐	☐	☐
Milk	☐	☐	☐	☐	☐
Egg	☐	☐	☐	☐	☐
Meat	☐	☐	☐	☐	☐
Others:	☐	☐	☐	☐	☐

5.5. Costs and benefits from livestock

Animal species	Costs of rearing (Nu/livestock)	Net return (Nu/livestock)	Rearing condition (Tick one response)				
			☐V. easy	☐ Easy	☐ Mod.	☐ Difficult	☐V. difficult
			☐V. easy	☐ Easy	☐ Mod.	☐ Difficult	☐V. difficult

Section Seven – Impacts of conversion to OF

6. Crop production

Crops	Area size (Langdo)	Sowing dates	Harvesting dates	Quantity of manure (kg)	No. of weeding	No. of irrigation	Mulching (Y/N)

6.1. Yield (Specify percent change or tick "No change" if appropriate)

After conversion, crop yield:	% increased =	% decreased =	No change
Reason(s) for the above answer:			

6.2. Production costs (Specify percent change or tick "No change" if appropriate)

After conversion, production costs have:	% increased =	% Decreased =	No change
Reason(s) for the above answer:			

6.3. Inputs (Specify percent change or tick "No change" if appropriate)

Inputs costs under OF as compared to CF are:	% higher =	% lower =	No change
Reason(s) for the above answer:			

6.3.1. Inputs used in the farm

Inputs	Unit	Quantity	Annual Expenditure (Nu)	Input source
Manure	Kg			
Leaf litters	Kg			
FYM	Kg			
Compost	Kg			
Seeds	gm			
Seedlings	No.			
Others				

6.4. Do you generate adequate organic fertilizers from your farm? □ Yes □ No

6.4.1. If No, answer the following:

Types of organic fertilizer	Source of organic fertilizers	*Quantity used (kg)	Price ($Nukg^{-1}$)
FYM			
Compost			
Manure (cow, horse, chicken, hog, etc.)			
Leaf litter			
Straw			
Others:			

**used in a year*

6. 5.Incomeand expenditure

6.5.1. Income from Agriculture (Specify percent change or tick "No change" if appropriate)

Income from crop production under OF as compared to CF:	% increased =	% decreased =	No change
Reason(s) for the above answer:			

6.5.2. Income from Livestock (Specify percent change or tick "No change" if appropriate)

Income from livestock production under OF as compared to CF:	% increased =	% decreased =	No change
Reason(s) for the above answer:			

6.5.3. Major sources of income

Sources of income		Average annual income (Nu)
Agriculture	□Vegetables	
	□Fruits	
	□Cereals	
	□Straw	
	□Seeds/Seedlings	
Livestock	□Milk	
	□Meat	
	□Egg	
	□Animal manure	
Off-farm		
Remittance		
Wild collection		
Others:		

6.6. Asset (Specify percent change or tick "No change" if appropriate)

After conversion to OF:	% increased =	% decreased =	No change
land holding			
livestock population			

6.6.1. Additional asset

Did you purchase any such asset that you think is because of the income from OF? If Yes, give details.		
Items	**Year of purchase**	**Approximate worth (Nu)**

6.7. Major expenses

Items	Average annual expenditure (Nu)
□Food	
□Clothing	
*□Education of children	
□Annual *Puja*	
□Travel	
□Medical	
□Donations	
□Taxes	
□Insurances	
□Others	

***specify the number of school going children:**

6.8. Food self-sufficiency (Tick appropriate response)

Food self-sufficiency under OF as compared to CF has :	□**Increased**	□**Decreased**	□**No change**
Reason(s) for the above answer:			

6.8.1. How much percent does production from your farm meet the food demand of your household?

□**10-20%**	□**21-40 %**	□**41-60%**	□**61-80%**	□**81-100%**
Reason(s) for the above answer:				

6.8.2. Food purchase

Do you purchase food?:□Yes□ No		
Type of food purchased	**Is it possible to produce in your field the food that you purchase? (Y/N)**	**Average monthly expenses on purchased food (Nu)**

6.8.3. Nutritional requirement (Specify percent change or tick "No change" if appropriate)

Access to nutritious and diverse food under OF as compared to CF has:	**Increased**	**No change**	**Decreased**
Reason(s) for the above answer:			

6.9. Work load (Specify percent change or tick "No change" if appropriate)

After conversion to OF, workload:	**% increase =**	**% decrease =**	**Same**
Reason(s) for the above answer:			

6.10. Employment and labor opportunity (Specify percent change or tick "No change," if appropriate)

After conversion to OF,	**% increased =**	**% decreased =**	**No change**
employment opportunity			
labor wage			
male to female labor ratio			

6.11. Soil health

Have you noticed any change in soil characteristics after conversion to OF? □ Yes □ No
If Yes, please describe the change(s):

6.12. Plant and animal health (Tick only one appropriate response)

Health of organically grown crops as compared to conventionally grown crops are : (Tick)	□**V. good**	□**Good**	□**Same**	□**Poor**	□**V. poor**
Reason(s) for the above answer:					
Health of organically reared animals as compared to conventionally reared animals is: (Tick)	□**V. good**	□**Good**	□**Same**	□**Poor**	□**V. poor**
Reason(s) for the above answer:					

6.13. Diseases, pests incidence and weed pressure (Tick appropriate response)

	Diseases			Pests incidence			Weed pressure		
Organically managed fields as compared to conventionally managed fields have:	☐M	☐L	☐S	☐M	☐L	☐S	☐M	☐L	☐S
Reason(s) for the above answer:									

M= More; L = Less; Same = Same

6.14. Crop protection

Crops	Pests		Disease incidence	
	Types of pest	Control measure	Types of disease	Control measure

Section Eight – Market

7. Market and price

7. Where do you normally sell your produce? (Tick more than one market, if relevant)

Market parameters	On farm	Roadside	Weekend market	Distant market	Export
Produce sale outlet	☐	☐	☐	☐	☐
Reasons for choosing a particular market	☐	☐	☐	☐	☐
Distance to market (Km)	☐	☐	☐	☐	☐
% of produce sold in different markets	☐	☐	☐	☐	☐
Cost of transportation (Nu)	☐	☐	☐	☐	☐

7.1. Mode of sale (Tick more than on marketing mode, if relevant)

☐Direct	☐Middleman	☐Customer come to pick	☐Others (Please specify):…

7.2. Price in different markets

Produce	Price in different markets (Nu/Kg)				
	On farm	Roadside	Weekend market	Distant market	Export
Paddy					
Potato					

7.3. Do you get any premium price for your produce?* ☐ Yes ☐ No

Section Nine – Community background

8. Community background

8.1. Total population of your community: …………………

8.2. Community level information (Tick the appropriate response)

Parameters	Strongly agree	Agree	Don't know	Disagree	Strongly disagree
Farmland in my community has decreased in the last 10 years.	☐	☐	☐	☐	☐
Willingness of community members to help in farming chorus has decreased in the last 10 years.	☐	☐	☐	☐	☐
Willingness of community members to assist in chorus other than farming has decreased in the last 10 years.	☐	☐	☐	☐	☐
Attractiveness of my community compared to other communities has decreased in the last 10 years.	☐	☐	☐	☐	☐
Economic prosperity of my community has improved in the last 10 years.	☐	☐	☐	☐	☐
Education level of my community has increased in the last 10 years.	☐	☐	☐	☐	☐
My community strongly believes in religion.	☐	☐	☐	☐	☐
Men and women share same work load in my community.	☐	☐	☐	☐	☐
No. of female as head of household is more in my community.	☐	☐	☐	☐	☐
No. of divorces has increased in the last 10 years in my community.	☐	☐	☐	☐	☐
There is conflict in resource sharing in my community.	☐	☐	☐	☐	☐

8.3. How is conflict in the community resolved?…………………………………………………

Section Ten – Religion and traditional and local beliefs

9. Belief system

Do you work on auspicious days? ☐ Yes ☐No			
If Yes, reasons for working: (Tick more than one, if applicable)		**If No, reasons for NOT working:** (Tick more than one, if applicable)	
Don't believe in such belief	☐	It is sinful	☐
Work should not be postponed	☐	Many insects and other organisms get killed	☐
Is a waste of time	☐	Just following tradition passed	☐
Need genuine rest	☐	Will bring good harvest	☐
Others (please specify)	☐	Other (please specify)	☐

9.1. How many times a month do you visit a temple on an average?……………..

9.2. Is anyone from your family in monastic body, including lay monk?☐ Yes ☐No

9.3. What traditional beliefs related to farming are you aware of?…………………………….

9.4. Which of the one listed above do you follow?……………………………………………………….

Section Eleven – Future

10. Will your children continue to work in the farm 15 years from now?☐ Yes ☐No

10.1. Reason(s) for the above answer: **……………………………………………………………………………**

10.2. Land size (Tick appropriate response)

Parameters	Strongly agree	Agree	Don't know	Disagree	Strongly disagree
Farm size will decrease in the coming 10 years in my community.	☐	☐	☐	☐	☐
Land left to fallow will increase in the next 10 years.	☐	☐	☐	☐	☐
Wildlife threat to crop production will increase in the next 10 years.	☐	☐	☐	☐	☐
Farming will be more profitability in the next 10 years	☐	☐	☐	☐	☐

10.3. Twenty years from now, what do you think will be the size of your farm? (Specify percent change or tick "No change" if applicable)

% increase =	% Decrease =	No change
Reason(s) for the above answer:		

Section Twelve - Happiness and some final thoughts

11. Would you like to share any other experiences related to organic farming?……………

11.1. What is(are) the most difficult thing(s) as a farmer?…………………………………………

11.2. What is your one best experience as a farmer?…………………………………………………

11.3. If given a choice, which profession would you choose? (Tick only one appropriate response)

☐Doctor	☐Teacher	☐Monk	☐Army
☐Farmer	☐Business	☐Others:	

11.4. How would you define happiness?……………………………………………………………………

11.5. I am happy as a farmer? (Tick only one appropriate response)

□Strongly agree	□Somehow agree	□Don't know	□Somehow disagree	□Strongly disagree

11.6. In general, what makes you happy?………………………………………………………………………

11.7. In general, what makes you unhappy?……………………………………………………………………

11.8. Organic farmers are happier than conventional farmers: (Tick appropriate response)

□Strongly agree	□Somehow agree	□Don't know	□Somehow disagree	□Strongly disagree

10.6 Appendix 5B: Questionnaire form number – One (B) – Conventional Farming

Section One -General characteristics of sample farmer

1. Farmer's background

Interviewee's name (Optional): …………………………	**Age :** (Tick) ☐ ≤ 30 ☐ 31-50 ☐ ≥51
Gender: (Tick) ☐ Male☐ Female	**Education :** (Tick) ☐ NFE ☐ Primary Education ☐ High School ☐ College ☐ None
Religion: (Tick) ☐ Buddhist ☐ Hindu ☐ Muslim ☐ Christian ☐ Others……………….	**Relation to the head of household:** (Tick) ☐ Wife ☐ Husband ☐ Father ☐ Mother ☐ Brother ☐ Sister ☐ Others
Age of household head : (Tick) ☐ ≤ 40 ☐ 41-60 ☐ ≥61	**No. of people living in the house:** ……….
Education level of the household head: (Tick) ☐ NFE ☐ Primary Education ☐ High School ☐ College ☐ None	
No. of non-family* members living in the house: ------	**No. of household members above 18 years of age:**
No. of permanent farm labor : …………	**No. of casual farm labor:** …………

No. of family labor available :	**Male =**	**Female =**	**Children (age)**	
			13 -18 =	**≤12 =**

** Family = grandparents+parents+children+brother/sister-in-laws*

Section Two – Farm characteristics

2. Location

Village:	**No. of households in the village:**	**Geog:**
Dzongkhag:	**Altitude (m.a.s.l.):**	
Mean annual temperature (^{O}C):	**Mean annual rainfall (mm):**	

2.1. Operational holding under farming

Total farm size (Langdo):		**Average distance from field to home (km):**		
Land use type	**No. of fields**	**Area (Langdo)**	***Soil types**	**Crops grown**
Chuzhing				
Khamshing				
Others				

**Soil type to be filled by the interviewer*

2.2. Land rental fee (Nu/Langdo/year)

For Chuzhing:	**For Khamshing:**	**For other type of land: Nu.**

2.3. Land ownership (Tick the appropriate response; tick more than one, if applicable)

☐**Self-purchased**	☐**Inherited**	☐**Lease (rental)**	☐**Share-cropping**	☐**Others:**

2.4. Land inheritance and future

Will you distribute some part of your current farm land to your family members (as a separated household)?
Yes☐ No ☐
If Yes, to whom will you distribute your land? (choose from the choices below)
☐ 1st Son How much land?: **...** langdo, or **…….**% of the current farm size. When?
☐ 2nd Son How much land?: **….** langdo, or **…….**% of the current farm size. When?
☐ 3rd Son How much land?: **……** langdo, or **…….**% of the current farm size. When?
☐ 1st Daughter How much land?:**……** langdo, or **…….**% of the current farm size. When?
☐ 2nd Daughter How much land?: **….** langdo, or **…….**% of the current farm size. When?
☐ 3rd Daughter How much land?: **….** langdo, or **…….**% of the current farm size. When?
☐**Others**: How much land?: **……** langdo, or **…….**% of the current farm size. When?

2.5. Fallow land

❖ **Do you leave any land fallow?** ☐Yes ☐No					
❖ **If Yes, how long have you been leaving your land fallow? (number of years): ……..**					
❖ **If Yes, how much of the different land use type do you leave fallow? (Langdo)**					
Chuzhing: ……langdo OR **…….**% of your Chuzhing	Khamshing:**…** langdo OR **…**% of your Khamshing				
Others: **………..** langdo OR **………**% of current landholding					
For how many months a year do you leave your farmland fallow?					
Start and end of fallow period (Months): Start (month): …………………; End (month): …………					
Reasons for leaving land fallow (Tick more than one, if applicable; "1" for Not Very Important, and "5" for Very Important).					
Reasons	**Rating of importance**				
Labor shortage	1	2	3	4	5
Water shortage	☐	☐	☐	☐	☐
Inadequate resources	☐	☐	☐	☐	☐
Scattered plots	☐	☐	☐	☐	☐
Wild life threat	☐	☐	☐	☐	☐
Already have adequate other sources of income	☐	☐	☐	☐	☐
Lack of market	☐	☐	☐	☐	☐
Unsuitable climatic condition	☐	☐	☐	☐	☐

Allowing land to rest	☐	☐	☐	☐	☐
Others :	☐	☐	☐	☐	☐
How much farmland in your village/community is left fallow? (Langdo):					

Section Three – Paddy production management practices and economics

3. Variety used

Rice variety	**Source** (Tick)	**Price (Nu kg^{-1})**	**Total area under each variety (langdo)**	**Reason for preferring a given variety** (Tick more than one, if applicable)
	☐NSC ☐Alpine Bhutan ☐Self-saved ☐Neighbor ☐Others ………..			☐High yield ☐Disease tolerant ☐Less pest attack ☐Faster growth ☐Good taste ☐ Easily available ☐Others ……………….
	☐NSC ☐Alpine Bhutan ☐Self-saved ☐Neighbor ☐Others ………..			☐High yield ☐Disease tolerant ☐Less pest attack ☐Faster growth ☐Good taste ☐ Easily available ☐Others ……………….
	☐NSC ☐Alpine Bhutan ☐Self-saved ☐Neighbor ☐Others ………..			☐High yield ☐Disease tolerant ☐Less pest attack ☐Faster growth ☐Good taste ☐ Easily available ☐Others …………….

3.1. Land preparation

Land preparation method	**Date**	**Area (langdo)**	**No. of man hours required**
☐Irrigate land (land soaking)			
☐Manual tilling			
☐Bullock tilling			Bullock use hr.:………..
☐Manual + bullock tilling			
☐Power tiller tilling			Power tiller use hr.: …
☐Others			
If bullock and power tiller are used, then what is the cost per day?			
For bullock (Nu day^{-1}) :	For power tiller (Nu day^{-1}). :		

3.2. Nursery raising

Method of raising nursery (Tick more than one, if applicable)	**Date**	**No. of man hours required**
☐Inside green house		
☐In open field		
☐Raised seed bed		
☐No raised seed bed		
☐Others:		
Nursery plot size (m^2):…………………		**Seed quantity used (kg) : ………**
If green house (GH) is used, what is the total cost of green house? Nu.		
How old is your greenhouse? (Year):		

3.3. Transplanting

Method of transplanting (Tick)	**Date of transplanting**	**Area (Langdo)**	**No. of man hours required**
☐Direct sowing/broadcasting			
☐Line sowing			
☐Random sowing			
☐Machine sowing			
☐Others:			
Seedling age (days) :	**Seedling rate per hill:**		**Spacing (p-p, r-r) (cm):**
Transplanting depth (cm) :			

3.4. Fertilizing

Fertilizer type	**Date**	**Area**	**Qty. (Kg)**	**Methods of application** (Tick)			**No. of man hour required**
				Broadcast	**Drill**	**Incorporate**	
☐Urea (basal dose)				☐	☐	☐	
☐SSP				☐	☐	☐	
☐MoP				☐	☐	☐	
☐Urea (Top dressing)				☐	☐	☐	
☐Others				☐	☐	☐	
Reason for the above application method: (Tick more than one, if applicable)			☐Convenient		☐ Cheap	☐ Faster	☐ Better result
			☐ No other technique known			☐ Others:	
Do you mix the above fertilizers while applying? ☐ Yes ☐ No							

3.5. Plant protection

3.5.1. Disease

What disease infested your paddy?	**% infestation**	**Control measures**	**No. of man hour required to control**
Rice blast			
Sheath blight			

Brown spot			
Bacterial leaf blight			
Seedling damping off			
Others			

3.5.2. Pests

Pest name	**% occurrence**	**Control measures**	**No. of man hour required to control**
Stem borer			
Army worm			
Case worm			
Whorl maggot			
Rice bugs			
White-backed hopper			
Brown plant hopper			
Others			

3.5.3. Weeds

Weed name	**% infestation**	**Control measures**	**No. of man hour required**
Sochum (*Potamogeton distinctus*)			
Total number of weedings from transplanting to harvest:			

3.6. Irrigation

Irrigation method (Tick relevant method)	**Date**	**Duration during each irrigation (hr.)**	**No. of man hour required**
☐Flooding			
☐Basin			
☐Rainfall			
☐Other …………………….			

3.7. Harvesting

Method of harvesting (Tick relevant method)	**Date**	**No. of man hour required**
☐Manual		
☐Machine		

3.8. Threshing

Method of threshing(Tick relevant method)	**Date**	**No. of man hour required**
☐Manual threshing		
☐Animal threshing		

☐Animal + manual threshing		
☐Machine threshing		
Do you thresh all your harvest in one go? ☐ Yes ☐ No		

3.9. Yield and Production

Paddy area this season (acre): ………….	**Paddy area last season (acre): ……….**
Total production this season (t): ………..	**Total production this season (t): ………..**
Yield this season (t ac^{-1}): …………….	**Yield last season (t ac^{-1})**: …………….

3.10. Price

Price in different markets (Nu/Kg*)				
Farm gate	**Local market**	**Weekend market**	**Distant market****	**Export** (to be filled by interviewer)
Sell: ………..	Sell:……..	Sell:………..	Sell:………..	
Buy:………	Buy: …………	Buy:…………..	Buy:…………..	

** Put affix (u) for un-pilled rice grains, and (p) for pilled rice grains*
***distant market refers to markets beyond 40 km*

3.11. Seed saving

Do you save your own seeds : ☐ Yes ☐ No	
Reasons for saving seeds:	**Reasons for NOT saving seeds:**
Are the saved seeds enough? ☐ Yes ☐ No	

Section Four – Conventional Farming

4. When did you first adopt conventional farming? (Year) ……………

4.1. Briefly describe your understanding of CF: ……………………………………………………………….

4.2. In general, how do you maintain the health and the fertility of soil? …………………………………

4.3. The reasons for adopting CF (Tick more than one, if applicable; "1" for Not Very Critical and "5" Very Critical)

Reasons	**Ranking importance**				
	1	**2**	**3**	**4**	**5**
Push/support from the govt.	☐	☐	☐	☐	☐
High yield possible	☐	☐	☐	☐	☐
Chemicals show immediate results	☐	☐	☐	☐	☐
Ease of farming	☐	☐	☐	☐	☐
More support available readily	☐	☐	☐	☐	☐
Inherited practice from elders	☐	☐	☐	☐	☐
Others:	☐	☐	☐	☐	☐

4.4. Training details

Did you receive any training on CF? ☐ Yes ☐ No	
If Yes, How many trainings did you attend so far?	
How long was each training? (Days):	
Where was the training conducted?	………………. ; ……………………….; …………………………
Who provided the training? ………………………………………………………………………………	

4.4.1. What areas of CF do you think you lack knowledge on?………………………………………

4.4.2. Do you intend to continue with CF if given the choice?☐ Yes ☐ No	
Reasons for continuing	Reasons for NOT continuing

Section Five – Women's contribution to paddy production

5.1. Is there a difference between the wages of men and women?	☐ Yes ☐ No
If, Yes, how much is the difference: Nu ………..	
If Yes, what is reasons for the difference?	

5.2. Women's contribution to paddy production as compared to men (in %)					
Ploughing		Puddling		Nursery raising	
Transplanting		Irrigation		Fertilizer transport	
Weeding		Plant protection		Harvesting	
Threshing		Winnowing		Others	

Section Six – Cropping practice and Livestock

5. Crop rotation

1st year		2nd year		3rd year	
1st crop	2nd crop	1st crop	2nd crop	1st crop	2nd crop

5.1. Cropping sequence in the field used for this study

		Reasons for choosing these crops
Crops grown last season in the field under study :		
Crops grown before last season in the field under study :		
Crops that will be grown after this harvest :		

5.2. Crop diversification

		Reasons for choosing these crops
Crops grown under multiple cropping :		
Crops grown in intercropping :		

5.3. Livestock

Animal species	Number of breeds	
	Improved	Local

5.4. Reasons for keeping livestock (Rank "1" for Not Important and "5" Very Important)

Reasons	Ranking importance				
	1	2	3	4	5
Draught purposes	☐	☐	☐	☐	☐
Manure	☐	☐	☐	☐	☐
Porter	☐	☐	☐	☐	☐
Milk	☐	☐	☐	☐	☐
Egg	☐	☐	☐	☐	☐
Meat	☐	☐	☐	☐	☐
Others:	☐	☐	☐	☐	☐

5.5. Costs and benefits from livestock

Animal species	Costs of rearing (Nu/livestock)	Net return (Nu/livestock)	Rearing condition (Tick one response)				
			☐V. easy	☐ Easy	☐ Mod.	☐ Difficult	☐V. difficult
			☐V. easy	☐ Easy	☐ Mod.	☐ Difficult	☐V. difficult

Section Seven – Market

6. Market and price

6.1. Where do you normally sell your produce? (Tick more than one market, if relevant)

Market parameters	On farm	Roadside	Weekend market	Distant market	Export
Produce sale outlet	☐	☐	☐	☐	☐
Reasons for choosing a particular market	☐	☐	☐	☐	☐
Distance to market (Km)	☐	☐	☐	☐	☐
% of produce sold in different markets	☐	☐	☐	☐	☐
Cost of transportation (Nu)	☐	☐	☐	☐	☐

6.2. Mode of sale (Tick more than on marketing mode, if relevant)

☐Direct	☐Middleman	☐Customer come to pick	☐Others (Please specify):

6.3. Price in different markets

Produce	**Price in different markets (Nu/Kg)**				
	On farm	**Roadside**	**Weekend market**	**Distant market**	**Export**
Paddy					
Potato					

Section Eight – Community background

7. Community background

7.1. Total population of your community: …………………

7.2. Community level information (Tick the appropriate response)

Parameters	**Strongly agree**	**Agree**	**Don't know**	**Disagree**	**Strongly disagree**
Farmland in my community has decreased in the last 10 years.	☐	☐	☐	☐	☐
Willingness of community members to help in farming chorus has decreased in the last 10 years.	☐	☐	☐	☐	☐
Willingness of community members to assist in chorus other than farming has decreased in the last 10 years.	☐	☐	☐	☐	☐
Attractiveness of my community compared to other communities has decreased in the last 10 years.	☐	☐	☐	☐	☐
Economic prosperity of my community has improved in the last 10 years.	☐	☐	☐	☐	☐
Education level of my community has increased in the last 10 years.	☐	☐	☐	☐	☐
My community strongly believes in religion.	☐	☐	☐	☐	☐
Men and women share same work load in my community.	☐	☐	☐	☐	☐
No. of female as head of household is more in my community.	☐	☐	☐	☐	☐
No. of divorces has increased in the last 10 years in my community.	☐	☐	☐	☐	☐
There is conflict in resource sharing in my community.	☐	☐	☐	☐	☐

7.3. How is conflict in the community resolved?………………………………………………………

Section Nine – Religion and traditional and local beliefs

8. Belief system

Do you work on auspicious days? ☐ Yes ☐No			
If Yes, reasons for working: (Tick more than one, if applicable)		**If No, reasons for NOT working:** (Tick more than one, if applicable)	
Don't believe in such belief	☐	It is sinful	☐
Work should not be postponed	☐	Many insects and other organisms get killed	☐
Is a waste of time	☐	Just following tradition passed	☐
Need genuine rest	☐	Will bring good harvest	☐
Others (please specify)	☐	Other (please specify)	☐

8.1. How many times a month do you visit a temple on an average?…………….

8.2. Is anyone from your family in monastic body, including lay monk? ☐ Yes ☐No

8.3. What traditional beliefs related to farming are you aware of?……………………………………….

8.4. Which of the one listed above do you follow?……………………………………………………

Section Ten – Future

9. Will your children continue to work in the farm 15 years from now? ☐ Yes ☐No

9.1. Reason(s) for the above answer: **……………………………………………………………………………**

9.2. Land size (Tick appropriate response)

Parameters	**Strongly agree**	**Agree**	**Don't know**	**Disagree**	**Strongly disagree**
Farm size will decrease in the coming 10 years in my community.	☐	☐	☐	☐	☐
Land left to fallow will increase in the next 10 years.	☐	☐	☐	☐	☐
Wildlife threat to crop production will increase in the next 10 years.	☐	☐	☐	☐	☐
Farming will be more profitability in the next 10 years	☐	☐	☐	☐	☐

9.3. Twenty years from now, what do you think will be the size of your farm? (Specify percent change or tick "No change" if applicable)

% increase =	**% Decrease =**	**No change**
Reason(s) for the above answer:		

Section Eleven – Happiness and some final thoughts

10. Would you like to share any other experiences related to organic farming?……………………………

10.1. What is(are) the most difficult thing(s) as a farmer?…………………………………………….

10.2. What is your one best experience as a farmer?……………………………………………………

10.3. If given a choice, which profession would you choose? (Tick only one appropriate response)

☐Doctor	☐Teacher	☐Monk	☐Army
☐Farmer	☐Business	☐Others:	

10.4. How would you define happiness?………………………………………………………………………

10.5. I am happy as a farmer? (Tick only one appropriate response)

☐Strongly agree	☐Somehow agree	☐Don't know	☐Somehow disagree	☐Strongly disagree

10.6. In general, what makes you happy?…………………………………………………………………

10.7. In general, what makes you unhappy?………………………………………………………………

10.8. Organic farmers are happier than conventional farmers: (Tick appropriate response)

☐Strongly agree	☐Somehow agree	☐Don't know	☐Somehow disagree	☐Strongly disagree

10.7 Appendix 6: List of experts involved in experts' group discussion and interviews

Sl. No.	Name	Designation
1	Yeshey Dorji	Hon'ble Minister of Agriculture and Forests
2	Dophu Dukpa	Hon'ble Member of Parliament (Agriculture Economist)
3	Tshering Dorji	Hon'ble Deputy Chair, National Council of Bhutan
4	Tashi Wangmo	His Majesty's nominee at the National Council
5	Nima	Hon'ble Member of Parliament (National Council)
6	Ganesh Bhd. Chettri	Specialist, Agriculture, MoAF
7	Thinley	Specialist, Plant Protection, MoAF
8	Mahesh Ghimiray	Specialist, Rice, Renewal Natural Resource Reseach Dev't Centre, Bajo
9	Jamyang	Specialist, Soils, Soil and Plant Analytical Lab, MoAF, Semtokha
10	Thukten Sonam	Asst. Prof. College of Natural Resources, Royal University of Bhutan
11	Penjore	Asst. Prof. College of Natural Resources, Royal University of Bhutan
12	Tulsi Gurung	Asst. Prof. College of Natural Resources, Royal University of Bhutan
13	Dorji Dhadrul	Director, Dept. of Agricultural Marketing and Cooperatives, MoAF
14	Ugyen Penjore	Director, Dept. of Cottage and Small Industries, MoEA
15	Karma Dema Dorji	Program Director, National Soil Service Centre, MoAF
16	Kinlay Tshering	Chief Horticulture Officer, MoAF
17	Wangda Dukpa	Program Director, National Seed Centre, MoAF
18	Kesang Tshomo	Program Director, National Organic Program, MoAF
19	Tshewang Namgay	Senior Research Officer, NOP, MoAF
20	A. Thimmaiah	Consultant, NOP, MoAF
21	Chencho Dukpa	Chief Research Officer, Council of RNR of Bhutan
22	Phub Dem	Chief Industries Officer, Dept. of Cottage and Small Industries, MoEA
23	Lhap Dorji	Program Director, RNR RDC Wengkhar
24	Yadunath Bajgai	Chief Research Officer, RNR RDC Bajo
25	Karma Yangzom	Proprietor, BioBhutan, Thimphu
26	Dhodo	Senior District Agriculture Officer, MoAF, Thimphu
27	Kuenzang Peldon	District Agriculture Officer, MoAF, Samdrup Jongkhar
28	Rebecca Pradhan	Ecologist, Royal Society for the Protection of Nature
29	Saamdu Chetri	Executive Director, Gross National Happiness Commission, Bumthang
30	Tshewang Dhedup	Executive Director, Samdrup Jongkhar Initiative
31	Karma Penjore	Field Specialist, Haa Organic Vegetable Production Initiative
32	Haka Dukpa	Research Officer, NSSC, Semtokha
33	Tanka Maya Pulami	Senior Research Officer and Organic Focal Person, RNR RDC Bajo
34	Denka	Manager, Toktokha Organic Farm
35	Kuenzang Lhadon	Senior ICT Officer, Centre for Bhutan Studies, GNHC, Thimphu

10.8 Appendix 7: SWOT analysis

Strengths	**Opportunities**
Principles of OA align well with the concept and development philosophy of GNH	Promote healthy lifestyle
Strong policy and political support	Huge regional export market
Similar to traditional farming	Huge global export market
Limited use of synthetic agro-chemicals	Promote self-sufficiency and food reliance
Pristine environment	Reduce dependence on import
Good local farming knowledge	Growing interest in OA
Strong National Organic Program	Premium price
Increasing international support	Build up soil fertility
Sustainable use of natural resources	Consistent yield
	Develop local organic manure suppliers
	Conservation of local crop species/varieties
	Create local seed sovereignty
	Strengthen culture
	Strengthen rural community
	More employment opportunities
Weaknesses	**Threats**
High production cost	Impending WTO membership
Lack of awareness of the benefits of OA	Global competition
Lack of clarity in policy	Variability in climate pattern
Labor shortage	Yield reduction
Lack coordination b/n different agencies	Dwindling supply of organic sources of manure
Limited technical expertise	Pest and disease incidence
Lack of certification	Higher certification cost
Poor soil fertility	Introduction of GMOs
Lack of quality planting materials	Compromise food self-sufficiency goal
Ltd. viable alternatives to plant protection interventions	
Nascent research in organic	
Small volume and irregular supply of produce	
Lack of incentives	

10.9 Appendix 8: Summary of the methods used in the study

For analysis (for two years: 2012 & 2013)							
			District	**Sample size**		**Comparative study on the following**	
Study sites	**3 AEZs**[+]	High	Bumthang	10 org. fields	10 conv. fields	Soil nutrient status	Yield
		Mid	Paro	10 org. fields	10 conv. fields	Soil nutrient status	Yield
		Low	Punakha	10 org. fields	10 conv. fields	Soil nutrient status	Yield
			Tsirang	10 org. fields	10 conv. fields	Soil nutrient status	Yield
			Mongar	10 org. fields	10 conv. fields	Soil nutrient status	Yield
			Samtse	10 org. fields	10 conv. fields	Soil nutrient status	Yield
Soil nutrient parameters: i. pH; ii. OM%; iii. Total N%; iv. Available P; v. exchangeable K; vi. exchangeable Ca; vii. Cation exchange capacity; viii. Bulk density							
Yield parameters: i. Plant height; ii. No. of tillers/hill; iii. No. of tillers/m^2; iv. Total no. of plants harvested; v. No. of grains per panicle; vi. Field weight (kg); vii. Yield (t ha^{-1})							
Economics parameters: i. Gross production cost per ha; ii. Gross production cost per kg; iii. Gross return; iv. Net return; v. Benefit-cost ratio							

Second analysis (for one year only: 2013)											
		Sample size	**Comparative study on the following:**								
Study site	**All 20 districts**	**393 organic*** / **353 conventional**	**Economics**	**Age grp.**	**Edu.**	**Land holding**	**Household size**	**Plant protection**	**Women's contribution to farming**	**Happiness**	**Job option preferred**

Experts' group discussion and interview					
Participant no.	**Venue**	**Discussion topics and interview questions**			
35	Thimphu	SWOT analysis	Synthetic agro-chemical phase out	Thoughts on going fully organic	Organic way forward

[+]Agro-ecological zones

*Higher number of organic respondents because two districts (Gasa and S/Jongkhar) do not have conventional paddy growers

10.10 Appendix 9A: Interpretation of soil analyses (SPAL)

Parameter	Very high	High	Medium	Low	Very low
pH	> 7.6 (Alkaline)	6.6 – 7.5 (Neutral)	5.6 – 6.5 (S. acidic)	4.6 – 5.5 (V. acidic)	< 4.5 (Ex. Acidic)
C%	> 5 > 1	3.1 – 4.9	1.2 – 3	0.6 – 1.1.	< 0.6
Total N%	> 1	0.5 – 0.99	0.2 – 0.49	0.1 – 0.19	< 0.1
Avail. P (mg kg^{-1})	> 30		15 - 29	5 - 14	< 5
Ex. K (mg kg^{-1})	> 300	200 - 299	100 – 199		< 40
Ex. Ca (mg kg^{-1})	> 20	10 – 19.9	5 – 9.9	2 – 4.9	< 2
CEC (me 100 g-1)	> 40	25 – 39.9	15 – 24.9	5 – 14.9	< 5

10.11 Appendix 9B: Ideal bulk densities of various soil textures

Soil texture	Ideal bulk density	Bulk densities that may affect root growth	Bulk densities that may restrict root growth
	$g\ m^{-3}$		
Sand, loamy sand	< 1.60	1.70	> 1.80
Sandy loam, loam, Sandy clay loam, clay loam, silt, silt loam, silty clay loam	< 1.40	1.60	> 1.75
Sandy clay, silty clay, clay	< 1.10	1.50	> 1.60

Source: USDA Soil Quality Test Kit Guide (1999)

10.12 Appendix 10A: Soil nutrients and other properties in organic and conventional paddy fields in the high AEZ (Bumthang and Paro districts) (2012 and 2013)

	2012			2013		
Soil parameter	**Organic (n=20)**	**Conventional (n=20)**	**Sig.**	**Organic (n=20)**	**Conventional (n=20)**	**Sig.**
Bumthang district						
pH	5.89 ± 0.04	5.90 ± 0.04	ns	5.89 ± 0.04	5.82 ± 0.07	ns
OM (%)	1.74 ± 0.05	1.69 ± 0.04	ns	1.71 ± 0.07	1.68 ± 0.05	ns
Total (N%)	0.11 ± 0.01	0.10 ± 0.01	ns	0.11 ± 0.01	0.10 ± 0.01	ns
Avail. P (mg kg^{-1})	11.1 ± 0.52	9.77 ± 0.56	ns	10.85 ± 0.53	10.21 ± 0.58	ns
Ex. K (mg kg^{-1})	143.59 ± 5.05	146.14 ± 7.88	ns	144.5 ± 4.85	146.2 ± 7.61	ns
Ex. Ca (mg kg^{-1})	725.3 ± 31.3	722.1 ± 24.0	ns	724.3 ± 48.0	721.7 ± 39.5	ns
CEC (me 100 g^{-1})	8.91 ± 0.42	8.39 ± 0.28	ns	8.96 ± 0.44	8.28 ± 0.47	ns
BD (g cm^{-3})	1.15 ± 0.01	1.17 ± 0.01	ns	1.16 ± 0.01	1.17 ± 0.01	ns
Paro district						
pH	5.99 ± 0.33	5.90 ± 0.03	ns	5.91 ± 0.06	5.90 ± 0.04	ns
OM (%)	2.60 ± 0.02	2.30 ± 0.20	ns	2.63 ± 0.20	2.27 ± 0.19	ns
Total (N%)	0.15 ± 0.01	0.17 ± 0.01	ns	0.17 ± 0.01	0.16 ± 0.01	ns
Avail. P (mg kg^{-1})	14.95 ± 0.72	13.48 ± 0.60	ns	14.89 ± 0.71	13.36 ± 0.65	ns
Ex. K (mg kg^{-1})	147.6 ± 9.42	145.6 ± 6.27	ns	147.5 ± 8.59	144.9 ± 1.01	ns
Ex. Ca (mg kg^{-1})	742.4 ± 35.0	739.4 ± 37.0	ns	742.0 ± 38.3	738.4 ± 33.1	ns
CEC (me 100 g^{-1})	9.72 ± 0.38	9.11 ± 0.44	ns	9.72 ± 0.46	9.12 ± 0.49	ns
BD (g cm^{-3})	1.11 ± 0.01	1.13 ± 0.01	ns	1.13 ± 0.01	1.15 ± 0.01	ns

*$P \leq 0.05$ ns=non significant

Avail.= available; Ex. = exchangeable; BD = bulk density; CEC = cation exchange capacity

10.13 Appendix 10B: Soil nutrients and other properties in organic and conventional paddy fields in the mid AEZ (Punakha and Tsirang districts) (2012 and 2013)

Soil parameters	2012 Organic (n=20)	2012 Conventional (n=20)	Sig.	2013 Organic (n=20)	2013 Conventional (n=20)	Sig.
Punakha district						
pH	5.85 ± 0.06	5.87 ± 0.04	ns	5.86 ± 0.06	5.87 ± 0.04	ns
OM (%)	2.07 ± 0.11	1.84 ± 0.05	ns	1.95 ± 0.12	1.88 ± 0.09	ns
Total (N%)	0.14 ± 0.01	0.12 ± 0.01	ns	0.13 ± 0.01	0.11 ± 0.01	ns
Avail. P (mg kg^{-1})	11.5 ± 0.40	10.8 ± 0.65	ns	11.1 ± 0.35	9.90 ± 0.56	ns
Ex. K (mg kg^{-1})	134.3 ± 5.61	131.7 ± 7.55	ns	132.3 ± 5.99	130.8 ± 7.65	ns
Ex. Ca (mg kg^{-1})	722.1 ± 44.4	717.3 ± 33.8	ns	724.2 ± 46.5	716.6 ± 38.8	ns
CEC (me 100 g^{-1})	8.59 ± 0.19	8.24 ± 0.39	ns	9.00 ± 0.47	8.25 ± 0.33	ns
BD (g cm^{-3})	1.14 ± 0.01	1.17 ± 0.01	ns	1.15 ± 0.02	1.17 ± 0.01	ns
Tsirang district						
pH	5.82 ± 0.04	5.85 ± 0.03	ns	5.85 ± 0.03	5.80 ± 0.03	ns
OM (%)	1.69 ± 0.08	1.69 ± 0.10	ns	1.71 ± 0.06	1.69 ± 0.10	ns
Total (N%)	0.13 ± 0.01	0.13 ± 0.01	ns	0.12 ± 0.01	0.12 ± 0.01	ns
Avail. P (mg kg^{-1})	11.7 ± 0.22	10.50 ± 0.48	ns	12.5 ± 0.39	10.63 ± 0.53	ns
Ex. K (mg kg^{-1})	132.1 ± 3.04	129.6 ± 0.88	ns	133.1 ± 2.49	128.2 ± 3.15	ns
Ex. Ca (mg kg^{-1})	719.3 ± 47.3	716.1 ± 43.0	ns	717.1 ± 44.3	715.3 ± 47.8	ns
CEC (me 100 g^{-1})	8.39 ± 0.34	7.96 ± 0.34	ns	8.50 ± 0.57	8.04 ± 0.31	ns
BD (g cm^{-3})	1.16 ± 0.01	1.18 ± 0.01	ns	1.17 ± 0.01	1.17 ± 0.01	ns

*$P \leq 0.05$ ns=non significant

10.14 Appendix 10C: Soil nutrients and other properties in organic and conventional paddy fields in the low AEZ (Mongar and Samtse districts) (2012 and 2013)

Soil parameters	2012 Organic (n=20)	2012 Conventional (n=20)	Sig.	2013 Organic (n=20)	2013 Conventional (n=20)	Sig.
Mongar district						
pH	5.86 ± 0.07	5.83 ± 0.06	ns	5.87 ± 0.06	5.84 ± 0.06	ns
OM (%)	1.99 ± 0.09	2.14 ± 0.04	*	1.97 ± 0.09	2.09 ± 0.04	ns
Total (N%)	0.14 ± 0.01	0.15 ± 0.01	ns	0.14 ± 0.01	0.15 ± 0.01	ns
Avail. P (mg kg^{-1})	12.1 ± 0.36	12.4 ± 0.16	ns	11.9 ± 0.47	12.9 ± 0.18	ns
Ex. K (mg kg^{-1})	129.3 ± 6.68	132.4 ± 8.35	ns	128.7 ± 5.01	132.5 ± 1.53	ns
Ex. Ca (mg kg^{-1})	725.6 ± 35.9	728.2 ± 4.39	ns	725.2 ± 44.4	726.3 ± 30.6	ns
CEC (me 100 g^{-1})	8.20 ± 0.48	8.64 ± 0.26	ns	8.31 ± 0.15	8.43 ± 0.25	ns
BD (g cm^{-3})	1.15 ± 0.01	1.15 ± 0.01	ns	1.15 ± 0.01	1.15 ± 0.01	ns
Samtse district						
pH	5.80 ± 0.11	5.81 ± 0.11	ns	5.81 ± 0.01	5.80 ± 0.01	ns
OM (%)	1.84 ± 0.07	1.79 ± 0.10	ns	1.85 ± 0.11	1.80 ± 0.09	ns
Total (N%)	0.13 ± 0.01	0.13 ± 0.01	ns	0.12 ± 0.01	0.11 ± 0.01	ns
Avail. P (mg kg^{-1})	11.7 ± 0.59	12.1 ± 0.69	ns	12.5 ± 0.62	11.1 ± 0.78	ns
Ex. K (mg kg^{-1})	141.2 ± 1.97	139.3 ± 2.23	ns	143.6 ± 4.66	140.3 ± 5.76	ns
Ex. Ca (mg kg^{-1})	718.2 ± 39.6	716.6 ± 46.0	ns	721.2 ± 55.0	713.1 ± 45.0	ns
CEC (me 100 g^{-1})	8.47 ± 0.51	8.02 ± 0.29	ns	8.46 ± 0.52	8.10 ± 0.57	ns
BD (g cm^{-3})	1.15 ± 0.01	1.16 ± 0.01	ns	1.16 ± 0.01	1.17 ± 0.01	ns

*P≤0.05 ns=non significant