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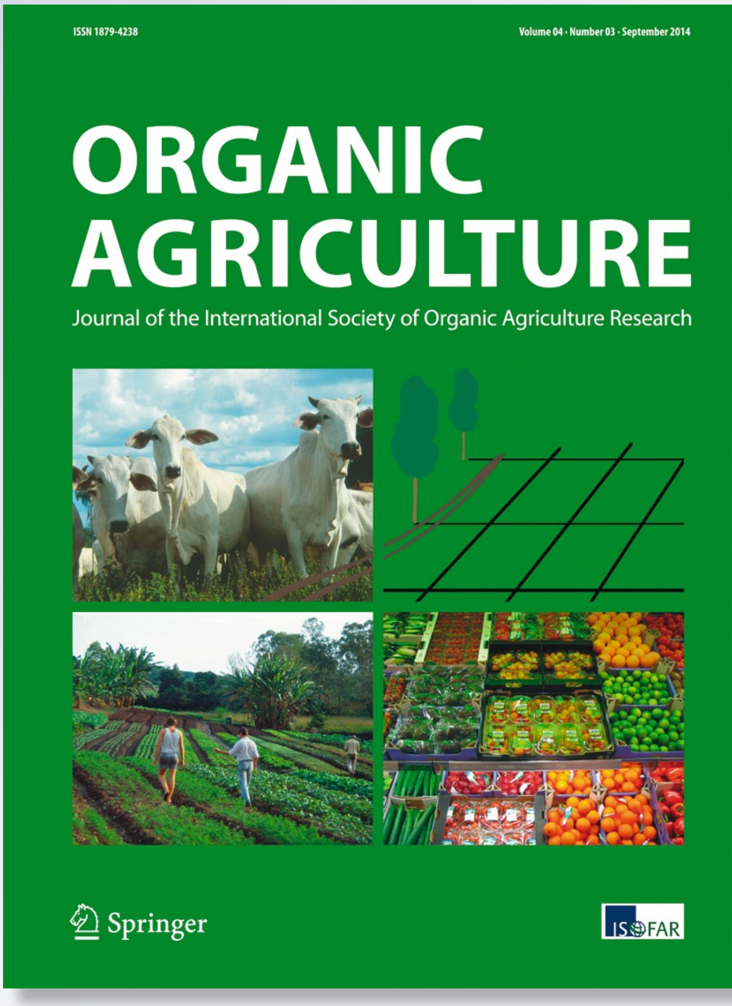

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Organic agriculture in Bhutan: potential and challenges

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Abstract The Government of Bhutan, a poor rugged mountainous kingdom in the Himalayas, aims to convert the whole agricultural area to Organic Agriculture (OA) by 2020 in an effort to provoke a substantial increase of productivity and farmers income while preserving the environment. Currently less than 10 % of the agricultural area of Bhutan is in OA production. We analysed the assumptions of the Bhutanese Government cited above from an agronomic perspective. According to our estimates, farmer incomes after conversion will increase only if organic crops will out-yield conventional crops or if farmers can realize higher market prices. Organic yields may partly increase beyond current productivity but may not become as high as in systems using agrochemicals. Under these premises, higher farmer incomes after mass conversion are not likely. The current low agricultural productivity is mainly a result of low soil fertility combined with other system-independent factors such as inadequate input supply, e.g. low quality seeds, lack of techniques and knowledge, inefficient management, labour shortage and poor infrastructure. These problems need to be tackled with integrated approaches, which should include organic management practices such as growing fodder legumes. Integrating more strategies of OA into Bhutanese agriculture is expected to have positive ecological effects. System comparisons between conventional and organic production require more empirical data on the agronomic and economic performances, which are yet to be generated in Bhutan. In addition to trade policies, market and infrastructure development, the organic sector will benefit from a well-resourced Centre of Excellence to focus on research and knowledge transfer.

Keywords Conversion · Agricultural productivity · Soil fertility · Constraints

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Introduction

Bhutan is a small kingdom in the Eastern Himalayas (27° 30′ N, 90° 30′ E) with ~720,000 inhabitants and an area of 38,394 km^2 (SYB 2013). It has a low Human Development Index (HD = 0.538, HDI rank = 140 in 2012) but ranking above the neighbouring countries Nepal (HDI rank = 157) and Bangladesh (HDI rank = 146) (HDR 2013, Table 1). The current socio-economic

Table 1 Key indicators of development in 2012 for selected South Asian countries, HDR (2013)

	HDI value	HDI rank	Life expectancy at birth	Mean years of schooling	GNI per capita PPP US $)	MPI[a]
Bhutan	0.538	140	67.6	2.3	5,246	0.119
India	0.554	136	65.8	4.4	3.285	0.283
Bangladesh	0.515	146	69.2	4.8	1.785	0.292
Maldives	0.688	104	77.1	5.8	7,478	0.018
Nepal	0.463	157	69.1	3.2	1,137	0.217
South Asia	0.558		66.2	4.7	3.343	

The education and health dimensions are based on two indicators each while the standard of living dimension is based on six indicators

HDI human development index, is a summary measure for assessing long-term progress in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living, the standard of living is assessed with one indicator (GNI), *GNI* gross national income, *PPP* purchasing power parity, *MPI* multidimensional poverty index, identifies multiple deprivations in the same households in education, health and standard of living, lower values mean lower risks

[a] Survey years between 2005 and 2009

situation of Bhutan is mainly a function of the cultural distinctions from the tantric form of Mahayana Buddhism and its geographical location. As a landlocked mountainous country, Bhutan supposedly maintained a strong self-imposed isolation from the rest of the world until the early 1960s, when the first roads started to connect the country to India and to the inland. Due to this isolationist policy and rugged mountainous terrains, Bhutan has successfully preserved much of its rich culture dating back to the mid-seventeenth century. Difficult accessibility of major parts of the country, low population densities and a mountainous landscape mainly dominated by forest are the main factors explaining the lack of industrial activity, with the notable exception of hydroelectric power production (MOAF 2013).

The agricultural sector is characterized by smallholder and traditional farming practiced mainly in unfavourable production environments resulting in low productivity, high production costs and low competitiveness (SYB 2012).

The recent history of Bhutan is also characterized by a strong awareness for environmental protection starting with the implementation of the concept of Gross National Happiness (GNH) by King Wangchuck in 1972 (Brown and Bir 2011). In contrast to the common gross domestic product (GDP) approach, the GNH is based on four criteria: sustainable development, preservation and promotion of cultural values, conservation of the natural environment and establishment of good governance (Pennock and Ura 2011). In 2007, the Bhutanese Government announced a new agricultural policy focusing on the development of Organic Agriculture (OA) envisioning that the country fully converts to organic by 2020 (Duba et al. 2008). This initiative was triggered by the overall green mentality of the country and the view of the government that the current agricultural practices in Bhutan, e.g. mixed farming and low use of inputs are virtually all organic, requiring only minimal steps for full conversion. During the Rio + 20 conference in June 2012, the Prime Minister of Bhutan Sir Jigmi Y. Thinley stated that “going organic will create new economic opportunities for farmers and rural communities both by adding value to what they produce and by reducing the costs of farming” (IFOAM 2012).

This country report describes and analyses the current situation of agriculture in Bhutan and discusses the challenges and opportunities of converting conventional agriculture to organic.

Outline

The manuscript is based on existing literature and insights resulting from a visit to the kingdom of Bhutan by the authors in October 2012. The agricultural scenario was assessed through farm inspections, discussions with experts and local people. The main sources for statistical data are (i) the Statistical Yearbook (SYB) published by the National Statistics Bureau (NSB) and (ii) the Renewable Natural Resources (RNR) statistics annually published by the Ministry of Agriculture and Forests (MOAF). First, the biophysical and socio-economic situations of Bhutan are described. The second main section focuses on Bhutan's current agricultural status. A concluding section critically analyses the situation and discusses the implications of full conversion to OA.

General description of Bhutan

Bio-physical profile

Bhutan is situated in the Eastern Himalayas surrounded by Tibet and India with elevations ranging from 200 m in the south to more than 7,400 m asl in the north. Consequently, there is a large diversity in topography, climatic conditions, local geographic features, ecosystems and species (SYB 2012).

About 70.4 % of the total land area is covered with forest dominated by broad leaf forest (16,850 km^2) and mixed conifer forest (6,129 km^2). Shrubs cover approximately 10.4 % of the land area (Table 2). Northern Bhutan mainly consists of a rugged, irregular and sloping terrain and the south features mostly grassy savanna and broadleaf tree species. The north of Bhutan, the Great Himalayas, is dominated by glaciated mountain ranges and high valleys. Cold, arid climate is predominant, with annual precipitation of 500 to 1,000 mm and elevations ranging from 3,000 to 7,500 m asl (DANIDA 2008). Alpine summer pastures depend on the water supply from glacial melt water. Conifers and birches prevail up to the end of the timberline; above rhododendron thickets are dominant (Ohsawa 1987).

In the central region, the inner Himalayas, at elevations ranging from 1,500 to 3,000 m asl, woodlands are the main contributors to Bhutan's forest production, especially the western areas with its cultivated valleys and terraced river basins. Variations in elevation and the degree of exposure to south-western monsoon rains cause regional differences. For instance, the forests are dense on the humid windward slopes and vegetation cover is scarce at higher elevations. Tree species are highly diverse including pine, oak, birch, cypress, spruce, fir, apples and peaches (Schweinfurth 1957). Central mountain valleys have a temperate climate with cool winters and hot summers. Accumulated precipitation fluctuates between 1,000 and 2,500 mm per year (DANIDA 2008).

Table 2 Land cover in Bhutan, data from MOAF (2013)

Type of land cover	Total area [km^2]	Total area [%]
Forest	27,053	70.5
Shrubs	4,005	10.4
Snow/glacier	2,854	7.4
Meadows/pastures	1,575	4.1
Bare and degraded areas	1,436	3.7
Arable land	1,125	2.9
Settlements/others	346	0.9
Total	38,394	100

To the south, the foothills of the Himalayas are covered by broadleaved trees down into the humid subtropical Duars plain or the Sub-Himalayan range. The vegetation cover of the plains is subtropical in character with annual precipitation ranging from 2,500 to 5,550 mm and elevations from 200 to 1,500 m asl (DANIDA 2008). The major river systems deposit predominantly sandy and gravelly sediments (Fraser et al. 2001).

The topography and the climate of Bhutan bring forth some specific characteristics and challenges. The monsoon is responsible for heavy rainfalls, high humidity, flash floods and landslides (SYB 2012). Due to the topography, cultivated areas are mainly concentrated in the big river systems and follow a north–south orientation. The main streets are built in to accommodate the landscape, with two main connecting roads in an east–west orientation.

Soils in Bhutan are very heterogeneous with respect to parent material, texture and nutrient content. They are mostly underlain by thick sheets of highly metamorphosed gneisses (~70 %), quartzites, schists and marbles (Baillie et al. 2004). About 27 % of Bhutan's soils are attributed as either cambisols of the medium-altitude zone or fluvisols of the southern belt (Caspari et al. 2006).

Podzols, acrisols and ferrasols are less fertile soil types and they represent 45 % of the land area. Approximately 21 % of the soils have shallow depths with lithosols occurring predominantly on steep slopes (Roder et al. 2001). Karan (1961) stated that cultivated land is scattered in the climatically favourable inner Himalayan valleys and the southern foothills bordering the plains of India.

With productive land representing only a small share, land degradation poses a threat to the population's livelihoods. Water-induced degradation, e.g. gullies, landslides and floods, and physical degradation, e.g. topsoil capping and compaction, are the most prominent processes (Norbu 2003). Almost 4 % (1,317 km^2) of Bhutan's total area is covered by glaciers (Mool et al. 2001) and their meltwater is vital for Bhutan's water supply and the Brahmaputra River in India. A study by Rupper et al. (2012) on the response of Bhutan's glaciers to global warming shows that even under a conservative scenario of an additional regional warming of 1 °C, about 25 % of the glaciated area will disappear over time. The annual meltwater flux would drop by 65 % after an initial rise during melting. The main challenges arising from initial deglaciation are glacial lake outburst floods, periodic landslides and flashfloods in mountainous areas; soil siltation and floods in the plains; as well as other geotechnical hazards (Dorji 2012). Changes in water supply are also expected to have a strong effect on land use systems and Bhutan's energy supply and export, which is partly ensured by hydropower plants (SYB 2012).

Socio-economic situation

In 2011, the total GDP of Bhutan was 1.744 billion US $ corresponding to a *per capita* value of ~2,449 US $ (MOAF 2013). The major national economic sectors are construction (16.3 % of GDP), agriculture and forestry (15.7 %), and electricity and water (13.9 %). Mining of mineral resources including limestone, gypsum, coal, graphite and slate play a minor but relevant role (2.3 %). Tourism has been growing significantly during the last decade resulting in about 43,943 visitors in 2012 (SYB 2013). The gross national income (GNI) per capita in 2012 was about 1,900 $ higher than the average of Southeast Asia (corresponds to 5,246 US $ purchasing power parity (PPP), Table 1).

About 60 % of the active population works in agriculture, most of them in subsistence farming (SYB 2012). In 2011, about 24.2 % of the Bhutanese population lived in multidimensional poverty and another 17.2 % were vulnerable to multiple deprivations (HDR 2013). The mean years of schooling in 2012 were much lower in Bhutan (2.3 years) compared with the average of Southeast Asia (4.7 years). Raising people's economic expectations, the prospect of higher incomes and educational perspectives currently foster a rural to urban migration flow that is a major concern for Bhutanese policy makers (Roder et al. 2008). Land abandonment and land left fallow are visible symptoms of this process.

Agriculture in Bhutan

Crop production

Bhutanese agriculture represents only 7 % of the total country area with 4.1 % (157,500 ha) used as extensive grassland and only 2.9 % (112,549 ha) for arable crop production (Table 2). Around 28 % (31,910 ha) of the arable land is wetland (SYB 2012), which is protected from drainage since 1979.

Cropping systems and land use are mainly determined by the agro-ecological zones, where climatic conditions range from alpine to wet subtropical along a gradient of altitude and precipitation (Table 3). The Samtse Dzongkhag (district) in the south of Bhutan has the highest share of arable land in the country (13.3 % of total land or 17,366 ha) whereas the western Haa Dzongkhag and the northern Gasa Dzongkhag (0 and 0.2 % respectively) have the lowest (SYB 2012). Rice is the dominant food crop for human nutrition produced on 22,909 ha, corresponding to a total production of 78,203 t in 2011 (Table 4). About 80 % of the total rice production takes place at mid (700–1,600 m asl) and low (200–700 m asl) altitudes (Ghimiray 2012). The average paddy rice yield in 2011 was 32.4 dt ha^{-1} ranging from 25.9 dt ha^{-1} in Samtse to 43.2 dt ha^{-1} in Paro (MOAF 2013).

Bhutanese farmers show a strong preference for local varieties with red-coloured grains demanded by the consumer and with long straw for use in animal husbandry as fodder or litter (Dorji 2008). The developed by IRRI began later than in other Asian countries, with the release of IR64 in 1988 followed by about 14 other cultivars. Insufficient local adaptation of high-yielding cultivars to mid and high altitudes resulted in a cross breeding programme with local varieties up from 1995 and the subsequent release of eight cultivars, which combine rice blast caused by *Pyricularia oryzae* resistance, high yield potential and favourable culinary traits (Ghimiray 2012). According to estimates by rice experts, the overall adoption rate of these new high-yielding cultivars has increased to 53 % during the last years. The local cultivar Khangma Maap represents 50 % of the rice area in high altitudes, while IR64 covers 50 % of mid altitudes and BR153 (70 %) in low altitudes rice areas (Ghimiray 2012).

The second important crop is maize, which is grown mainly in the eastern regions on some 28,397 ha with an average corn yield of 28.0 dt ha^{-1} and a total production

Table 3 Agro-ecological zones in Bhutan, data from GNHC (2003)

Agro-ecologicalzone	Altitude range (m. asl)	Annual rainfall (mm)	Air temperature (°C)			Farming systems, crop production and animal husbandry
			Max	Min	Mean	
Alpine	3,600–4,600	<650	12.0	-0.9	5.5	Semi-nomadic people, yak herding, dairy products, barley, buckwheat, mustard, vegetables
Cool temperate	2,600–3,600	650–850	22.3	0.1	9.9	Yaks, cattle, sheep, horses, dairy products, barley, wheat, potatoes, buckwheat and mustard under shifting cultivation
Warm temperate	1,800–2,600	650–850	26.3	0.1	12.5	Rice on irrigated land, double cropped with wheat and mustard, barley and potatoes, temperate fruit trees, vegetables, cattle for draft and manure,
Dry subtropical	1,200–1,800	850–1,200	28.7	3.1	17.2	Maize, rice, millet, pulses, fruit trees and vegetables, lemon grass, cattle, pigs, poultry
Humid subtropical	600–1,200	1,200–2,500	33.0	4.6	19.5	Irrigated rice rotated with mustard, wheat, pulses and vegetables, tropical fruit trees
Wet subtropical	150–600	2,500–5,500	34.6	11.6	23.6	Irrigated rice rotated with mustard, wheat, pulses and vegetables, tropical fruit trees

m asl meter above sea level

of 79,667 t in 2011 (MOAF 2013). Other cereals and pseudo-cereals only cover a small percentage of the arable land (Table 4). These are wheat (2,273 ha), barley (1,533 ha), millet (3,657 ha) and buckwheat (3,821 ha). The average grain yield of these crops is low ranging between 19.1 dt ha^{-1} for millet and 26.9 dt ha^{-1} for wheat (MOAF 2013). There is more or less no growing of fodder legumes in Bhutan, although seeds for alfalfa and red clover are available. Other promising species such as Spanish clover (*Desmodium uncinatum*) still need to be tested for local adaptation. The total production of grain legumes including faba bean, soybean, kidney bean and peas covered less than 5 % of the arable land and only amounted to a harvest of about 5,150 t in 2011 (MOAF 2013).

Table 4 Cereal production and yields in Bhutan in 2011 (MOAF 2013)

Crop	ha	Yield (dt ha^{-1})	Range (dt ha^{-1})	Production (t)
Paddy	22,909	32.42	43.19–25.95	78,203
Maize	28,397	28.05	35.56–20.58	79,667
Wheat	2,273	26.86	34.57–20.24	6,105
Barley	1,533	19.74	34.74–12.80	3,027
Buckwheat	3,821	20.61	24.96–13.20	7,874
Millet	3,657	19.15	25.97–17.69	7,007
Total	62,591			181,883

During the past decades, potatoes have become the most important cash crop in particular for mountainous farmers (>1,800 m asl) in Bhutan (Roder et al. 2009). The average tuber yield is low (82.5 dt ha^{-1}) ranging from 45.9 dt ha^{-1} (Zhemgang) to 106.7 dt ha^{-1} in the Wangdue Dzongkhag (MOAF 2013). In most regions, there is a trend for increasing tuber yields except for Central Bhutan where missing crop rotations reduce the productivity. Mineral fertilizer use in potatoes is proportionally greater than for other crops (Roder et al. 2008). In eastern Bhutan (Mongar region), potato farmers apply ~20 t of farmyard manure (FYM) per ha with a trend for reduction due to keeping less cattle (Dema et al. 2012). Interestingly, the most important biotic constraint in potato production is wildlife (mainly feral pigs) followed by late blight caused by *Phytophthora infestans* and viruses (Roder et al. 2008).

Other important cash crops targeted for export are mainly grown at lower altitudes and include citrus (5,490 ha), cardamom (3,600 ha) and arecanut (1,200 ha). Apple is the main cash crop (2,080 ha) grown at high altitudes (SYB 2013).

Rice yields in Bhutan (32.4 dt ha^{-1} in 2011) are on average comparatively low but slightly higher than in Nepal (29.8 dt ha^{-1}). In contrast, rice productivity in India (35.9 dt ha^{-1}) and Bangladesh (42.2 dt ha^{-1}) was higher in 2011 (FAO 2014) and fostered by favourable climatic conditions and intensive production with up to three seasons. Corn and wheat yields in Bhutan are low and comparable to Nepal, India and Bangladesh. Potato yields, in contrast, are much lower in Bhutan (82.5 dt ha^{-1}) than in Nepal (137.3 dt ha^{-1}), India (227.2 dt ha^{-1}) and Bangladesh (180.9 dt ha^{-1}). The low crop productivity in Bhutan is a function of many factors such as low soil fertility, inadequate input supply, e.g. low quality seeds, ineffectual techniques, inefficient management, labour shortage and missing infrastructure. According to a survey conducted in 1999, some 40 % of 374 interviewed farmers reported a trend to lower yields in the last 15 years, mainly for wheat and buckwheat. On the other hand, 27 % of the respondents observed an increase in crop yields. Decreasing yields were mainly explained with the lower fertility status of the soil, while the impact of pests and diseases as well as of wild animals was considered to be less important. The main reasons given for increased yields were improved fertility management via both mineral and organic fertilizers and the use of high-yielding varieties (Norbu and Floyd 2004). The study also revealed that nearly half of the 374 soil samples assessed had a low or very low pH (<5.5), while soil carbon contents were frequently moderate or high. Approximately 98 % of the samples had a low or very low (40 %) or moderate (58 %) total nitrogen content, resulting in wide soil C/N ratios. About 50 % of the samples were rated low in available phosphorous (<5 ppm P) and potassium (<40 ppm K). Cation exchange capacity and base saturation were low or very low in 70 % of the samples including low values for exchangeable magnesium and calcium (Norbu and Floyd 2001). Further research conducted in potato–maize-based farming systems in eastern Bhutan demonstrated that crop yields and soil organic matter decreased over the years (2002–2008) although mineral fertilizer input with ammonium nitrate granular (44 kg N ha^{-1} $year^{-1}$) and urea (101 kg N ha^{-1} $year^{-1}$) remained constant (Dema et al. 2012).

Traditionally, soil fertility management in Bhutan has been based on farmyard manure. Manures were gained either by tethering animals in the fields or stables. These systems were often combined with the integrated use of forest as a source of fodder and litter (Norbu and Floyd 2001). The average input of FYM to arable land is estimated to be ~7 t ha^{-1} resulting in nutrient inputs of ~41 kg N, ~9 kg P and ~59 kg K per ha (Dorji 2008). The use of mineral fertilizers, predominantly urea, has increased since the 1960s but the absolute application rates still remain low compared to other Asian countries due to physical unavailability, lack of purchasing power and low farm profitability.

Another issue of concern in Bhutan is the missing availability of high quality seeds for a range of important crop species. Even in regions with a well-developed organic sector such as the European Union, seed-borne diseases, e.g. common bunt (*Tilletia caries*) in wheat, may limit the productivity of organic cropping systems (Lammerts van Bueren et al. 2003). Rice seed quality in Bhutan generally seems not to be of major concern, since yields are similar to Nepal, which has comparable growing ecology. The low wheat yields in contrast suggest that seed quality is insufficient. For the grass and legume seed production in Bhutan, guidance is provided by the National Fodder Seed Production Centre in Bumthang. Seed quality standards however are low, and there are unprecise requirements, e.g. for white clover only a germination ability of >60 % (Dorji 2002). To improve the seed sector in Bhutan, similar approaches as suggested for the EU are needed including improved seed quality standards, protocols for seed health testing and efficient organic seed treatments. Prospectively, the implementation of organic breeding programmes focusing on additional targets such as adaptation to low inputs, improved root systems and weed suppression ability (Lammerts van Bueren et al. 2002) will also be required in Bhutan.

Similarly, the amount of pesticides applied in the fields is low and shows a high annual variation, with a trend for increasing herbicide and insecticide use. In 2010, an amount of 11.3 t (or about 100 g per ha) of pesticides has been supplied to the farmers compared with 20.6 t in 2011 (MOAF 2013). Interestingly, wild animals such as monkeys and feral pigs are a major source of crop losses. Protecting the crops by sleeping in the fields is therefore a common method used by farmers in mountainous areas (Roder et al. 2008).

Overall productivity is also limited by lack of mechanization and inadequate agricultural machinery in particular for soil tillage and harvesting. The vast majority of the farmers use animal power for soil tillage and cereals are often harvested by hand (Fig. 1). The frequent lack of irrigation systems rather than water availability may limit productivity of rice and vegetable growing at mid and high altitudes. Cold water irrigation however may negatively affect rice yield and quality and may require adaptations such as using tolerant cultivars (Farrell et al. 2006). The technological underdevelopment of Bhutan is also reflected by limited

Fig. 1 Hand-harvesting of rice in Yayung, Mongar Dzongkhag, 6 October 2012

research infrastructure with five research centres on natural resources (RNR) and only one agricultural laboratory. Academic libraries in Bhutan still have a low standard (Ransom 2011).

Finally, in contrast to most other Asian countries, Bhutan suffers from a serious labour shortage, resulting in a visible increase of the proportion of fallow land (author's observation). According to Roder et al. (2009), labour shortage and minimal use of herbicides are the main reasons for the increase of weed problems in most potato-growing regions in recent years.

In summary, the low crop and labour productivity in Bhutan is a function of various factors and any improvement will require investments in soil fertility management, machinery and dissemination of know-how.

Animal husbandry

Bhutan has a wide range of farming systems with livestock in tropical and cold mountainous areas, small-scale subsistence (<5 ha) and commercial farming (>5 ha). Throughout the country and the farming systems, diverse livestock species—including cattle, yak, sheep, goats, horses, chicken, pigs, ducks and geese, bees and others—play an important role supplying services and products such as draught, manure, milk, meat, eggs, honey, protection (dogs) and pest management (cats). Most of the animals are kept in a traditional way in free range flocks and would comply with any standard or regulation of organic farming certification. Because livestock is kept only for subsistence purposes or local marketing without quality distinction, no organic certification of animals is currently conducted.

Cattle play the main role in livestock farming with ~303,000 heads in 2011 (MOAF 2013), resp. 0.43 cattle per capita. These ruminants graze on steep marginal grassland and shrub land (in sum ~14.5 % of Bhutan's surface, Table 2) corresponding to roughly 550,000 ha. They are kept on farm land or on communal and free range areas and fed with additional rice straw and maize, since grassland yields are generally less than 2 t ha^{-1} a^{-1} (Roder et al. 2001).

Uncontrolled cattle are typical for Buddhism and countries influenced by Indian traditions. Free roaming cattle of both sexes and all ages normally search for feed in the rural and urban areas. Many suffer from seasonal and regional feed shortage and are low quality. Consequently, animals are skinny, sick and relatively unproductive, producing on average 1–2 l milk day^{-1} for dairy, and low or no weight gain.

The local cattle breeds Mithun and Nublang dominate the population, while more productive cross breeds with imported Jersey and Brown Swiss genetics have only a low share, making up less than 20 % of all cattle (MOAF 2013). Due to the tradition, cattle are not slaughtered, and in part left on their own. Transmission of diseases, minimal animal welfare and abuse of scarce resources by overgrazing and *Rumex* spp. infestations are potential problems related to this type of cattle husbandry. The cattle on farm land (mainly dairy cows) are usually in better condition and are more productive (the production is low input − low output as well) and animals receive acceptable nutrition and health care. For many self-sufficient households, farmyard manure is the main product of the cattle.

Besides the cattle, poultry for eggs and meat sold through local markets are being promoted by the government. Nevertheless only 200,000 chicken, some ducks and geese were kept (0.3 animals per capita) in 2011 (MOAF 2013). Alongside the free range local breeds of chicken, some farmers have sheds with flocks of a hundred or more hybrid chickens.

Small ruminants—colloquially known as "cows of the poor"—do not play much of a role in farming. In 2011, there were only ~12,500 sheep and ~43,000 goats in Bhutan (MOAF 2013). The country law only allows up to five sheep and/or goats per household producing meat, wool and manure. These species are much less accepted than the multi-purpose cattle, which provide manure, milk, meat and draught. Pig farming is rare, with only 21,000 heads, and only for local or home consumption. One or two sows are kept in corresponding households to use the kitchen waste and cropping by-products. There are about 23,000 horses and to a lower extent mules used for transport in the few urban and peri-urban areas, for rural work or for long-distance journeys (MOAF 2013).

Organic agriculture in Bhutan

In 2003, the National Organic Programme affiliated with the Ministry of Agriculture and Forests was established to promote OA in Bhutan. Strategic steps to accomplish this goal were (i) developing a coordination and advocacy institution, (ii) establishing organic communities and pilot activities, (iii) ensuring political recognition, (iv) providing critical inputs for organic farming, (v) establishing advisory services, (vi) developing organic markets and (vii) implementing a certification system (Duba et al. 2008).

Currently (2011), organic production is estimated to amount 20,995 ha (Willer et al. 2013) which in theory corresponds to 7.8 % of the total agricultural area. The wild collection of medicinal and aromatic plants covered another 15,605 ha in 2011 (Willer et al. 2013). Certification is done by Indian agencies since Bhutan has national organic standards but no certification system. Certified products including honey, tea, spices, herbs, essential oils and soaps are predominantly marketed by the private export company BioBhutan. Most of the organic production is just an occasional compliance with the regulations, e.g. no use of agrochemicals due to missing availability. Other principles of OA such as the primacy of soil fertility are not necessarily attended to, however.

The government does not currently provide direct financial support for conversion or maintenance of OA. Also, the total financial budget provided to support OA is low (~550,000 US $ for 2008–2013, GNHC 2013) and is largely outcompeted by other agricultural sectors such as the citrus production (~900,000 US $). Hence, the tenth 5-year plan concludes that OA in Bhutan is still in the very early stages of development (GNHC 2009).

Rural households and food supply

The vast majority of the rural households live from subsistence farming. The average farm size is about 1.2 ha and the annual income per capita of the rural population was about 451 US $ in 2011 (MOAF 2013). In 2011, about 45 % of the rural households did not produce enough grains for subsistence (MOAF 2013). The most important food commodity (rice) had a self-sufficiency ratio of only 51.3 %. The average self-sufficiency ratio of all cereals other than rice was 63.6 %. In contrast, fruits and vegetables had a self-sufficiency ratio above 100 % (MOAF 2013).

Food habits in Bhutan are changing rapidly mainly due to growing purchasing power and the availability of cheap imported food. Rice is a household staple in the eastern and central regions, with an annual supply of 137 kg per capita. Other grains such as maize and buckwheat are consumed at an annual rate of 118 kg per capita (MOAF 2013). The national average energy intake per person and day was 2,657 kcal in 2011 (MOAF 2013). Livestock and dairy products form an important part of Bhutanese diet and are consumed at least once a day. In contrast, vegetable and fruit consumption is low.

Agricultural policy in Bhutan

Agricultural policy in Bhutan started in 1961 with the implementation of the first 5-year plan. In that first phase, a clear food security focus was set on the increase of production via capacity building. At that time, institutions and the first research farms were established (Roder et al. 2009).

In the 1970s, more public resources were invested in nutrition improvement, marketing, poverty alleviation and in biodiversity conservation. Infrastructure and communication were enhanced in the following two decades resulting in a more market-oriented agricultural production. The concept of RNR was implemented in the early 1990s, which made Bhutan a pioneer of nature protection in Asia (Roder et al. 2008). The country is known for its commitment to preserve its cultural and natural heritage. Bhutan's natural legacy and wildlife make the kingdom a worldwide biodiversity hotspot (Kubiszewski et al. 2013). More than half of the land is under environmental protection (MOAF 2013) and ecosystem services in Bhutan have recently been estimated to amount to 15.5 billion US $, a value that by far exceeds the annual GDP (Kubiszewski et al. 2013).

Specialised agricultural services, including the release of high quality seeds, e.g. hybrid white cabbage and broccoli, were implemented during the last decade. The tenth 5-year plan (2008–2013) is mainly focussing on poverty reduction by strengthening the economy in all sectors (GNHC 2009). With regards to the RNR sector, the policy objectives were (i) to enhance sustainable rural livelihoods through improved agricultural and livestock productivity and (ii) to ensure sustainable food security and income generation. The proposed strategies also include the diversification of the RNR sector economic base through the promotion of high value crops or organic products. In the recently published 11th 5-year plan (2013–2018), the government has identified four core areas to develop agriculture and achieve food self-sufficiency. These include (i) investment in irrigation, (ii) farm mechanization, (iii) electric fencing to ward off wild animals and (iv) land development (GNHC 2013).

Discussion and outlook

The political reasons for promoting the conversion to OA are linked mainly to the positive ecological performances of this production system. Organic Agriculture is known to favour biodiversity compared with conventional farming (Mäder et al. 2002; Hole et al. 2005), to reduce resource consumption and environmental pollution (Nemecek et al. 2011), and to better protect animal welfare (Kijlstra and Eijck 2006). The likely result from Organic Farming is a high quality product, less detrimental to human health and to the environment compared with conventional management.

In view of the extensive production systems currently practised in Bhutan, the government considers the full conversion to OA to be a calculable risk with promising opportunities, in particular the reputation of a positive unique characteristic, i.e. a 100 % organic country. Furthermore, the government expects positive effects on farmer incomes and on productivity of marginal areas from this conversion (GNHC 2009). While the positive ecological effects of converting to OA are indisputable, the socio-economic implications deserve further analysis starting with a coherent definition of OA.

According to the USDA "Organic Agriculture is production system which avoids or largely excludes the use of synthetic compounded fertilisers, pesticides, growth regulators, and livestock feed additives. To the maximum extent feasible, organic farming systems rely upon crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients, and to control insects, weeds, and other pests" (Lampkin 1990).

According to the International Federation of Organic Agriculture Movements (IFOAM) "any system that is based on the principles of OA and uses organic methods, is regarded as 'Organic Agriculture' and any farmer practicing such a system as an 'organic farmer'. This definition includes various forms of certified and non-certified OA. Guarantee Systems may be for instance third party certification, including group certification, as well as participatory guarantee systems" (IFOAM 2013).

The tenth 5-year plan (2008–2013) states that both types, certified and non-certified OA, are suitable for Bhutan (GNHC 2009). Subsistence farmers will opt for non-certified systems while market-oriented production will need to be certified, at least for export. The economic and agronomic perspectives of OA in Bhutan still need further analysis. The basic concept of market-oriented OA follows the simple equation that certified organic products, with an expected higher process quality than conventional goods, are rewarded by the consumer. The high market price compensates for lower yields and higher production costs. The equation is favourable when both factors are present: skilled producers ready for conversion and consumers purchasing organic products.

Export of certified organic crops such as banana, cotton, tea or spices may be a valuable tool to raise farmer incomes (Jimenez et al. 2007; Bachmann 2012; Moumoni et al. 2013). The approach is consistent and has a growing potential also in Bhutan provided that marketing, infrastructure and logistics work. Competitiveness will mainly depend on the quality and image of the organic products from Bhutan. Premium price is a major factor for OA conversion. A recent survey on the adoption of organic cotton production in Benin showed that for farmers ($n = 100$) the most important drivers for conversion were income stability (89 %) and income level (75 %) as a result of the premium of 20 % on top of conventional prices. Health issues related to pesticides were only mentioned by 36 % of the respondents. Only 2 % of the respondents adopted organic cotton production for environmental reasons (Moumoni et al. 2013).

The success of organic products on the Bhutanese home market is difficult to predict. Environmental awareness and adapted consumer behaviour depend on various factors including access to information, purchasing power and pressure by environmental problems. In Mexico, for example, less than 5 % of the organic production has been estimated to be sold as organic on the internal markets (Gómez Tovar et al. 2005). The specific situation of Bhutan with a sensitive population and a vigilant government with great commitment to nature protection may support the establishment of organic markets. Nonetheless, it is questionable whether Bhutanese consumers will be ready to pay premium prices for organic quality in large scale. Already today, the more expensive red rice from Bhutan is less competitive than the cheap rice from India. Higher farmer prices however will result in higher consumer prices unless organic compared to conventional yields are maintained or increased and production costs significantly reduced. The impact of OA on farmer incomes relying on local marketing is therefore mainly a function of crop yields before and after conversion.

A comparative study between conventional and organic rice growing systems carried out on the Philippines showed that rice yields were on par between both groups with average yields ranging between 3,424 kg ha^{-1} for organic farmers and 3,478 kg ha^{-1} for conventional farmers. An important factor for success turned out to be the participation in rice breeding and improvement programs offered by MASIPAG, a network of farmers' groups, scientists and NGO's on the Philippines (Bachmann et al. 2009).

With respect to food policy, it is problematic that a country has a strong imbalance between domestic production and consumption in particular in situations where prices increase (Seck et al. 2010). Although Bhutan does not play a relevant role for rice demand on the world market, an increase of the self-sufficiency rate (48.7 % import in 2011) still remains an important strategy to increase food security.

Furthermore, it is unclear whether the conversion to OA will have a positive impact on the livelihoods of subsistence farmers, as expected by the Government. A recent study carried out with 240 farmers in three Indian states generally supports this assumption. Reduced input costs without affecting the net margin resulted in higher benefits of organic compared with conventional farmers. Lower average yields for organically produced rice (2.95 versus 3.16 t ha^{-1}) and wheat (1.45 versus 2.46 t ha^{-1}) were compensated by higher equivalent yields from intercropping (Paneerselvam et al. 2010). The authors concluded that OA has a real potential to increase food security of smallholder farmers in India. The importance of organic management practices to raise productivity in low input agriculture is widely recognized. A meta-analysis of 202 successful low input systems projects in 52 developing countries revealed that key elements of OA, including more efficient water use, soil fertility improvement and non-chemical weed and pest control, were major factors for a sustainable productivity increase (Pretty et al. 2003).

Currently, the impact of a conversion to OA on crop yield and yield stability is under discussion. A recent meta-analysis of 362 data sets (including 22 sets from Asia) comparing conventional and organic crop yields showed that organic yields were on average 80 % of the conventional agriculture ones (Ponti et al. 2012). In Asia, mainly India, average yields of OA were 11 % lower than conventional yields. A further meta-analysis partly confirmed these estimations (Seufert et al. 2012). Over 316 comparisons organic yields were on average 25 % lower than conventional yields. Interestingly, yield differences were much higher in developing countries. Based on a comparison of 67 data sets mainly from India, yields of organic versus conventional production were on average 43 % lower (Seufert et al. 2012).

Yield comparisons of individual crops are of limited validity, however, since yields over time, i.e. rotation yields, are not considered adequately (Connor 2013). Organic systems require time periods to grow fertility building crops such as fodder legumes (non-food crops) or have to rely on using unrepresentative amounts of manure (e.g. Gopinath et al. 2009). Therefore, OA is best suited for areas where population density relative to agricultural area is low (Smithson and Giller 2002).

Yield data comparisons also have to be interpreted on different levels and need to consider the dynamics within the systems in particular with respect to progress induced by innovation. A first comparison level has to consider actual yields of both systems. First assessments on rice in Bhutan suggest that conventional and organic yields now do not differ due to the low general yield level (own observations). However, under field experimental conditions (CNR in Lobesa), high rice grain yields could be obtained through intensification systems (SRI) including high-yielding varieties, transplanting, manure and herbicide application. For example, the best rice variety (IR64) yielded 10.1 t ha^{-1} (Lhendup et al. 2009). Some of the proposed intensification strategies however are ambivalent from a practical and ecological point of view.

A second level of comparison needs to target yields that can be attained if major constraints were resolved (Titonell and Giller 2013). While organic systems are constrained by standards that prohibit the use of mineral nitrogen and other chemical inputs, conventional systems can increase yields by application of chemical inputs provided that they are available, accessible and affordable. Yield stability is crucially important for the economic viability of a farm. Although this aspect has not yet been subjected to a large-scale empirical analysis, there are hints that the production risk due to pest and diseases is higher in organic than in conventional farms (Ponti et al. 2012). In 1995, for example, a weather-induced epidemic outbreak of rice blast probably resulting from latent seed infections surprised many farmers in Bhutan leading to yield losses of up to 100 % (Thinlay et al. 2000). Unfavourable weather conditions, in particular frequent rainfall after potato tuber initiation, may cause heavy leaf infestation with late blight (*P. infestans*) potentially resulting in significant yield losses (Fontema and Aighew 1993; Roder et al. 2008).

Farmers and their attitudes are important drivers for conversion. In Bhutan, however, they are often unskilled and only have poor access to information (Tobgay 2005). Currently, it is not known whether Bhutanese farmers are really in favour of converting to OA. A recent survey carried out with 240 conventional and organic farmers in three Indian States gives some indications on farmer attitudes concerning conversion. Conventional farmers were mainly worried about yield decreases, pests and diseases, and problems with marketing after conversion. Interestingly, the willingness to convert greatly varied between the Indian States ranging from 25 to 93 %. Most respondents considered institutional support to be a key element for successful conversion (Paneerselvam et al. 2012). Public support to OA in Bhutan, in contrast, is currently restricted to the conceptual level such as releasing documents. On the operational level, no support, e.g. payments during the conversion period, is provided by the government.

Outlook

The population of Bhutan is expected to increase by about 160,000 people (23 %) until 2030 (SYB 2012). There is a political consensus that agricultural productivity needs to be increased. Many of the key approaches to improve productivity are independent of the growing system in particular soil organic matter management, liming, increased nutrient efficiency, use of high quality seeds, agricultural engineering, improved livestock husbandry and farmers training (Tilman et al. 2002). Enriching the basket of technologies with the specific methods used in OA, in particular the inclusion of fodder legumes in crop rotations of the prevalent mixed farm systems, will have a positive effect on overall productivity provided that P-supply is sufficient (Peoples et al. 1995). Likewise, mechanical weed control adapted to the topography is a promising option for Bhutan. In general, priority should be given to ecological intensification, which incorporates natural biodiversity and processes to increase crop productivity (Tscharntke et al. 2012). In any case, a large financial commitment will be necessary to start a comprehensive investment programme focussing on the bottlenecks of agricultural productivity.

At this stage, it is still unclear whether a binding system of OA is Bhutan's best option. A thorough evaluation requires more comparative empirical data on the agronomic and economic impacts of organic and conventional systems than has been done until now. In addition to trade policies, market and infrastructure development, the organic sector can benefit from a well-resourced Centre of Excellence focussing on research and knowledge transfer.

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