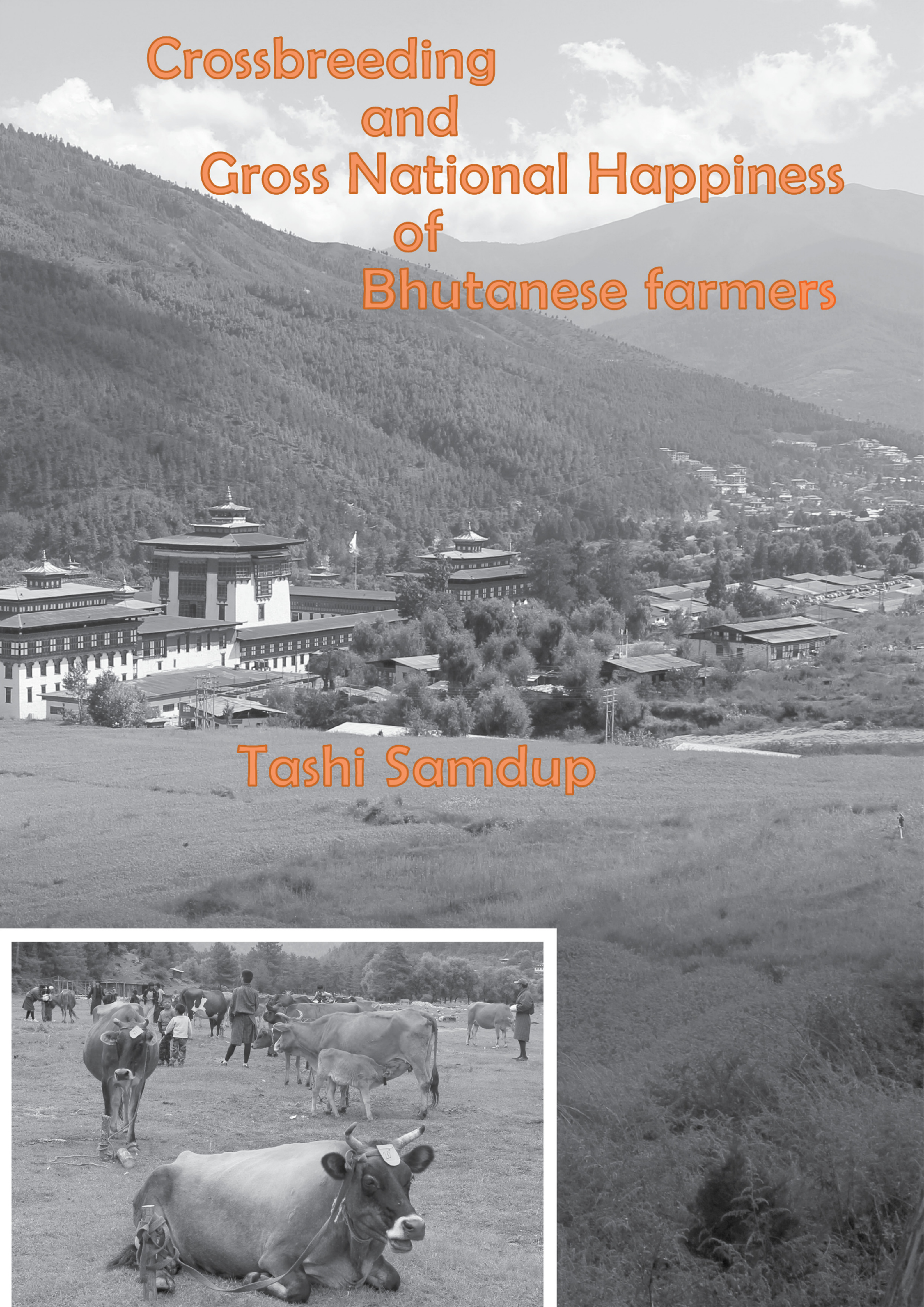
Crossbreeding and Gross National Happiness of Bhutanese farmers

Tashi Samdup



Propositions

1. To enhance the wellbeing of the Bhutanese, crossbreeding should target the many not the few.
   (this thesis)

2. Bhutan's gross national happiness was ahead of its time in acknowledging the four dimensions of sustainability: good governance, environmental integrity, economic resilience and social well-being.
   (this thesis)

3. Achieving the first sustainable development goal of the United Nations – end poverty in all its forms everywhere by 2030 – is a myth.

4. Alternative medicine is plagued by fallacies that confuse or mislead the public and thus prevent many patients from making the right therapeutic decisions.

5. Bhutan's desire to share in global economic development collides with retaining its traditional cultural identity.

6. Despite the negative connotation of women quota, they are essential in Bhutan.

Propositions belonging to the thesis, entitled
'Crossbreeding and Gross National Happiness of Bhutanese farmers'.
Tashi Samdup

Wageningen, 16 May 2018

Crossbreeding
and
Gross National Happiness of Bhutanese farmers

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Abstract

Bhutan has embarked on the gross national happiness (GNH) development concept. However, its operationalisation needs more focus on the issues of the smallholder farmers which comprise about two-thirds of the population. A practical implementation of GNH for rural areas is cattle crossbreeding for dairying, aiming not only to improve livelihoods of farming households and to meet the increasing demands of livestock products, but also to sustainably use natural resources. This thesis evaluates whether crossbreeding has benefited farmers from a GNH perspective across time and space. The study areas are described as extensive, semi-intensive, intensive and intensive peri-urban. In 2000, in each area participatory field workshops with farmers (n=120) and other stakeholders (n=28) were organised to select issues at farm level. Data on households, cropping, livestock and off-farm activities were collected by trained enumerators through interviewing 183 households in 2000 and 2004. In 2015 only 123 of the same households could be revisited; the other households had migrated to other areas or had given up farming, as rearing of livestock was no longer permitted in the intensive peri-urban area. In 2002, a national workshop with 20 experts was organised to select issues and their indicators for developing an integral approach to communicate progress in GNH development in the four areas. Selected indicators were standardised by establishing a performance value range for five performance categories of each indicator. The standardised indicator values were aggregated to an economic, societal and environmental index. The adoption of crossbreeding varied strongly between areas with high percentages of crossbred cattle in intensive areas and low percentages in the extensive area. Favourable conditions for adoption of crossbreeding were support by projects, functioning farmers' groups, access to urban markets and access to artificial insemination and extension services. Farmers in the intensive areas find livestock intensification through crossbreeding attractive as a source of regular and reliable income. Crossbreeding has not yet been able to reduce the gap between supply and demand of dairy products in Bhutan, but it reduces grazing pressure on common property resources. The integral assessment shows that challenges in the implementation of the GNH concept in rural areas are the increases in rural-urban migration and farm labour shortages, and the need for more equitable socio-economic development.

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Chapter 1

General introduction

1.1 Background of the study

Gross National Happiness (GNH) is the overarching development philosophy of Bhutan (DoP 2004; Rinzin et al. 2007; GNHC 2010). The idea of the GNH concept was initially conceived by the 4th King of Bhutan in the late 1980's (Ura and Galay 2004). It comprises of four pillars: sustainable and equitable socio-economic development, environmental preservation, preservation and promotion of culture and promotion of good governance (GNHC 2013). According to Priesner (1999), the GNH philosophy has evolved in Bhutanese society from the socio-economic system, based on a Buddhist and feudal set of values, before Bhutan opened to the world in the 1960's.

Bhutan's efforts in developing GNH as measure of the country's well-being have coincided with increased distrust in the use of Gross Domestic Product (GDP) as a measure of a country's national development. Several authors have criticised GDP as a materialistic indicator (e.g. Dixon 2004; Costanza et al. 2014). Costanza et al. (2014) conclude that the emphasis on GDP in today's world 'blinds' developing countries to explore possibilities for more sustainable models of development. They advise countries to explore possibilities for more sustainable models of development and comprehensive measures of interventions for sustainable well-being for their population.

Bhutan's constitution directs the state to promote those conditions that will enable the application of GNH. A major challenge, however, is to translate it into reality, in particular in rural areas (Ura and Galay 2004). About 69% of the Bhutanese population live in rural areas, where poverty is a main issue (GNHC 2013). Though poverty rates have declined over the last decades (GNHC 2013), the socio-economic development of regions differs largely, due to differences in altitude and climatological conditions (Rinzin et al. 2007). The GNH policy also has as main focus environmental conservation. The constitution mandates that a minimum of 60% forest cover should be maintained forever. Currently, Bhutan has forest coverage of about 73% (NSB 2016). So, GNH policies for development in rural areas focus on livelihoods, and sustainable use and management of natural resources with a synergy among forests, crops and livestock (GNHC 2009).

Livestock play a vital role in the rural livelihoods in Bhutan (MoA 2009). Cattle are the most dominant livestock, with over 78% of the rural households owning cattle. Crossbreeding of local Siri cattle with Jersey and Brown Swiss is promoted to increase dairy productivity and improve livelihoods of cattle owners in rural areas (MoA 2009). Crossbreeding is also expected to reduce the wide gap between supply and demand of livestock products and to reduce cattle grazing in forest areas. However, whether such a livestock intensification strategy could be a panacea for Bhutan as a whole is not clear, especially because agro-ecological conditions differ widely. So, there is a need to understand how the GNH concept has worked out at farmers' level. Has the intensification strategy benefited all smallholder farmers? Did it have an impact on the use of natural resources? Further, if there have been changes in terms of developments in rural areas, how can we assess such changes?

1.2 Bhutan

1.2.1 Demography and governance

Bhutan is a small Himalayan country bordered by Tibet, an autonomous region of China, and India, and has about 757,042 inhabitants (NSB 2016). In 2015, the average population density was estimated at 19.7 persons per km^2 (NSB 2016). Bhutan comprises 20 districts and 205 geogs (blocks), with Thimphu city as the capital. A district can have between 4 to 15 geogs. A geog is an administrative unit comprising 7 to 112 villages.

From a closed centralised monarchy government system, Bhutan has evolved into a democratic, constitutional monarchy, with a decentralised governance system (Rinzin et al. 2007). This process started in 1981 with the establishment of the District Development Committees (Dzongkhag Yargye Tshogchungs), and in 1991 with the establishment of the Geog Development Committees (Geog Yargye Tshogchungs). The leaders of the geogs are elected by the community and participate in the planning process in prioritising the development activities of the geog. This decentralisation process has brought decision- making closer to local communities (Rinzin et al. 2007).

1.2.2 Socio-economic development

Over the last decades, infrastructure and technologic capacity improved, especially in industry (e.g. hydropower, cement and wood based industries) and tourism (MoA 2002). The GDP per capita increased from US $545 in 2000 (CSO 2001) to US $2879 in 2016 (NSB 2016). The contribution of the agricultural sector (crops, livestock and forestry) to the GDP increased in absolute terms, but decreased from 35% in 2000 to 16.5% in 2016 (NSB 2001; NSB 2016). The latter was due to a marked increase in the contributions of hydropower and tourism to the GDP.

In 2000, the first household income and expenditure survey (HEIS) was conducted by the Department of Planning along with the International

Monetary Fund and World Bank. This survey attempted to estimate a poverty baseline, defined as total monthly per capita expenditure of a household adequate to meet the basic food requirements. This was estimated at US $24 (in Bhutanese currency Nu this equals 1097) per capita per month (DoP 2004). This estimate, in combination with international standards, showed that the poverty rate in Bhutan in 2003 was about 32%, and reduced to 23% in 2007 and 12% in 2012 (NSB 2014). Furthermore, the Gini-coefficient, being an income inequality index ranging from 0 (i.e. everybody earns the same) to 1 (i.e. one person earns all the money), decreased from 0.416 in 2003 to 0.352 in 2007, reflecting a decrease in inequality (HDR 2011). The Gini-coefficient of Bhutan is comparable to its neighbouring countries India and Bangladesh. The observed economic development is largely attributed to the effective implementation of targeted poverty reduction programmes, such as the rural economy enhancement programme, which includes field crops, horticulture and livestock commodity development, and marketing and cooperative development (GNHC 2013).

Crops and cattle (including yaks) are the main sources of farm income (MoA 2009). Dominant crops are: maize and potatoes in Eastern Bhutan, maize and rice in Southern Bhutan, buckwheat, potatoes and apples in Central Bhutan, and rice and apples in Western Bhutan (MoA 2001). In all areas, milk and milk products are an important source of income (MoA 2001).

Bhutan's cattle population consists mainly of local Siri (*Bos indicus)* cattle, their crossbreds with Jersey and Brown Swiss (*Bos taurus*), and Mithun *(Bos frontalis)*, which is a domesticated Gaur (wild cattle species from South and South East Asia (Nowak 1999).

Off-farm activities, such as weaving and working as part-time labourers in construction sites, are common in Bhutan. Farmers also collect different types of mushrooms and other non-timber products (e.g. medicinal plants, bamboos) from the forests to supplement their income (MoA 2001; Cannon et al. 2009). Common non-timber forest products are *Tricholoma matsutake* (matsutake), *Cordyceps sinensis* (cordyceps*)*, and *Cymbopogin flexuosus* (lemon grass) (Turkelboom et al. 2001).

1.2.3 Environment and land use

Bhutan encompasses an area of 38,394 km^2, with about 73% being forest land; 8% arable land, and 4% pasture land (NSB 2016). The altitudes range from 100 m asl (above sea level) in the south to more than 7500 m asl in the north. The large variation in altitude has resulted in a great diversity of climatic conditions. There are six main agro-ecological zones distinguished from north to south: alpine, cool temperate, warm temperate, dry sub-tropical, humid sub-tropical and wet sub-tropical (FAO 1996). This zoning enables to plan and prioritise research and develop activities in the fields of agriculture and natural resources management, based on available resources. Furthermore, four seasons can be distinguished: spring from February to April (cool and dry), summer from May to July (warm and moist), autumn from August to October (warm and wet), and winter from November to January (cold and dry).

Bhutan is one of the ten biodiversity hot spots of the world, home to a diverse array of flora and fauna (HDR 2011). Given its fragile geologic conditions and rugged mountain terrain, conservation and sustainable use of natural resources is essential (MoA 2009). The most important common property resources (CPR) in rural Bhutan are forests, non-timber forest products, pastures, water and agro-genetic resources, such as bamboo, medicinal plants and wild vegetables (Turkelboom et al. 2001). Farmers generally agree that CPR provide a large proportion of their animal feed requirements. Grazing in the forests and natural grasslands is either managed by communities or individual farmers with grazing rights. Therefore, the majority of Bhutan's rural households highly depend on these CPR (MoA 2001). At present, however, CPR are under pressure. This is related to a complex combination of factors, such as presence of locally agreed arrangements, legal status of CPR, methods of commercialisation, and government regulations and facilitation (Turkelboom et al. 2001; Cannon et al. 2009).

Bhutan's river system has an estimated potential to generate 30,000 mega watts (MW) of hydroelectricity (GNHC 2011). Currently, Bhutan produces about 1606 MW of hydroelectricity, and after meeting its domestic demand over 90% is exported to India (DRE 2015). The sound use of the CPR and the watersheds in the forests is extremely important to harness its hydropower potential (MoA 2009; GNHC 2013).

The soils in most parts of Bhutan have a low pH and are poor in nitrogen (Norbu and Floyd 2004). Physical limitations include steep slopes; poor soil depth (organic layer) and high gravel content (Roder et al. 2003). Bhutanese farmers are highly dependent on farmyard manure to fertilise their crops, so animals bring manure into the agricultural system by grazing in CPR and feeding on supplements from outside the farms (MoA 2002). However, the manure and organic fertilisers are not used efficiently to realise the potential yields (NSSC 2010).

A survey on peoples' perceptions of GNH policies showed that the majority of the respondents rated environmental conservation as very important, although farmers and herders face difficulties with predation from wild boars, bears and tigers (Rinzin et al. 2007; Namgay et al. 2014).

1.2.4 Culture

At the national level, preservation and promotion of Bhutanese culture, such as the national language, traditional customs (national dresses, local festivals, art and crafts) and religious heritages (monasteries), is considered vital, because once lost it cannot be regained or compensated by other means (Planning Commission 2002; GNHC 2013). Public opinion is that Bhutanese culture serves to identify Bhutan as a nation state (Rinzin et al. 2007).

At the community level, values such as family cohesion, culture of bonding of individuals as members of extended families and communities are very important (Thinley 1999). To what extent such cohesion still exists is not well documented. Buddhist cultural beliefs also emphasise a harmonious co-existence with the natural elements. Buddhists in Bhutan believe that mountains, deep ravines, ancient trees and rocks are the abode of spirits, god and demons (Rinzin et al. 2007). Disturbing these elements would enrage them and bring ill luck, sickness and even death to the family, while appeasing them may bring luck and prosperity. Similarly, Bhutanese generally do not slaughter their domesticated animals. Paradoxically, the Bhutanese per capita consumption of meat (mainly beef, pork and chicken) in 2012 was about 14 kg per year, which is considered to be one of the highest in South Asia (DoL 2013b). It is only in the yak rearing areas where herders occasionally slaughter yaks, and in the southern areas (mainly people of Hindu belief) where farmers slaughter pigs, chickens and goats for their own consumption and sale (DALSS 2002). In the southern parts of Bhutan, culled cattle are usually sold to Indian Muslim butchers across the border and the Bhutanese buy the meat from them. Beef available on the markets is mostly imported. Beef available on the farms comprises of animals that died naturally and those that died due to predation or accidental fall from the cliffs into the ravines.

1.3 GNH concept

1.3.1 Concepts to measure development of nations

Besides GNH, there are various other alternative concepts to GDP to measure national development of countries, such as the Human Development Index (HDI), the Genuine Progress Indicator (GPI) and, recently, the United Nations Sustainable Development Goals (SDGs). GDP was developed by Simon Kuznets for a US Congress report in 1934. It measures the value of economic activity within a country. Kuznets already warned for equating economic growth with well-being (Colman 1998). Costanza et al. (2014) quoted Robert F Kennedy, who once said that a country's GDP measures 'everything except that which makes life worthwhile'. Costanza et al. (2014) postulate that it is time to leave the concept of GDP behind. However, advantages of GDP are that it is used internationally, monitored frequently and widely, and it allows comparisons of the standard of living in different countries (BEA 2007; Costanza et al. 2014).

The HDI of the United Nations was developed in 1990 by the Pakistani economist Mahbubul Haq. It is commonly used for measuring human well-being of nations (HDR 2009), and is a composite measure of average achievements in key developments in human development: a long and healthy life, being knowledgeable and having a decent standard of living (HDR 2011). The health dimension is assessed by life expectancy at birth; the education dimension is measured by mean years of schooling for adults aged over 25 years, and expected years of schooling for children of school entering age. The standard of living dimension is measured by gross national income per capita. The scores of these three dimensions are aggregated into the HDI. Compared to GNH, the HDI does not include indicators for ecological and cultural preservation, and good governance (Thinley 1999).

The GPI was developed in 1997 by GPI Atlantic, Nova Scotia, Canada, a non-profit research group, to assess whether or not a country's growth, increased production of goods and expanding services has actually resulted in national progress (Colman 1998). The GPI adjusts economic measures to reflect social and environmental factors (Costanza et al. 2014). It, for example, values unpaid voluntary and household work as paid work and counts sickness, crime, pollution as economic costs (Colman and Sagebien 2004; Costanza et al. 2014).

Compared to GNH, the GPI has no indicators pertaining to preservation of culture and good governance.

In 1987, the World Commission on Environment and Development defined the concept of Sustainable Development (SD) as 'a development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987). While the two broad concepts of SD and GNH seem rather similar, there are also differences. SD does not explicitly mention cultural and good governance dimensions. In September 2015, however, the United Nations adopted the new SD agenda with 17 goals and 169 targets for people, planet and prosperity for the next 15 years. These so-called sustainable development goals (SDGs) address poverty reduction, protection of the environment, and ensuring peace and prosperity (United Nations 2016). They are intended to be universal; however, they represent different degrees of challenges for different countries depending on their present state of development (Osborn et al. 2015). The SDGs do compass all the four pillars of GNH. So, GNH and SDGs concepts share many similarities: they are holistic approaches to development; they emphasise the need for a balanced and equitable economic growth, equitable access to public services and goods to promote social harmony; and both emphasise environmental sustainability.

1.3.2 The concept of GNH: theory and practice

The Gross National Happiness (GNH) development philosophy has been a major source of international attention for Bhutan. The first time it drew attention was during the millennium meeting for Asia and the Pacific in Seoul, Korea in 1998 (Thinley 1999). Subsequently GNH gained international popularity following the 1st (Bhutan, 2004), 2nd (Canada, 2005), 3rd (Thailand, 2007), 4th (Bhutan, 2008) and 5th (Brazil, 2009) international conferences on GNH. In July 2011, the United Nations adopted Bhutan's proposal of "Happiness" as a resolution and the UN General Assembly invited countries "to pursue the elaboration of additional measures that better capture the importance of the pursuit of happiness and well-being in development to guide their members' public policies" (UN News Centre 2011). The GNH concept has also captured wide attention in the international press ranging from The Times of India (2018) to the New York Times (2018) and The Guardian (2018).

The current official definition of GNH is a development approach that seeks to 'achieve a harmonious balance between material well-being and the spiritual, emotional and cultural needs of an individual and society' (GNHC 2010).

Efforts to operationalise GNH were initially directed at the national level. All ministries have formed a GNH committee. These GNH committees meet once in two weeks to review related policies and projects of their ministry for coherence with the four pillars of GNH (GNHC 2009). This is a challenge as trade-offs can occur.

The GNH concept is operationalised through subdividing the four pillars of GNH into nine domains: psychological well-being, standard of living, governance, health, education, community vitality, cultural diversity, time use and ecological diversity. These nine domains are equally weighted; they are considered equally valid for happiness (Ura et al. 2015). Within the nine domains there are in total 33 indicators (CBS 2016).

In 2010 the Centre for Bhutan Studies developed the GNH index to assess the development progress of Bhutan as a country and at the district level (CBS 2012). The index uses elaborated surveys, which ask how content people feel in the nine domains.To measure the GNH a profile for each person is created, and for each of the 33 indicators a person is asked if (s)he has achieved sufficiency in that indicator or not i.e. – yes or no (Ura et al. 2015). If a person has a sufficiency (yes) for six of the nine domains or at least two-thirds (66%) of the all the indicators then (s)he is considered 'happy', i.e. extensively happy (66-76%) or deeply (77-100%) happy. Persons not yet happy are categorised as unhappy (0-49%) or narrowly happy (50%-65%) (CBS 2016).

Upon identifying who is happy, the GNH index per district is calculated using the formula (CBS 2016):

$$\text{GNH index} = H^H + (H^U \times A^U_{suff})$$

where GNH index is a number ranging from zero (lowest possible value) to one (highest possible value); H^H is the percentage of people being happy; H^U is the percentage of people being not yet happy (unhappy and narrowly happy); A^U_{suff} is the extent of sufficiency that people are not yet happy (unhappy and narrowly happy) (i.e. 100% minus H^H). The GNH index in Bhutan was 0.743 in 2010 and 0.756 in 2015, an increase by 1.8% which is reported as a significant increase ($p < 0.05$) (CBS 2016).

In terms of enjoying 'sufficiency' in the nine domains, in 2010, on average, 50% of the people in urban areas were happy and only 37% in rural areas were happy. In 2015 the corresponding figures were 55% and 30% respectively which was a statistically significant difference between urban and rural areas

($p<0.001$) (Ura et al. 2015). This indicates that there is a need to specifically address the GNH issues at the smallholder farm level.

1.4 Problem statement

Policy makers are in need of appropriate tools to assess the contribution of different strategies to the development of their country (CBS 2016). Bhutan's GNH index aims to guide policy makers to address questions like how to increase GNH and to track changes over time (CBS 2012). In 2015 during the 'State of the Nations Address', the Prime Minister of Bhutan mentioned that the GNH index provides a snap shot on how Bhutanese citizens are faring in the nine domains; 'we catch a glimpse of their well-being'. Tobgay (2015) concluded that its simplicity helps to make it an effective communication and evaluation tool. The GNH index at the national level, like many comparable assessment tools, however, requires measuring variables for which data are lacking especially issues important for smallholder farmers. Therefore, there is a need to have a methodology to derive GNH issues and indicators which are important for farmers while at the same time keeping in mind the national interests over different spatial and temporal dimensions. Consequently, the application of the GNH development concept at farm level requires a different set of indicators compared to national level assessments.

Many farmers in rural areas in Bhutan live in poverty (MoA 2001). Increasing crop and livestock production is seen as a possible solution to improve the livelihoods of farmers (MoA 2002). In theory, crop and livestock production can increase by either increasing the area of farming or grazing land, and/or by increasing crop yield per ha of land and animal productivity. The first option of increasing the agricultural area is difficult, given the very limited availability of land, as farming on forest land is not permitted due to the national policy to maintain at least a forest cover of 60% (MoA 2002).

As in many developing countries (Udo and Cornelissen 1998; Delgado et al. 2001; Tulachan et al. 2002; Udo et al. 2011), crossbreeding of local cattle with exotic dairy breeds is promoted as a key strategy to increase livestock production. Crossbreeding can result in rapid improvement in animal productivity, implying that you need fewer cattle, but crossbreds also need to fit within the production system (Thornton 2010). Crossbreds need more feed than local cows, because they produce more milk and are bigger (Syrstad 1996). This feed, however, might not be available locally, and, therefore, input of feed might be needed. Moreover, crossbreds might be more susceptible to diseases and require more veterinary services (Bebe et al. 2002; Ojango et al.2016). Other challenges associated with using crossbreds are reproduction problems, high calf mortalities, shortage of replacement stock, inadequate breeding systems and recording facilities, and a loss of local breeds (de Jong 1996; Samdup 1997; Wollny 2003; Udo et al. 2011; Widi 2015).

Before 1998, the cattle breeding policy in Bhutan included provision of Brown Swiss semen to farmers in high altitude areas, Jersey semen to farmers who had good market access especially in the peri-urban areas, and promotion of local breeds in remote areas with harsh environmental conditions. From 1998 onwards, however, the breeding policy was modified upon farmers' request, and the National Dairy Development Centre located in Thimphu provided semen of exotic bulls to farmers all over Bhutan. The question, however, arises how this policy change has impacted the implementation of crossbreeding and to what extent crossbreds have really benefited rural households.

Generally, cattle are evaluated at individual animal level for milk production and reproductive performance (Syrstad 1996), but if crossbreeding is expected to contribute to smallholder livelihoods, it has to be evaluated at farm level. Therefore, there is a dire need to study the impact of Bhutan's cattle crossbreeding policies and the impact on the livelihoods of the smallholder farmers in different livestock production systems.

The most important interaction between cattle and the environment is grazing in the forests (Roder 1990). It is generally suggested that intensification will mitigate the negative environmental impact of livestock (Steinfeld et al. 2006). Little is know, however, about the environmental impact of cattle intensification at the smallholder farms (Widi et. al 2015). Some studies in Bhutan (Dorji 1993; Moktan et al. 2008) state that the number of cattle is too high, resulting in a high pressure on the CPR in the forests. Moktan et al. (2008) observed that the bulk of the cattle population is underfed and is highly dependent on CPR and that these CPR are heavily overgrazed. Overgrazing, forest fires and unsustainable land use have led to land degradation, in particular in Eastern and Southern Bhutan (GNHC 2009). According to Norbu and Floyd (2004), views of the impact of cattle grazing in the forests differ. Some argue that cattle while grazing deplete CPR, since grazing causes damage to trees and seedlings (Rosset 1997). Others argue that grazing of cattle is an effective management strategy to reduce competition between tree seedlings, by eliminating unwanted shrubs and grasses (Roder et al. 2002). This is also in line with the intermediate disturbance hypothesis (IDH) wherein grazing can actually favour plant biodiversity, implying that grazing can play a synergetic role in rangeland and nature conservation (Connell 1978).

Hardin's theory of the 'tragedy of the commons' (Hardin 1968) has influenced government policies on use of CPR for grazing. In the Himalayan region it is mentioned that livestock population exceeds the carrying capacity of land resources (ICIMOD 1985). Therefore, in Bhutan one of the objectives of crossbreeding is to reduce dependence on grazing in CPR, by keeping fewer but more productive cattle and keeping them close to the homestead and complementing the local feed resources with commercial concentrates (Roder et al. 2001).

Quantitative studies on the impact of livestock on the use of natural resources in Asia are scarce (Pilbeam et al. 2000; Thorne and Tannner 2002). This is also evident in Bhutan, with no proper documentation of such studies. Therefore questions arise as: to what extent farmers depend on CPR for maintenance of their cattle herds? Does the cattle herd size match the available feed resources? What is the role of cattle as agents of nutrient cycling, especially in terms of transferring nutrients, such as nitrogen and phosphorus, from the CPR to the farms? Further, to gauge development we need time horizons long enough to capture the long-term trends (Hodge and Hardi 1997). Such assessments could provide some indication as to whether the GNH concept conceived at the national level has benefited the farmers.

1.5 Research approach

1.5.1 Objective

The objective of this study is to evaluate whether crossbreeding of dairy cattle has benefited rural farmers from a GNH perspective across time and space. To this end, the national GNH concept needs to be translated first from the national/district level to the farm level. We therefore, identified important GNH issues and indicators at the farm level through participatory approaches and literature review. Subsequently we aim to evaluate whether livestock intensification through crossbreeding for dairying has benefited the farmers from a GNH perspective over different temporal dimensions. As the potential for crossbreeding is expected to differ across agro-ecological zones, four geographical areas of Bhutan were selected.

1.5.2 Description of the four agro-ecological areas

The four agro-ecological areas selected varied widely in terms of farm intensification, i.e. the number of crossbred cattle per farm, feeding of concentrates per cow, and market accessibility (Figure 1).

They include the Khaling area (in the east of Bhutan) representing Bhutan's extensive farming systems; the Dala area (in the south) representing the semi-intensive farming systems; the Chokhor (in the central part) representing the intensive farming systems; and the Chang area (in the western part) representing the intensive peri-urban farming systems.

The Khaling study area (extensive) is characterised by mainly local Siri cattle grazing in the forest and on natural grasslands with some night feeding, no crop irrigation, a mild temperate climate, and poor market access (no motorable road to local markets, 4-5 h needed by vehicles to reach large markets). Dala (semi-intensive) is characterised by Siri and crossbred (Siri x Jersey) cattle in equal proportions, mainly grazing with some stall feeding, limited commercial concentrate feeding, some irrigation, and medium market access (no regular transport services, 2 h needed for vehicles to reach large markets). The Chokhor area (intensive) has mainly Siri x Brown Swiss crossbred cattle, while Chang (intensive peri-urban area) is characterised by Siri x Jersey crossbreds and pure

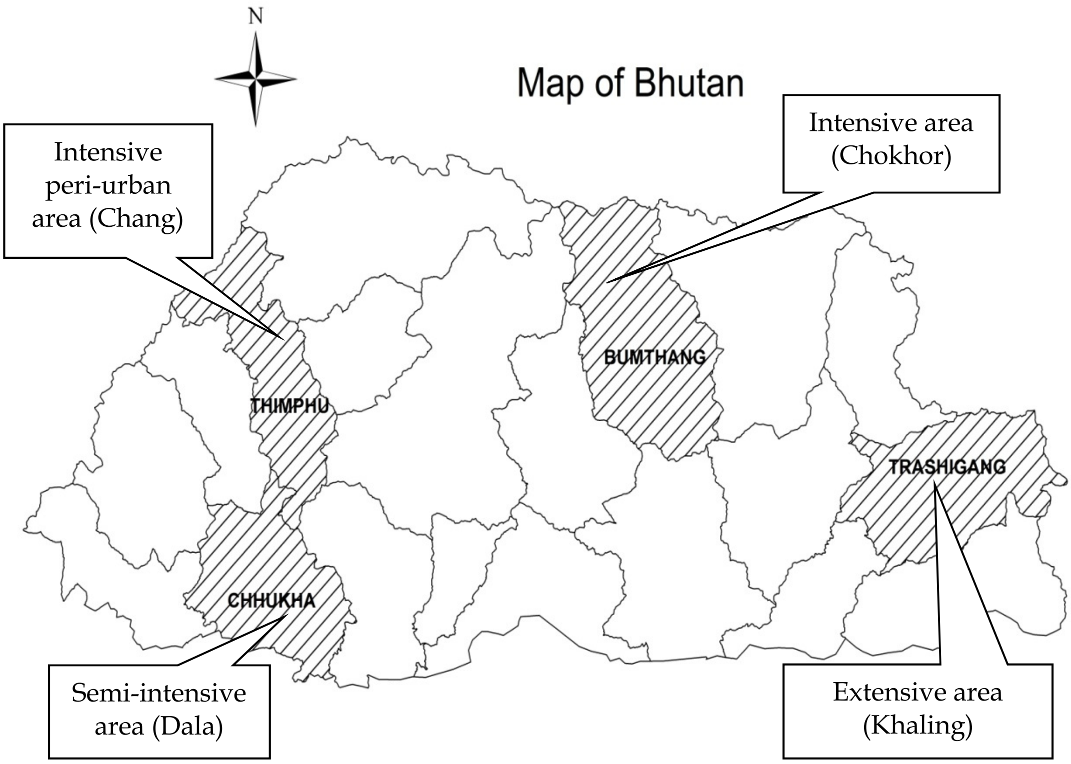

Figure 1. Locations of the four study areas in Bhutan (DoS & LR 2007)

Jersey coupled with stall feeding, commercial concentrate feeding, access to markets, irrigation and use of inorganic fertilisers. The Chang area is close (20-30 min) to the capital city Thimphu.

1.5.3 Developing and applying a GNH concept at farm level

The GNH index includes indicators at a national and district level, most of which are not suitable at the farm level. Therefore a different methodological framework is applied: an approach that is comparable to studies where SD is used to assess environmental, societal and economic performances of different farming systems or farming practices (e.g. Mollenhorst 2005; Thomassen 2008; Phong 2010; Dekker 2012). Common steps in these studies are: identification of stakeholders and issues using participatory approaches, expert consultation, selection of indicators, assessing the indicators and integrative assessment.

After having identified the study areas and stakeholders, participatory approaches were used to identify important GNH issues (Chevalier 2004; Reed et al. 2008). We organised four field level workshops (one and half days) in each of the four study areas. In each of the study areas we invited 30 farmers for the field level workshops. In 2002 a national level workshop was held in Thimphu. Collection of technical, societal, economic and environmental data from 183 households started in 2000 and was repeated in 2004 and 2015. Households were selected at random. A household in this study refers to adults and children actually residing in the area during the survey period.

Table 1 provides an overview of the research methods and sample categories in the research chapters during 2000, 2004 and 2015. The base year of 2000 was chosen since this year was the first year in Bhutan that a detailed nationwide census for crop and livestock activities was done (DoL 2001; MoA 2001). This resulted in availability of published and reliable field data. The year 2000 was also chosen to capture changes in the livestock breeding policy in 1998 (DALSS 2002). To capture the short and long trends in the changes at farm level we used a time horizon of 2000-2004-2015 in the integral assessment.

Table 1. Overview of research methods and sample categories in research chapters

Research method	Study sample unit	Total respondents
chapter 2		
field level workshops (4)	household heads in 37 villages	120
	representative of the village	4
	livestock traders	4
	district MoAF extension staffs	28
national level workshop (1)	district MoAF officers	12
	representative of farmers	4
	livestock production expert	1
	social science expert	1
	veterinarian	1
	policy and planning officer	1
chapter 3	(37 villages)	
in-depth interviews	Khaling (extensive area); 6 villages	
and monitoring	Dala (semi-intensive area); 9 villages	
	Chokhor (extensive area); 16 villages	
	Chang (peri-urban ext. area); 6 villages	183
chapter 4	(37 villages)	
in-depth interviews	Khaling (extensive area); 6 villages	
and monitoring	Dala (semi-intensive area); 9 villages	
	Chokhor (extensive area); 16 villages	
	Chang (peri-urban ext. area); 6 villages	183
chapter 5	(31 villages)	
in-depth interviews	Khaling (extensive area); 6 villages	
and monitoring	Dala (semi-intensive area); 9 villages	
	Chokhor (extensive area); 16 villages	123

1.6 Thesis outline

This thesis consists of six chapters, starting with a general introduction with emphasis on the major objectives of the study, four empirical chapters, and a general discussion and conclusions as visualised in Figure 2.

Chapter 2 sets the scene to understand the importance of the GNH concept at the farm level. It presents a participatory methodological framework to identify issues for the GNH concept at the farm level. Furthermore, this chapter identifies priorities for development of the majority of the farming population related to the theoretical concept of GNH.

Chapter 3 evaluates the impact of crossbreeding and livestock intensification for dairying in Bhutan. It looks into the impact of livestock intensification through crossbreeding on farming systems in the four areas differing in agro-ecological

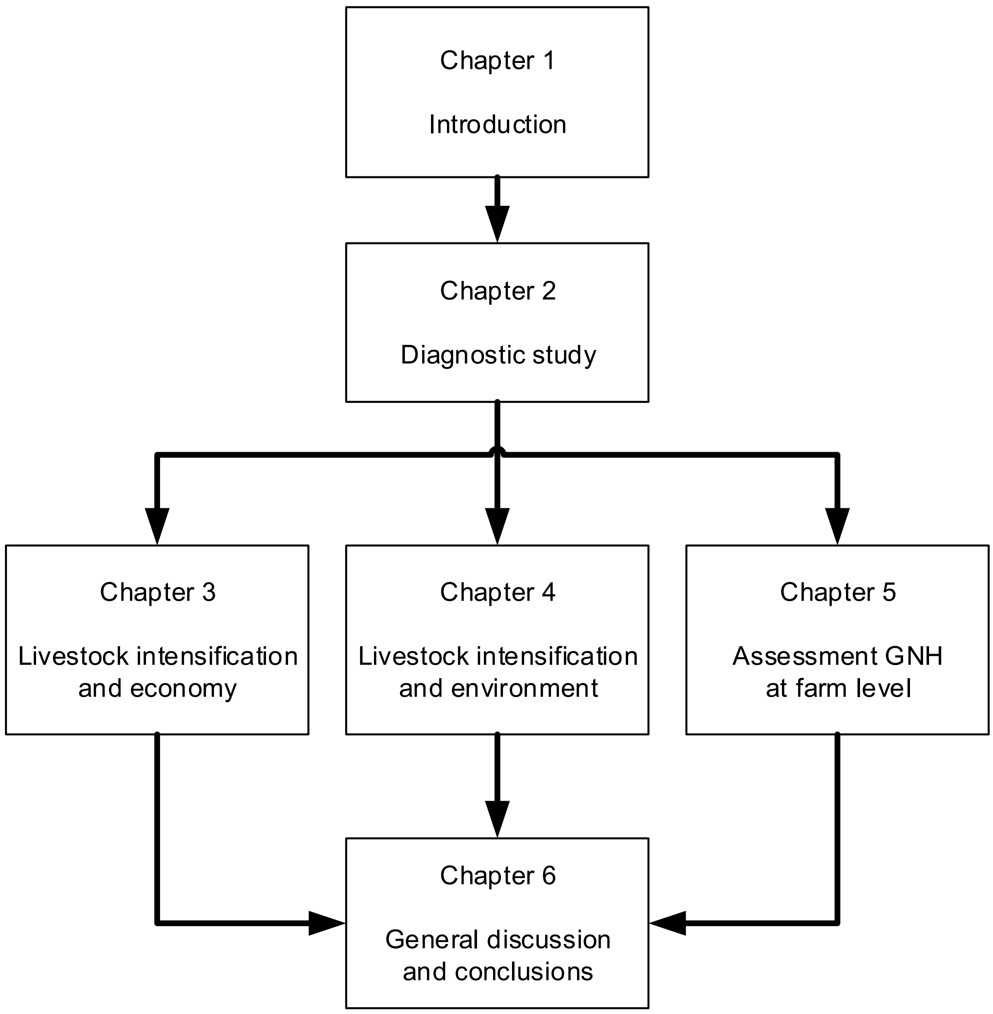

Figure 2. Overview of the thesis structure

conditions. This is because crossbreeding is considered an important intervention in the rural areas, however, what is the socio-economic impact of crossbreeding at farm level is yet to be explored.

Chapter 4 assesses the impact of livestock intensification on the farm feed balances (including the use of CPR) and macro nutrient balances for nitrogen (N) and phosphorus (P). This is because the judicious use of the environmental resources is one of the GNH pillars. The perception is that with livestock intensification the use of CPR is reduced. Therefore questions arise such as what is the impact of livestock intensification on the use of natural resources especially the use of CPR, are the cattle numbers in balance with the feed resources base, and what are their contributions to the farm nutrient balances?

Chapter 5 assesses whether the GNH policies have benefited the development of farmers from a societal, economic and environmental perspective. An integral assessment to gauge GNH development progress at the farm level is presented for different temporal and spatial dimensions. It is felt that such farm level methodologies would be useful to monitor the trends of GNH development progress.

Chapter 6 discusses the core aspects of cattle crossbreeding in terms of benefits and consequences at farm and country level and whether the GNH development concept has benefited the farmers in Bhutan.

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Chapter 2

A participatory framework to identify Gross National Happiness issues for the development of smallholder mixed farming systems in Bhutan

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Abstract

This paper presents a participatory methodological framework to identify Gross National Happiness (GNH) issues at the smallholder level in Bhutan. GNH is a development paradigm of Bhutan that has increasingly drawn international attention. Its four pillars are sustainable and equitable socio-economic development, preservation of the environment, preservation and promotion of culture, and promotion of good governance. Since GNH is usually discussed at the national level, its domains and indicators have been defined through a top-down intellectual exercise, with possibly limited relevance of the major issues for most rural Bhutanese, which represent 69 percent of the country's population. The methodology applied in this study was useful in identifying key GNH issues from a systems perspective at the smallholder level. Socio-economic development and the environmental aspects were found to be the pertinent issues. The study also revealed trade-offs and dependencies among the four GNH pillars and their indicators. Inclusive policies are needed to address the concerns of smallholder farmers. If GNH is to work for the present and future generations, then it is essential to embrace the GNH issues of smallholder farmers who compose the backbone of the Bhutanese population. Further, the GNH concept is currently a mix of issues and indicators. Translating the issues identified by the study into indicators is required to properly evaluate the progress at the farm level and to support GNH policy development.

Keywords: gross national happiness, Bhutan, smallholder farming

2.1 Introduction

The challenge in developing countries is to find the appropriate mix of policies and institutions that would maximise the benefits from globalisation while addressing risks such as environmental degradation and effects on local cultures (Balisacan et al. 2005). Bhutan has responded to globalisation through the concept of Gross National Happiness (GNH), which seeks a path of development that considers Bhutanese society and culture (Planning Commission 2002). The concept has four pillars to achieve holistic development: (1) sustainable and equitable socio-economic development, (2) preservation of the environment, (3) preservation of culture, and (4) promotion of good governance (Planning Commission 2002).

The fourth King of Bhutan initially conceived of GNH in the late 1980s (Ura and Galay 2004). The concept opposes conventional economics, which equates happiness and well-being to increasing material wealth and gross domestic product (GDP). In July 2011, the United Nations (UN) in a resolution adopted Bhutan's proposal of "happiness" and invited countries to pursue the elaboration of additional measures that better capture the importance of the pursuit of happiness and well-being in development to guide their members' public policies (UN News Centre 2011).

Discussions on the GNH concept have largely been done on the national level. On the other hand, smallholder farmers compose about two-thirds of the Bhutanese population (NSB 2007), so that the government has given priority to addressing rural poverty and improving rural livelihoods by intensifying crop and livestock production, while at the same time giving due consideration to environmental and cultural aspects (MoA 2002). Bhutan has wide ranging agro-ecological conditions—from subtropical to alpine areas and varied access to markets (Samdup et al. 2010). Therefore, possibilities of intensifying agriculture and impacts on the environment differ from region to region. To operationalise the GNH concept, understanding the issues to be addressed not only at the higher aggregate level (national) but also at the lower levels (farms) is imperative.

This study intended to develop a methodological approach to identify the important GNH issues at the farm level and to evaluate the importance of GNH to smallholder farmers. Given the different agro-ecological zones and varying levels of agricultural intensification in Bhutan, the study selected four representative areas from which to obtain a comprehensive view of GNH issues.

2.2 Background

2.2.1 Bhutan: An overview

Bhutan is a small, land-locked country bordered by China in the north and India in the south. It encompasses an area of 38,394 square kilometers (km^2), with forest areas covering 72.5 percent and arable land, 7.8 percent (NBS 2007). It has 20 districts and 205 blocks, with Thimphu city as the capital. Its population in 2011 was 738,300 (HDR 2011). A constitutional monarchy since 1907, Bhutan adopted in 2008 a democratic constitutional monarchy type of government, with a decentralised system of governance.

Bhutan is one of the world's 10 biodiversity hot spots; it is home to a diverse array of flora and fauna, including 5,603 species of vascular plants, 400 lichens, 200 mammals, and about 700 birds, in addition to the currently known 105 endemic plant species. The country also hosts a number of globally threatened species, including 27 mammals and 18 birds (HDR 2011; MoAF 2011).

A nationwide household income and expenditure report indicates that the percentage of the Bhutanese population living below the national poverty line declined from 32 percent in 2003 (NSB 2004) to 23 percent in 2007 (NSB 2007) mainly due to increased economic activities. In 2011, 90 percent of the population had health coverage, 83 percent had access to safe drinking water in 2010, and about 55 percent had mobile phones (NSB 2011).

Bhutan's gross national income (GNI) in 2012, converted to dollars using 2005 purchasing power parity (PPP) rates per capita, was USD 5,246 (USD 1 = BTN 45.73) (HDR 2013). The annual GNI growth in 2012 increased by 3.5 percentage points over that in 2010, but in both years Bhutan ranked 140 out of 187 countries in terms of the Human Development Index (a composite index of income, life expectancy, and education indicators). The GNI coefficient showed a skewed distribution of income: rural income was generally far lower than the urban income (HDR 2013). Therefore, Bhutan needs to adapt the concept of GNH to address the needs of the country's largely rural population. In 2010, the primary sector (consisting of crops, livestock, and forestry) accounted for 16.8 percent of the country's GDP; the secondary sector (manufacturing, hydro-electricity, and construction) contributed 40.5 percent; and the tertiary sector (service industries, wholesale, retail, trade, finance, and insurance) was responsible for the remaining share (NSB 2011). In terms of food sufficiency, Bhutan aims for 70 percent self-sufficiency in cereal production (MoA 2002). The current cereal sufficiency level—66 percent—is already close to the target (MoAF 2011). The staple food crop is rice and the rice self-sufficiency target by 2013 was set at 65 percent, which was optimistic given the previous level of 48 percent (MoAF 2011). In agriculture, the economic opportunities are in producing commodities that can capture the off-season markets and in small-scale agro-industries that can produce exclusive products for niche markets in India and elsewhere (e.g., organic rice, vegetables, cheese) (MoA 2009). Importing primary products, like rice and milk, is imposed minimal taxes, which make the imported items much cheaper than the local produce. In response to such trends, the government developed an intensification strategy called Production, Accessibility and Marketing (PAM) (MoA 2002). This strategy encourages farmers to work in groups to reduce their production and marketing costs, to maintain product quality (inspected by the food regulatory body in Bhutan), and to become more competitive with imported products.

2.2.2 GNH: A historical perspective, definitions, and operationalisation

The term GNH was first coined by the fourth King of Bhutan, when he declared that GNH is more important than gross national product (GNP) (Ura and Galay 2004). International interest in the GNH concept ensued and international conferences on GNH were conducted in 2004 (1st, Bhutan), 2005 (2nd, Canada), 2007 (3rd, Thailand), 2008 (4th, Bhutan), and 2009 (5th, Brazil). Many opinions and interpretations of the GNH concept have been offered, and the most widely used description is that "GNH measures the quality of life of a country in a more holistic way (than GNP) and believes that beneficial development of human society takes place when material and spiritual development occur side by side to complement and reinforce each other" (CBS 2012). The current official definition of GNH is that it is a development approach that seeks to "achieve a harmonious balance between material well-being and the spiritual, emotional, and cultural needs of an individual and society" (GNHC 2010). The GNH concept guides the five-year planning process in Bhutan (DoP 2004). At the national level, the erstwhile Planning Commission was designated as the GNH Commission of Bhutan to operationalise GNH. Subsequently all ministries formed a GNH Committee to review all policies and projects so that these will be coherent with the four GNH pillars.

The Centre for Bhutan Studies has developed a GNH index to assess human well-being and progress at the national level (CBS 2012). The GNH index aims to provide an overall picture of how GNH is distributed in Bhutan, and can also zoom in to identify who is "happy" and who is "not yet happy." Since the GNH index can be unpacked into subgroups such as districts, age groups and gender, policymakers can use it as a tool to address questions like how to increase GNH and to track changes over time (CBS 2012).

The four GNH pillars (Rinzin et al. 2007) are further classified into nine domains or areas and 33 indicators (Table 1) to have a better understanding of GNH and to reflect its holistic range (CBS 2012). The socio-economic pillar has three domains (health, education, and living standard) with 11 indicators; the environment pillar has one domain (ecological diversity and resilience) with four indicators; the cultural pillar has four domains (psychological well-being, time use, community vitality, and culture) with 14 indicators; and the good governance pillar has one domain (good governance) with four indicators. The four pillars are connected; progress in one indicator can influence another indicator in another domain.

To ensure that policy interventions are in line with the four GNH pillars, the government, through the Center for Bhutan Studies (CBS), developed a GNH screening test (GNHC 2010). The test has 22 variables encompassing the nine

Table 1. The four pillars, 9 domains, and 33 indicators of Gross National Happiness

Pillars[a] and Domains	**Indicators**
sustainable & equitable socio-economic development [a] (3 domains with 11 indicators)	
health (4)	self reported health status; healthy days; long term disability; mental health
education (4)	literacy; educational qualification; knowledge; values
living standard (3)	household income; assets; housing quality
conservation of environment [a] (1 domain and 4 indicators)	
ecological diversity and resilience (4)	pollution; environmental responsibility; wildlife; urban issues.
preservation of culture [a] (4 domains and 14 indicators)	
psychological well-being (4)	life satisfaction; healthy days; long term disability; mental health
culture (4)	language; artisan skills; socio-cultural participation; driglam Namzha (etiquette)
community vitality(4)	social support; community relationship; family; victim of crime
time use (2)	working hours; sleeping hours
good governance [a] (1 domain and 4 indicators)	
good governance (4)	political participation; political freedom; service delivery; government performance

Source: CBS (2012)

domains. These variables are different from the GNH indicators; for example, in the domain "living standards," one of the variables is equity but the indicators are per capita income, assets, and housing. Scoring is 1-4: 1 (the policy will negatively impact the equity income distribution), 2 (do not know), 3 (will not have any negative effect), and 4 (will have a positive impact). A recommended policy intervention must score a minimum of 70 percent in the GNH screening test before it can be submitted to the cabinet for approval. This means that, on average, a variable must score at least 3 (to cross the 70% cut-off mark). To date, only five policies have passed the GNH screening test. To what extent the GNH concept is trickling down and benefiting the rural areas needs more assessment.

Today the stage of the GNH conceptualisation resembles an era when sustainable development (SD) was being conceptualised, about 2.5 decades ago (WCED 1987). SD covers economic, ecological, and societal dimensions. Compared with GNH, SD has no separate dimension for culture and good governance. Considerable amount of research on the operationalisation of SD had been conducted in the last 2.5 decades. Early pioneers who attempted to operationalise sustainability (e.g., De Wit et al. 1995; Bell and Morse 2003) proposed sets of indicators. Based on these methodologies, Cornelissen (2003) and Mollenhorst and de Boer (2004) developed a participatory approach for SD assessment. This includes the following steps:
(1) stakeholder meetings; (2) determining the context-dependent SD issues defined as problems related to economic, environmental and societal aspects by stakeholders, literature review, and consulting experts; (3) translating the SD issues into measurable indicators; (4) calculating the level of the indicators; and (5) assessing the progress of SD. This study makes use of this concept to identify GNH issues in smallholder farming communities.

2.3 Materials and methods

2.3.1 Study approach

To identify the GNH issues at the farm level, the study selected four areas representing the four main agro-ecological zones of Bhutan: extensive, semi-intensive, intensive, and intensive peri-urban. The categories are based on cattle and crop management practices, the use of external inputs, and market accessibility. The selection of the four areas recognises that diverse issues affect smallholder farmers in different agro-ecological conditions.

Table 2 shows the characteristics of the four study areas. Market access varied by distance based on the existence or absence of motorable roads to the local and major markets. Khaling (east Bhutan), representing the extensive farming system, is characterised by cattle grazing mainly in the forest and on natural grasslands with some night feeding, no crop irrigation, low market access, and a mild temperate climate. Dala (south Bhutan), representing the semi-intensive system, has cattle grazing with some stall-feeding, crop irrigation, medium market access, and a sub-tropical climate. Chokhor (central Bhutan) and Chang (west Bhutan) represent the intensive systems, which are characterised by cattle grazing and stall-feeding, crop irrigation, and a temperate climate. Chang is a peri-urban area close to the capital city; hence, it and Chokhor had relatively good access to markets. Many farmers were members of dairy groups, which collectively sold milk. In all four areas, cattle were fed crop residues (e.g. straws of rice, wheat, maize, and buck wheat) when available.

The study surveyed the perceptions of various stakeholders (e.g., farmers, consumers, development workers, and policymakers) on GNH issues. It

Table 2. Major characteristics distinguishing the four study areas in Bhutan

Area	**Khaling**	**Dala**	**Chokhor**	**Chang**
System	**Extensive**	**Semi-intensive**	**Intensive**	**Int. peri-urban**
altitude (msl)	1800-1900	1500-1800	2500-3500	2300-2500
agro-ecological zone	warm temperate	sub-tropical	cool temperate	cool to warm temperate
soil types	clay and loam	sandy, clay and loam	clay and loam	clay and loam
cropping system				
rain-fed	+++	+++	++	++
irrigated	-	+	++	+++
major crops	potatoes, maize	rice, maize, cardamom	buckwheat, potatoes, apples	rice, wheat, apples
cattle management	mainly grazing with night feeding	mainly grazing with some stall-feeding	stall-feeding and grazing	stall-feeding and grazing
market access				
time taken to walk to local markets	30 minutes to 1 h	1 to 2 h	30 minutes to 1 h	no need to walk as taxis and buses ply frequently
time taken by vehicles to reach local markets	no motorable road	no regular transport services; if available 15 to 30 minutes	no regular transport services; if available 10 to 20 minutes	local market in the capital, Thimphu, at 20 to 30 minutes

+++ high frequency ++ moderate; + little; - none
Source: Samdup et al. (2010)

ensured that a mix of smallholder farmers (in terms of gender, age, and status) attended the stakeholder meetings. Both top-down and bottom-up participatory approaches were used (Figure 1). The top-down approach (opinion of policymakers and experts, data from literature) is known to neglect the values and needs of stakeholders as it leans heavily on the technical aspects. On the other hand, the bottom-up approach risks neglecting national and global issues (Mitchell 1996), and may also be more risk averse.

2.3.2 Determining the GNH issues

The study organised a field workshop in each area (1.5 days each) to identify GNH issues (Figure 1). The use of participatory methods (e.g., participatory rural appraisal) facilitated the exchange of views, experiences, and knowledge of relevant stakeholders (Chevalier 2004). Each workshop was attended by about 30 farmers; the locally elected farmer representative; a private retailer active in the area (dealing with crop and livestock food products); the agriculture, forest and livestock extension staff working in the area; and a representative of

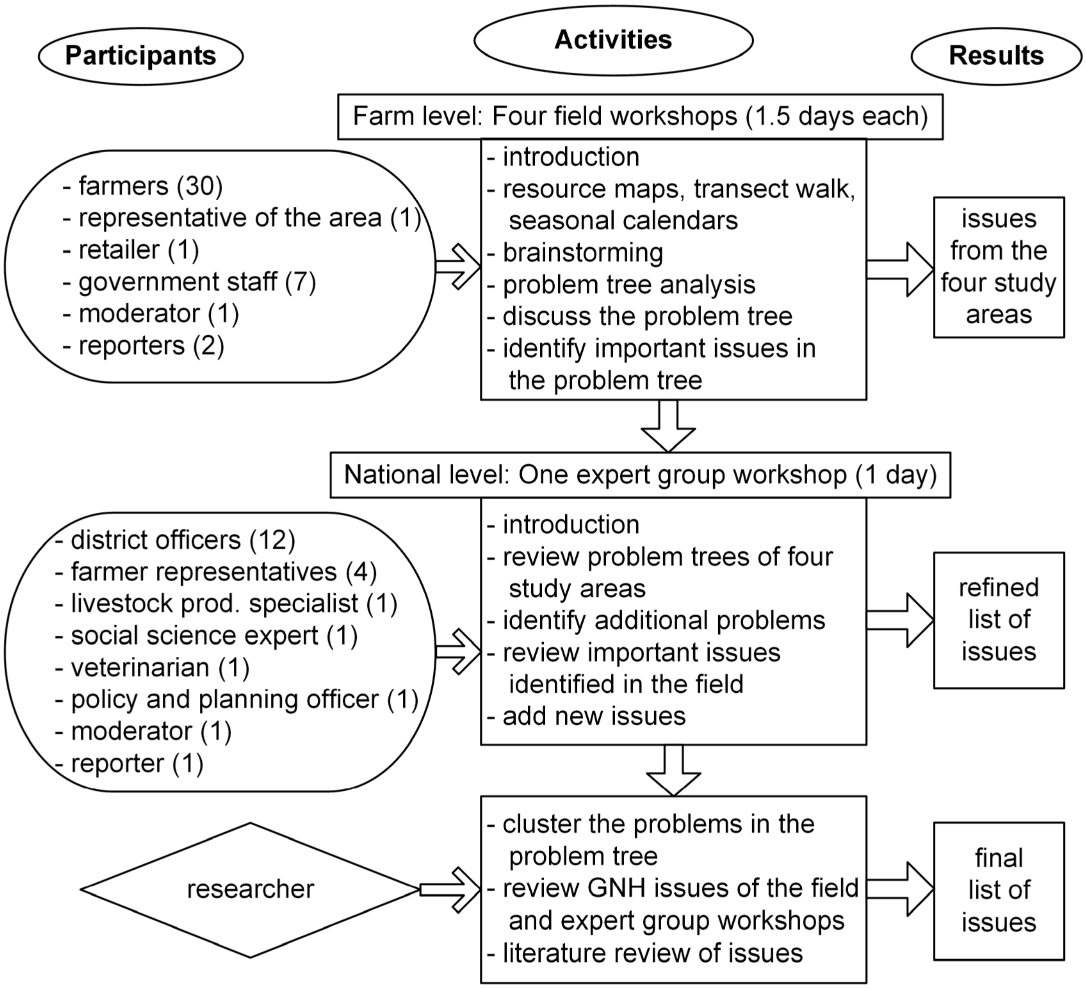

Figure 1. The processes involved in identifying Gross National Happiness issues

the district veterinary office and central livestock office in Thimphu. The participants identified the main issues (Figure 2) as well as their causes and effects using a problem tree.

A national level workshop was held in Thimphu in 2002 (Figure 1). The participants included a multidisciplinary team composed of three district

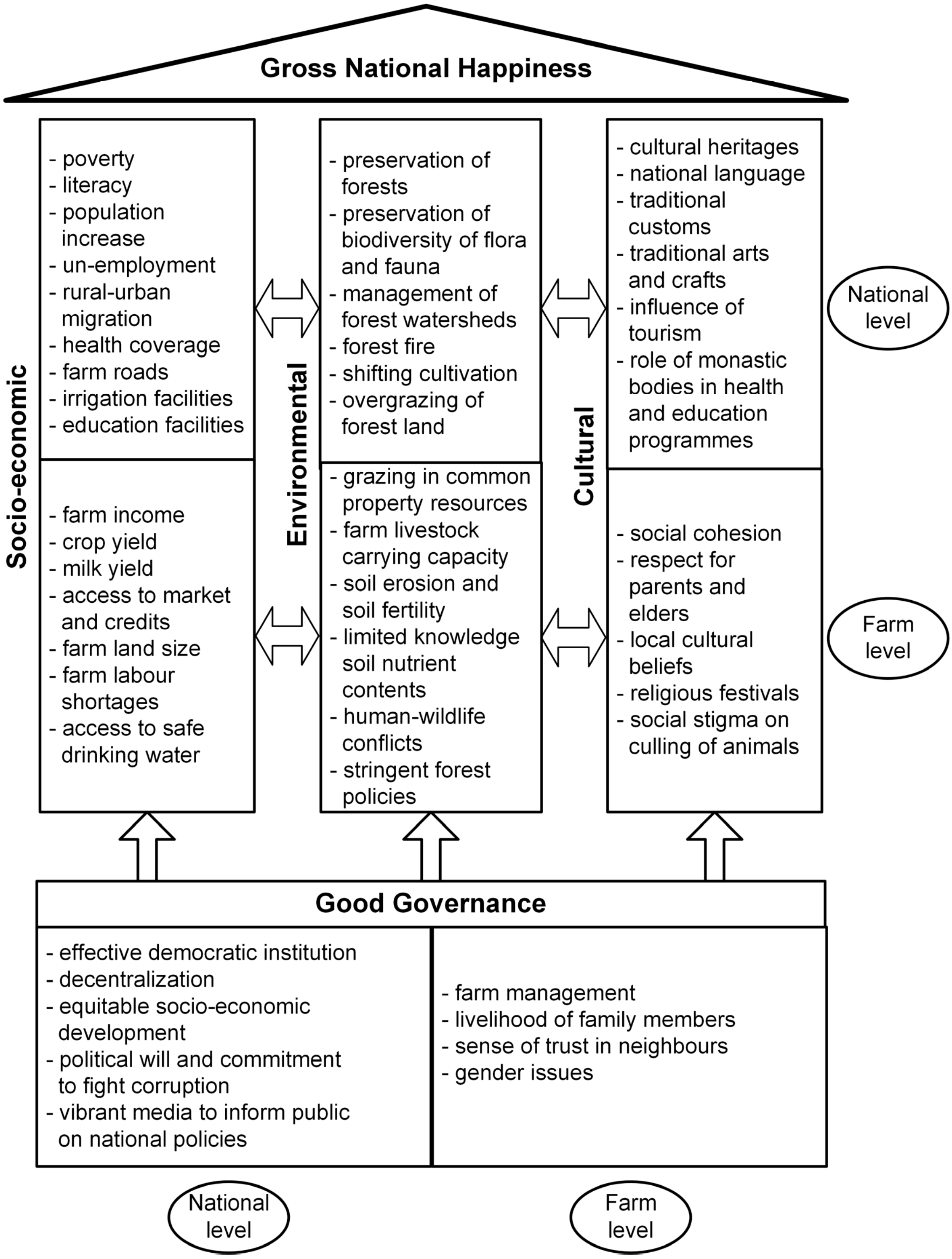

Figure 2. Important GNH issues derived at the national and farm levels, trade-offs and dependencies

officers (livestock, agriculture, and forestry) from each study area (total of 12), a farmer representing each study area (total of 4), a livestock production specialist, a social science expert, a veterinarian, a policy and planning officer, and a moderator. The moderator briefed the participants about the various GNH issues derived from the four field workshops (Figure 2) and the problem tree. Some documents were reviewed to complement the workshops (Figure 2), such as the Livestock Sector's Ninth Five-Year Plan (DALSS 2002), Renewable Natural Resources' Ninth and Tenth Five-Year Plans (MoA 2002; MoA 2009), and the Ninth Five-Year Plan, main document (Planning Commission 2002).

2.4 Results

Figure 3 presents the results of the problem tree analysis. The problem tree derived from the field workshops was used during the discussion at the national workshop. Additional issues such as overgrazing of forest lands, grazing in common property resources (CPR), ban on shifting cultivation, and influence of tourists on local culture and traditions were identified at the national workshop. The different perceptions obtained from the national level are indicated in italics.

A summary of important issues for the four GNH pillars are given in Figure 3, based on the field and national workshops and the literature review. It should be noted that this study refers to "good governance" as a foundation rather than the fourth pillar, since good governance is extremely important to address the GNH issues of the three pillars.

2.4.1 Sustainable and equitable socio-economic development issues

2.4.1.1 National level

The national workshop viewed poverty as a major socio-economic concern. Poverty incidence in 2007 was 23 percent: rural poverty was 31 percent and urban poverty 1.7 percent (NSB 2007). Twenty-eight percent of the districts reported seasonal food insecurity in 2000; 75 percent of the food-insecure households were located in the eastern and central districts of the country (DoP 2004). Bhutan's internal migration rate was 6 percent in 2009 (HDR 2009), contributing to farm labour shortages.

In 2010, the population rose at a rate of 3 percent, while unemployment rate was 3.3 percent (2.1% in the rural and 5.8% in the urban areas) (NSB 2011). Literacy rate was about 60 percent and basic health coverage was 90 percent,

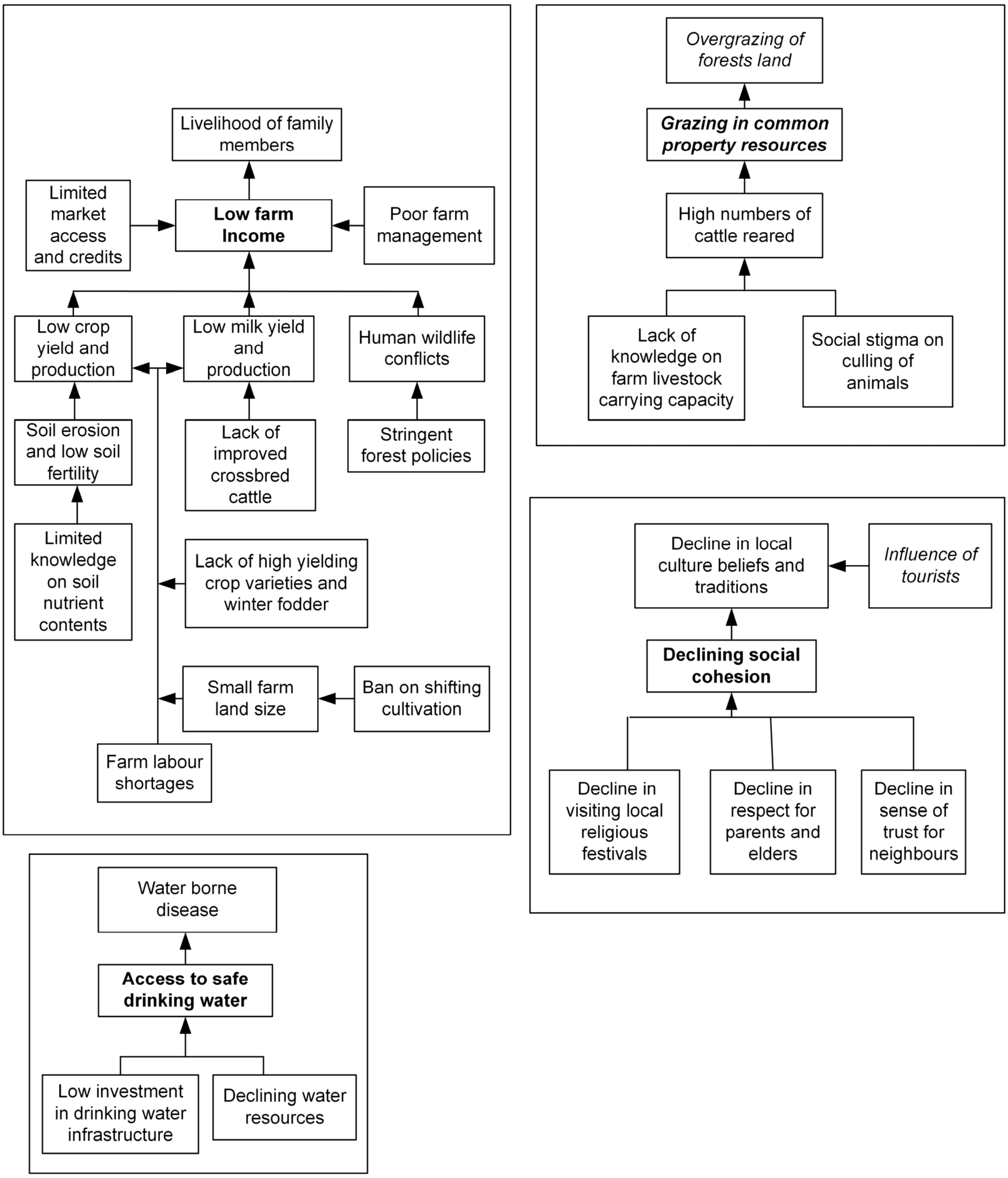

Figure 3. Summary of the problem tree analysis in the four study areas

however, there was only one doctor per 3850 persons (NSB 2011). The national workshop expressed the need for better market accessibility in the rural areas such as farm roads and irrigation facilities. Another major issue mentioned was the need for better education facilities in rural areas.

2.4.1.2 Farm level

All the field workshops identified low farm income as the major socio-economic issue in the rural areas. Farmers generally attributed low farm income to low crop yields, lack of high-yielding crop varieties, low milk yield, and lack of improved crossbred cattle. They also indicated limited access to markets and credit (especially in the extensive area). The farmers supplemented low farm income by working off-farm as hired laborers; remittances from relatives working in urban areas also contributed to the family income. The small farmland size was another major factor for the low crop and livestock production: the average household in the intensive area owned 2.9 hectares and those in the extensive area, 1.2 hectares (Samdup et al. 2010). Farm labour shortage was an important issue also, especially in intensive peri-urban and extensive areas. Access to safe drinking water was a concern in the extensive area.

2.4.2 Environmental preservation issues

2.4.2.1 National level

Bhutan has given priority to environmental and biodiversity conservation in its development strategy, which, reflecting traditional norms and culture, aims to maintain at least 60 percent of the country forested in perpetuity (HDR 2011). However, the national workshop cautioned that given the high human population increase and infrastructure development, a forest cover of 60 percent for all time would be a challenge. The environmental impacts of anthropogenic actions include overharvesting of timber and firewood, poor logging practices, and overgrazing (MoA 2009).

Given that hydropower is a major economic activity in Bhutan, proper management of the forested watersheds is required to guarantee minimal sedimentation of rivers for effective hydropower generation (MoA 2009). Participants in the national workshop also cited forest fires as largely contributing to forestland degradation in Bhutan. A total of 643 forest fires occurred between 1998 and 2008, razing 83,759 hectares (MoA 2009). Moreover, shifting cultivation (*tseri*), a form of slash and burn farming in the sub-tropical districts of Bhutan, is an ecological concern. Traditionally, after a crop or two, the *tseri* land is usually left fallow for a period ranging from 4 to 12 years. With increasing human population, however, farmers practice shorter fallow periods, which result in soil erosion, poor soil fertility, and forest fires (MoA 2002). The Land Act of Bhutan 2007 bans such farming practices (MoA 2009). However, at the field workshops some farmers mentioned that such practices continue in remote areas.

Forests in Bhutan are state owned, but communities in the districts have user rights for grazing cattle and collection of fuel wood, timber for rural housing and farm buildings, and non-wood forest products (MoA 2009). Overgrazing of forestland is another area of concern (MoA 2002; Moktan et al. 2008).

2.4.2.2 Farm level

During the field workshops, the extension agents noted the intensive use of common property resources (CPR) for cattle grazing. This is a concern because it leads to overgrazing of forestland. They said farmers rear excess cattle on their farms due to lack of knowledge of the carrying capacity of the land and the social stigma of culling cattle. The farmers indicated, however, that the use of CPR was indispensable for them and that overgrazing issues varied from village to village.

The problem tree analysis revealed concerns on soil erosion in farmlands due to excessive rains and steep topography, resulting in depletion of soil nutrients. Acknowledging their limited knowledge of soil nutrients, the extension agents noted that only a few studies have been done on soil nutrient (nitrogen-phosphorus-potassium or NPK) balances in their respective areas. All farmers in the four study areas expressed that environmental conservation—in terms of timber, food, carbon sequestration, and other various ecological functions—is useful. However, they considered some of the government's forest policies as very stringent such as the ban on killing wild boars and other wild animals that predate, which cause frequent human-wildlife conflicts and economic losses.

2.4.3 Preservation and promotion of cultural issues

2.4.3.1 National level

The national workshop cited cultural heritage, the national language, and preserving traditional customs, art, and crafts as important cultural values. Promotion of cultural values and social cohesion is vital because nothing can compensate for their loss (Planning Commission 2002). The national workshop emphasised that balancing Bhutan's approach to globalisation with the Bhutanese value systems is a major challenge of this pillar. As more tourists visit Bhutan because of its cultural heritage and traditional customs, the irony is that the increasing number of tourists could influence the country's cultural heritage and traditional customs. However, the government's policy is to increase tourism, especially ecotourism and cultural tourism. The workshop participants mentioned that the monastic bodies have also been catalytic in conveying the government's health and educational programs.

2.4.3.2 Farm level

Within Bhutanese society, social cohesion (bonding of individuals as members of extended families and communities) is a very important cultural value (Thinley 1999). Some farmers noted that some practices, such as providing support to neighbours in terms of farm labour and borrowing food after failed crop harvests, are now waning. They observed a weakening in family cohesion as many family members have settled or are working in other parts of the country. Family members used to visit their village once or twice a year; now the visits have become rare—once in 2–5 years—due to economic reasons (travel costs and the custom of bringing many gifts for relatives and well-wishers) and hectic urban work responsibilities. Other reasons include improved mobile phone coverage, private telephone booths, and better banking coverage.

The farmers indicated that the age-old customs of honoring parents and respecting elders and participation of family members in annual traditional religious rites and religious festivals need to be preserved. Annual religious festivals exist all over Bhutan and maintenance of cultural practices and traditions is required, but most farmers observed that fewer and fewer people working in the urban areas have been participating.

Buddhist cultural beliefs emphasise a harmonious coexistence with the natural elements. Buddhists believe that mountains, deep ravines, and ancient trees and rocks are the abode of spirits, gods, and demons (Rinzin et al. 2007). Disturbing these elements would enrage them and bring illness and even death to the family, while appeasing them may bring luck and prosperity. Farmers, especially from the intensive and extensive areas, still believed in these cultural values to avoid ill luck in their families and farm work.

Farmers in the two intensive areas said that the social stigma of culling and slaughter of animals was high due to the presence of many monasteries and religious sites. To address the situation, in 2005 the Department of Livestock put in place a bull rearing center, where farmers could sell the male cattle they do not wish to rear. The center had a capacity of 70 bulls. Butchers procured these animals and slaughtered them in Bhutan. This center closed in 2010 due to public resentment on cattle slaughtering. The center is now a heifer-breeding farm.

2.4.4 Promotion of good governance issues

2.4.4.1 National level

In 2008, Bhutan became a democratic constitutional monarchy. The good governance issues in the context of GNH are efficiency, accountability, transparency, and professionalism of the government, with people's participation in the planning and decision-making processes (RGOB 2005). These issues underscore the need to have the political will to vigorously fight corruption and a vibrant media to inform the public on important national and local policies.

Prior to the change in the form of government, district development committees (DDC) and block development committees (BDC) were established in 1981 and 1991, respectively (Planning Commission 2002). The DDCs and BDCs make their respective local development plans, prioritise the needs, and delegate financial and administrative powers to local leaders. Farming communities in the districts and blocks elect the members of their DDCs and BDCs. The major role of these members is to communicate the concerns and needs of their respective farming communities in committee meetings. The elected DDC and BDC chairpersons have the authority to approve the implementation of activities for the farming communities.

2.4.4.2 Farm level

The conventional GNH good governance issues were irrelevant to farmers. For them good governance refers to a farmer's management decisions within their farm system that affect the performance of the farm. They cited the need for the household head to ensure judicious use of the family's financial resources to secure the livelihood of the family members and their social needs (e.g., children's health and education). For instance, excessive alcohol consumption should be avoided, since it could affect the family's ability to secure basic necessities (i.e., food, clothing, and shelter). The extension agents, on the other hand, noted the need to promote trust among neighbouring farmers to facilitate discussion and implementation of community projects in their village.

Regarding gender issues, the farmers (both women and men) did not find such issues of major importance. Currently both women and men share in most of the work as well as in making decision on use of the family income. As to education, the school enrollment rates of boys and girls were almost the same in 2011, but the enrollment of females in training institutions was just almost half that of the males (NSB 2011).

2.4.5 Common GNH indicators and issues

The national and local workshops yielded only a few common GNH indicators at the national level (Table 2) and perception of issues at the farm level (Table 3). Some indicators are linked to issues at the farm level, including household income (sustainable and equitable socio-economic development pillar), incidence of human-wildlife conflicts (preservation of the environment pillar), and socio-cultural participation, family values, and community relationship (preservation of culture pillar). In the case of the good governance pillar, none of the indicators were linked to issues derived at the farm level.

Table 3. The four pillar and indicators of Gross National Happiness vis-à-vis the issues derived at the farm level

GNH pillars [a] and Indicators	Issues derived at farm level
I sustainable & equitable socio-economic development [a]	
household income	low farm Income
	low crop yield and production
	low milk yield and production
	small farm land size
II conservation of environment [a]	
incidence of human-wildlife conflicts	human-wildlife conflicts
	stringent forest policies
III preservation of culture [a]	
socio-cultural participation	decline in visiting local religious festivals
family values	decline in respect for parents and elders
community relationship	declining social cohesion
IV good governance [a]	no issues linked to the GNH indicators

2.5 Discussion

2.5.1 Participatory GNH approach

The participatory methods enabled farmers to be involved in activities that facilitated the capture of the local knowledge and intellectual capabilities in this process. Formalisation of community knowledge through participatory techniques can generate an impressive amount of information in a relatively short space of time, leaving time for a more selective structured formal survey (IDRC 2013). Encouraging the farmers to be proactive in the field workshops was catalytic to obtaining transparent and independent views; the use of the problem tree analysis helped to structure views on real life problems of the farmers, the causes and effects of issues, and indicators.

Without such a methodological approach, issues such as the policy on shifting cultivation, use of CPR, and soil nutrient issues would not have been identified. Farmers from the intensive areas were more vocal, due to their exposure to development activities. However, the problem tree approach focuses on identifying negative issues. Therefore, the positive aspects of GNH (e.g., meditation practices, cultural literacy, and community vitality) that make farmers 'happy' were not captured (CBS 2012). If the socio-economic pillar (Figure 3) were separate, then it may be possible that the specific economic and social issues could be better defined and understood as has been done in the three dimensions of sustainable development. The participatory approaches used in the study showed that some issues identified by the participants during the farm-level workshops were not reflected in the national-level issues. Such participatory approaches can raise local expectations, however, and if nothing tangible emerges, local communities may come to see the processes as a transient external development phenomenon (IDRC 2013).

2.5.2 GNH domains and indicators

The CBS-generated indicators (Table 2) do not address several of the GNH issues at the smallholder level. Consultations at the smallholder level had been minimal, which may be because the agriculture sector contributes only 17 percent of the GDP, although it constitutes 69 percent of the population (NSB 2007). The allocation of the domains and indicators among the four GNH pillars is biased toward the cultural pillar (Table 2). This concern is important since all nine domains are given equal weights; all the indicators are also of roughly equal weights. Many of the 33 indicators are qualitative and rather subjective. In the GNH concept, some of the issues and indicators are similar (in contrast, sustainable development issues and indicators are separate concepts and well defined). The refinement of the GNH assessment criteria should consider the above concerns.

2.5.3 Important GNH issues

The issues presented in Figure 3 indicate the need to study trade-offs and dependencies among the different GNH pillars (e.g., grazing in CPR and farm income) and between the national and farm levels (e.g., role of monastic bodies in health and education programs and social stigma of culling of animals). Table 4 summarises the differences in perceptions of the GNH issues in the four study areas. While most of the GNH issues were experienced in all study areas, their levels of intensity varied. For instance, access to markets and credit and shifting cultivation were not concerns in the intensive areas, which are located near the urban areas.

The stakeholders in the field workshops unanimously identified sustainable and equitable socio-economic development as their main concern among the four GNH pillars. The expert group workshop likewise cited the need to improve rural livelihoods through crop and livestock intensification programs.

Table 4. Perception of Gross National Happiness issues in the four study areas

Area	**Khaling**	**Dala**	**Chokhor**	**Chang**
System	**Extensive**	**Semi-intensive**	**Intensive**	**Int. peri-urban**
I sustainable & equitable socio-economic development [a]				
low farm income	+ +	+ +	+	+
limited market access and credits	+ + +	+ +	-	-
farm labour shortages	+ + +	+ +	+ +	+ +
low crop yield and production	+ + +	+ +	+ +	+
soil erosion and low soil fertility	+ + +	+ + +	+ +	+
limited knowledge on soil nutrient contents	+ + +	+ + +	+ +	+ +
low milk yield and production	+ + +	+ +	++	+
lack of improved crossbred cattle	+ + +	+ +	+ +	+
lack of high yielding crop varieties and winter fodder	+ + +	+ +	+	+
access to safe drinking water	++	+ +	+	+
II conservation of environment [a]	+ + +	+ +	+	+
ban on shifting cultivation	+ + +	+ +	-	-
human-wildlife conflicts	+ + +	+ +	+ +	+
stringent forest policies	+ + +	+ +	+	+
lack of knowledge on farm livestock carrying capacity	+ + +	+ +	+ +	+ +
III preservation of culture [a]				
decline in respect for parents and elders	+ +	+ +	++	+ +
social stigma on culling of animals	+ + +	+	+ + +	+ + +
decline in visiting local religious festivals	+ + +	+ +	+	-
declining social cohesion	+	+	+ +	+ +
IV good governance [a]				
poor farm management	+ + +	+ +	+	+
livelihood of family members	+ + +	+ +	++	+
decline in sense of trust for neighbours	+	+	++	++

[a] pillars of Gross National Happiness
+++ major issue; ++ moderate issue; + minor issue; - no issue

This result corresponds with the findings of Rinzin et al. (2007) that although the government accords high priority to environmental conservation, farmers consider sustainable and equitable socio-economic development as more important because without economic development, environmental preservation is not possible. The views expressed during the national and field workshops on the socio-economic issues, though expressed differently, were consistent. The national workshop mentioned poverty, illiteracy, and the need for a more balanced and equitable socio-economic development; the field workshops highlighted practical concerns on farm income and crop and milk yields.

Notably, the national workshop identified grazing in CPR, which the farmers did not mention. Views on grazing in CPR in the literature vary. Rosset (1997) considers cattle grazing as a serious threat to biodiversity, because it reduces undergrowth and changes structure and tree species composition. Roder et al. (2002) argue that grazing enhances conifer species regeneration by removing the herbaceous biomass, but concede that grazing does diminish the number and density of broadleaved species. Several authors (e.g., Norbu 2002; Chophyel 2009) cite the need for farmers to practice appropriate grazing practices in CPR.

While forest fires occur due to a number of factors, the national workshop indicated that shifting cultivation is a significant factor, which is probably the reason for its ban. However, most farmers in the extensive and semi-intensive areas are not happy with the ban policy. They view it as a top-down decision that negatively affects their livelihoods. On the other hand, shifting cultivation may not have been banned if farmers practiced controlled and proper "slash and burn" practices and kept the land fallow for appropriate periods. It is noted that the CBS-generated GNH indicators (Table 1) do not address forest fires and shifting cultivation.

The farmers' appeal for the government to reconsider its stringent forest policy against killing wild animals is a serious concern since the government has limited or no compensation for losses due to wild animals. The GNH indicators on human-wildlife conflicts assess only whether or not there has been incidence of such conflicts (i.e., a lot, some, little, not at all, or not applicable).

The views of farmers and extension agents on soil nutrient depletion (due to steep topography) and limited knowledge of soil nutrients (NPK) were consistent. According to Norbu and Floyd (2004), soils on mountain slopes inherently exhibit low fertility due to high erosion potential and limited organic content, so that organic matter is lost and nutrients are depleted. Capacity building in soil science and nutrient management for the extension agents is urgently needed.

Bhutan considers forest and biodiversity conservation as important. As such, it issued a policy that 60 percent of its land area should be forested in perpetuity. This policy, however, has compromised the direct economic benefits from logging and timber export. On the other hand, it has enabled Bhutan to preserve its forest watersheds for the production of hydroelectric power and to serve as sources of clean water and ecotourism. The environmental pillar has only one domain and a few indicators (CBS 2012), which could undermine its importance in the development of a holistic set of GNH indexes. The GNH environmental indicators focus on pollution, ecological responsibility (e.g., waste reduction, water conservation, incidence of human-wildlife conflicts), and urban aspects (e.g., visit to green spaces or nature reserves, travel sustainability [walk, bicycle, public transport]). Of these issues, only human-wildlife conflict was identified in both the field and national workshops.

On the cultural front, some of the expert group members noted the influence of tourists visiting Bhutan and their impact on the local culture. Tourists travel to different countries to experience a different culture, among other reasons (Alhamidi et al. 2003). While some of the expert group members cautioned about the influence of large-scale tourism, others argued that the culture of any nation state is dynamic and is subject to change over a period. This concern was not mentioned in the field workshops, however.

The social stigma of culling animals was high especially in the extensive and intensive areas. The paradox is that although Bhutan is a Buddhist society, the Bhutanese consume a lot of meat (DALSS 2002). In 2005, the annual per capita consumption of meat was 10.3 kilograms (DoL 2005), higher than the average annual per capita consumption in South Asia at 5.8 kilograms (FAO 2009). Yet when it comes to culling animals, the Bhutanese are restrained. Local meat production in 2005 was 2560 metric tons and imported meat amounted to 4666 metric tons (DoL 2005). Slaughtering of cattle is not common in Bhutan; therefore, unproductive cattle tend to be kept in the forest. Recently, some animal activists (e.g., Jangsa Animal Saving Trust in 2010) who are against animal slaughter have started to procure animals from butchers and then release the animals in the forests. The government is debating over such intervention since once released in the forests, the animals are on their own—there is no one to care for them. There is also the risk from predation, overgrazing of CPR, and disease outbreaks (e.g., foot-and-mouth disease in cattle, peste des petits ruminants (PPR) in goats, and bird flu (H5N1) (DoL 2013).

As a part of good governance, administrative and political authorities have been decentralised to the districts. Rinzin et al. (2007) conducted a poll on the benefits and risks of decentralisation on 775 respondents in 10 of the 20 districts in Bhutan. The majority (58%) of respondents indicated that the new system of local governance has raised the risk of corruption; more than one-third (38%) said governance capacity was lacking; and more than a quarter (28%) said that leadership was inequitable.

Notably, views on good governance (e.g., corruption) were hardly expressed during the field workshops. Farmers generally do not criticise openly when associated authorities are present (in this case, the head of the block). This is a methodological concern that needs to be addressed. Farmers in general (both men and women) did not note any gender issues at the farm level. HELVETAS (2010), however, mentions that in general both women and men perceive women as less confident than men. It was observed that while this perception has not been a barrier to women's participation in agriculture, household decisions, property inheritance, and getting involved at village level meetings, it has negatively influenced participation of women in tertiary education and vocational training.

That the issues identified at the farm and national workshops were not consistent points to the different priorities of the stakeholders involved, particularly, farmers, policymakers, and technical experts. Therefore, the two-pronged participatory approach of having both bottom-up and top-down strategies are required to address both farm and national level issues.

2.6 Conclusion

The GNH concept has been widely discussed at different hierarchical levels in Bhutan. However, more efforts are required from the policymakers to address and incorporate the concerns and issues of smallholder farmers. Among the four GNH pillars, sustainable and equitable socio-economic development was identified as the top concern by all stakeholders in the four study areas; this was followed by environmental preservation. Low farm income from crop and livestock production and human-wildlife conflicts were issues that came out strongly in the field workshops. By using participatory approaches, this study was able to obtain the farmers' views on real-life problems, the causes of these problems, and the effects of GNH policies. In addressing GNH issues, the trade-offs and dependencies among the four pillars and between farm and national level as well as inclusive governance should be considered. Further, to ensure that the GNH issues of smallholder farmers are mainstreamed into the government policies, the GNH screening test should include more inclusive variables that address smallholder farmers' needs. Unlike the case in sustainable development assessment, wherein the issues and indicators are separate concepts and well defined, some GNH indicators are similar to the issues. To properly evaluate the progress of GNH at both farm and national levels, the GNH issues must be translated into indicators.

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Chapter 3

Crossbreeding and intensification of smallholder crop–cattle farming systems in Bhutan

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Abstract

This paper evaluates the effect of livestock intensification through crossbreeding for dairying in Bhutan, where crossbreeding policies aim to improve smallholder livelihoods. It is also expected that crossbreeding will reduce dairy imports, and will reduce the environmental impact on forests and other common property resources. Since 1985, breeding policies have promoted the Brown Swiss crossbred for high altitude areas and the Jersey crossbred for other areas with suitable agro-ecological conditions. From 1998 onwards, farmers were allowed to choose their desired cattle breed irrespective of the agro-ecological conditions. Data on household, cropping and livestock activities were collected through interviewing 183 households in extensive, semi-intensive, intensive, and intensive peri-urban areas in the years 2000 and 2004. Herd composition on the study farms reflected the policy of promotion of crossbreds in areas with suitable agro-ecological conditions, as well as the preferences of the farmers and their cultural values. The change in livestock breeding policy in 1998 had no apparent impact on the breed composition of the herds. Crossbred cows had 2.4–4.6 times higher milk off-takes than local cows. The livestock gross margins were 1.4–2.4 times higher in the intensive than in the semi-intensive and extensive areas. Crossbreeding has contributed to the higher livestock gross margins in the intensive areas. Cattle management was characterised by high reproductive wastage and poor survival. Crossbreeding has not reduced cattle numbers per farm, but lactating crossbred cows are mainly stall-fed and, so, crossbreeding reduces grazing pressure on common property resources. Crossbreeding has not yet been able to reduce the gap between supply and demand of dairy products in Bhutan. In areas with suitable market conditions, farmers will continue with crossbreeding for dairying, as it is a regular and reliable income source.

Keywords: mixed farming, crossbreeding, technical performances, gross margins, agro-ecological conditions, Bhutan

3.1 Introduction

Intensification of livestock production is widely promoted in developing countries, both to meet increasing demand for livestock products and to contribute to the development of rural households (Delgado et al. 2001). In Asia, roughly 80% of the increase in livestock production occurs on large commercial farms (FAO 2005). However, the large majority of rural households are smallholder farmers. Can the increase in demand for livestock products help these farmers to improve their livelihoods?

In Asia, Bhutan follows a unique development concept of Gross National Happiness (GNH). GNH strives for a balance between the socio-economic, ecological, cultural and good governance dimensions of development, rather than for economic development only (Rinzin et al. 2007). Crossbreeding local cattle with higher-yielding exotic dairy breeds is an important tool for intensifying smallholder farming (Udo and Cornelissen 1998; Tulachan et al. 2002). This is not different in Bhutan. Policies directed at crossbreeding local cattle with exotic dairy breeds are expected to contribute to improvements in the livelihoods of smallholder rural households without causing ecological damage or interfering with cultural values (MoA 2002). Livestock intensification is also expected to reduce the wide gap between supply and demand of livestock products. To become self sufficient Bhutan would have to increase dairy production by 20% and to double beef production (Samdup and Rai 2007).

Bhutan has wide differences in ecological conditions and in access to markets. The 1985 national cattle breeding policy differentiated between the agro-ecological zones: it proposed Brown Swiss × (local) Siri crossbreeding in the high altitudes; Jersey × Siri crossbreeding in other areas with relatively better market access; and using local breeds in remote areas that have harsh environmental conditions. In 1998, in response to farmers' requests, the cattle breeding policy was changed to provide semen and bulls of any breed to all districts based on farmers' demand.

When deciding on crossbreeding strategies, cattle are generally evaluated at individual animal level for milk production and reproductive performance (Cunningham and Syrstad 1987; Syrstad 1996), but if the crossbreeding is expected to contribute to smallholder livelihoods, it has to be evaluated at farm level. This paper compares the livestock sub-systems and the whole farm systems of smallholders in four areas of Bhutan differing in ecological conditions, infrastructure, market access and crossbreeding policies to assess the effects of livestock intensification through crossbreeding.

3.2 Materials and methods

3.2.1 Study areas, farming systems and cattle breeding

Only 8% of Bhutan's land is considered suitable for arable farming and 4% is pasture land; most land is forest and natural grazing (LUPP 1997). About 80% of the population belongs to mixed, mainly crop–cattle, farming households. The selected study areas were the Khaling, Dala, Chokhor and Chang blocks in the districts of Trashigang (east Bhutan), Chukha (south Bhutan), Bumthang (central Bhutan) and Thimphu (west Bhutan) respectively (Figure 1). A district has several blocks and a block comprises of a number of villages. Villages which were less than 2 h walking distance from a motorable road were considered for the study.

Table 1 shows the characteristics that distinguished the four study areas. Market access varied by distance and existence or absence of motorable roads to the local and major markets. The Khaling area represented Bhutan's extensive farming system characterised by cattle grazing mainly in the forest and on natural grasslands with some night feeding, no crop irrigation, low market access, and a mild temperate climate. The semi-intensive system,

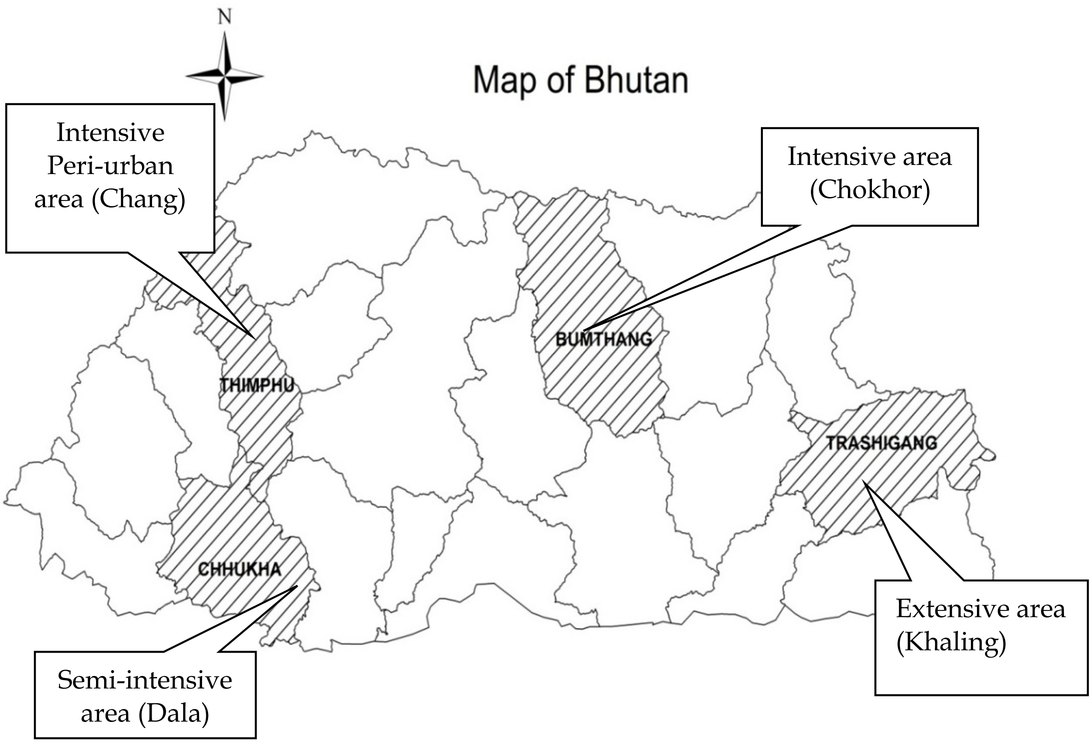

Figure 1. Map of Bhutan and the location of the four study areas

Table 1. Major characteristics distinguishing the four study areas in Bhutan

Area **System**	**Khaling** **Extensive**	**Dala** **Semi-intensive**	**Chokhor** **Intensive**	**Chang** **Int. peri-urban**
altitude (msl)	1800-1900	1500-1800	2500-3500	2300-2500
agro-ecological zone	warm temperate	sub-tropical	cool temperate	cool to warm temperate
soil types	clay and loam	sandy; clay and loam	clay and loam	clay and loam
av. rainfall (mm)#	1679	3287	675	673
temperature (°C)#	4 to 29	5.2 to 30	-5.6 to 21	-2.7 to 26
cropping system				
rain-fed	+++	+++	++	++
irrigated	-	+	++	+++
major crops	potatoes and maize	rice; maize and cardamom	buckwheat; potatoes and, apples	rice; wheat and apples
cattle management	mainly grazing with night feeding	mainly grazing with some stall-feeding	stall-feeding and grazing	stall-feeding and grazing
market access				
time taken to walk to local markets	30 minutes to 1 h	1 to 2 h	30 minutes to 1 h	no need to walk as taxis and buses ply frequently
time by vehicles to reach local markets	no motorable road	no regular transport services; if available 15 to 30 minutes	no regular transport services; if available 10 to 20 minutes	local market in the capital Thimphu; at 20 to 30 minutes
time by vehicles to reach large markets	4 - 5 h	2 h	7-8 h	20 to 30 minutes to reach Thimphu
dairy farmers' group	no	no	yes	yes

average of 2000-2004

+++ high frequency ++ moderate; + little; - none

represented by Dala block, was characterised by cattle grazing with some stall-feeding, crop irrigation, medium market access and a sub-tropical climate (Table 1). Bhutan's more intensive systems were represented by Chokhor and Chang blocks which were characterised by cattle grazing and stall-feeding, crop irrigation and a temperate climate. Chang is a peri-urban area close to the capital city, hence it and Chokhor had relatively good access to markets: many farmers were members of dairy groups for the collective marketing of milk. By contrast, in Dala block the dairy group collapsed in 1997 due to irregularities in milk payments but, at the same time, a large influx of Indian employees to the Dala hydro-power project offered farmers the opportunity to sell their milk directly to consumers at relatively good prices. In all these areas crop residues (e.g. the straws of rice, wheat, maize and buck wheat) were fed according to their availability.

The national cattle population is mainly the local Siri breed, which is found in most parts of the country (Dorji 2007). They have probably descended from crosses of zebu with the humpless cattle of Tibet. Siri are known for their resistance to diseases and ease of management. Their milk production is low. In the harsh environment of the east of the country, farmers cross Siri with the Mithun (*Bos frontalis*) (Dorji 2007). The F_1 Jatsum females are prized for their high milk fat production, adaptability to foraging in the forest, and homecoming instincts, but the F_1 Jatsa male is infertile. Therefore, the Jatsum are backcrossed to the Siri to obtain the Yangkum. Government breeding farms are the main source of Mithun bulls. The government supplies Jersey, Brown Swiss and Siri semen to Artificial Insemination (AI) centres in the different areas. AI is provided at no cost by trained livestock extension agents. Brown Swiss crossbred cattle are appreciated for their milk production and meat quality but, according to some farmers, they lack agility in mountainous areas. Jerseys are appreciated for their relatively high milk yields. In remote areas where an AI service is not possible, bulls of a breed chosen by the community are provided. In the semi-intensive and intensive areas the breeding policies aimed at producing animals with a 50:50 ratio of local and exotic genes by crossing the local with purebred Jersey or by *inter-se* mating of the F_1 cattle. In peri-urban areas the policy aimed at a 25:75 ratio of local and Jersey genes (by crossing the 50% Jersey crossbred with purebred Jersey) or a purebred Jersey animal.

3.2.2 Data collection

A two-phase time series household survey was carried out in which the same households were visited in 2000 and 2004. Based on the 2000 census (DoL, 2001), in each block 30–40% of the villages (6, 9, 16 and 6 villages in Khaling, Dala, Chokhor and Chang blocks, respectively) and in each village 5–15% of the households (63, 35, 55 and 30 households in Khaling, Dala, Chokhor and Chang respectively) were sampled. Households were selected at random. Weather conditions were comparable in both survey years.

Recall data covering one year were collected through household interviews conducted in the local language by trained enumerators using a pre-tested, semi-structured questionnaire. Individual farmers were interviewed on family background, sources of income, land-use, crop and livestock management practices and production and financial results. In each year households were visited once and the interview lasted about 3 h. In 2000, animal performances for different cattle breeds were obtained via a recall questionnaire and via the farmer groups (intensive areas). This included information on milk off-take (calves were at foot), mortalities and reproductive performances.

For each farm, external and internal flows were quantified in monetary terms for the livestock and crop sub-systems for 2000 and 2004. Data were collected for these two years to capture changes in farming practices and, in particular, the impact of the change in breeding policy in 1998. Some flows were in cash, others in kind. Opportunity costs for household consumption of farm products were based on farm-gate prices. Inputs to the crop sub-system were mainly family and hired labour, inorganic fertilisers, manure, and the use of bullocks and farm machinery. Outputs from the crop sub-system were food crops, cash crops and animal feed. Straw was used mainly as animal feed and bedding. Inputs to the livestock sub-system were locally compounded concentrates (composed of ingredients from the farm or procured), commercial concentrates, conserved fodder, straw and grazing. Most cattle had the opportunity to graze in the forest and on natural grasslands (Common Property Resources, CPR): on average, 6.5 h in the intensive areas and 8 h in the semi-intensive and extensive areas. Concentrates were fed to lactating cows, cows in the last trimester of gestation, breeding bulls, and working bullocks. Animal health treatments and artificial insemination were provided by the government free of charge. Outputs from the livestock sub-system were milk, draught power, manure, and sale of animals. Part of the milk was processed into cottage cheese and butter, which were sold or consumed at home.

One livestock unit (LU) was defined as an adult bovine weighing about 300 kg. Cows, bullocks, and breeding bulls were considered as 1 LU, heifer and young bulls as 0.7 LU and calves as 0.2 LU. The estimation of the quantity of manure produced was based on the assumption that 1 LU consumes about 6 kg DM per day (2% of body weight). With an assumed DM digestibility of 60%, it was estimated that the annual manure production was 880 kg DM per LU. With the N, P and K content of manure taken at 1.6%, 0.8% and 1.2% on dry matter basis, respectively (ICAR 1986), the annual N, P and K content of manure per LU was estimated at 14 kg, 7 kg and 11 kg, respectively. The annual monetary contribution of manure per livestock unit was based on the market value of NPK fertilisers. Nutrient losses of NPK during storage were estimated as 50%

for N and P and 40% for K (Moore and Garroth 1993). Based on the average number of hours grazed per day in the CPR, it was assumed that 27% to 33% of the manure was deposited in the CPR and the remainder on the farm land.

3.2.3 Data analysis

Gross Margins (GM) in Ngultrum (Nu; US$ 1 = 45.3 Nu in 2004) for each sub-system were calculated as the outputs minus inputs (variable costs). The farm (livestock and crop GM) and total incomes (farm plus off-farm income) per household and per capita (household member) were calculated. As measured by the consumer price index, the average inflation rate was about 2.7% from 2001 to 2003 (ADB 2003). All internal and external flows were corrected for these inflation rates.

Least-squares methods (Harvey 1977) were used to explain variation in household and farm characteristics, and major external inputs, outputs and GM per farm sub-system in terms of area and year effects. A nested design was used with years nested within areas. Least-squares methods were also used to explain variation of milk off-take per day of lactation due to cattle breed. For the different cattle breeds, the critical calving rate, i.e. the calving rate necessary for the cattle to replace themselves, was calculated for the whole herd according to the formula used by Hermans et al. (1989):

$CR_{cr} = (n * S_1 * Z_2)^{-1}$,

where: CR_{cr}: critical calving rate (y^{-1}); n: proportion of female calves born; S_1: survival rate of immature females (y^{-1}); Z_2: proportion of the sum of adult females to those reaching maturity each year where:

$Z_2 = (1-m) + (1-m)^2 \ldots\ldots: + (1-m)^t;$

m : annual mortality rate of adult females (y^{-1}); t : breeding life (y).

3.3 Results

3.3.1 Labour, land use and livestock

Table 2 gives the least square means and least square differences (2004 minus 2000) of selected family, labour and land-use parameters, and LUs in the four areas. The areas differed significantly in household size. The relatively high number of household members in the semi-intensive area (9.9) is the result of the extended family tradition in the majority Hindu community and the opportunities for off-farm work due to the hydro-power project. In the other areas the average household size ranged from 7.4 to 8.2. The number of household members involved in agriculture ranged from 2.4 (intensive peri-urban area) to 2.8 (semi-intensive area) full time equivalents (fte). In the intensive peri-urban area the family labour force for agriculture significantly decreased between 2000 and 2004. Household members spent slightly more time on crop than livestock activities. The number of family members involved in off-farm work was significantly lower in the intensive area (0.7 fte) than in the other areas (1.5–2.2 fte), although family labour employed in off-farm work increased significantly in the intensive area by 0.6 fte between 2000 and 2004. Farm size was significantly higher in the intensive and semi-intensive areas (2.6–2.9 ha) than in the extensive and the intensive peri-urban areas (1.2–1.3 ha). In the extensive area, farm sizes were small due to the harsh topography. Most farm land (68–97%) was used for cropping. In the intensive peri-urban area farm size decreased by 0.4 ha between 2000 and 2004: many farmers sold land because of the escalation of land prices due to the plans of the government to expand Thimphu city.

Herd size was highest in the intensive area (9.4 LU) and lowest in the intensive peri-urban area (5.3 LU). Cows formed 47% (semi-intensive area) to 62% (intensive peri-urban area) of the herds; between 2000 and 2004 the proportion increased only slightly. Approximately a third of the herds were young stock, while approximately a fifth were draught bullocks in the extensive and semi-intensive systems and a tenth or less in the intensive areas. From 2000 to 2004, there was a significant decrease in LU per farm in the intensive peri- urban area (−3.5 LU) and in the extensive area (−1.6 LU). The decline in LU in the intensive peri-urban area was significant for both pure Jersey and Siri cattle. Brown Swiss crossbreds were only present in the intensive area where they were originally promoted, and their population remained steady over the four-year period. Farmers in the other areas reported not liking Brown Swiss crossbreds because of their relatively large body sizes and high feed requirements. Jersey crosses and Siri cattle were found in all areas but with relatively larger numbers of Jersey crosses in the semi-intensive area and Siri in the extensive area (Table 2). Jatsum and Yangkum were only found in the extensive area. The average percentages of exotic and crossbred cattle on the farms in the extensive, semi-intensive, intensive and intensive peri-urban areas were 21, 54, 84 and 70%, respectively, in 2000; they had slightly increased to 24, 63, 87 and 81%, respectively, in 2004.

There were few other livestock: small ruminants per farm ranged from 0 in the intensive peri-urban area to 5 in the semi-intensive area; poultry from 1.8 in the

Table 2. Household (hh) characteristics, farm area and livestock units (LU) in four areas of Bhutan, averages (least square means, lsm) and change from 2000 to 2004 (least square differences, lsd)

Area	**Khaling**		**Dala**		**Chokhor**		**Chang**			
System	**Extensive**		**Semi-intensive**		**Intensive**		**Int. peri-urban**			
	lsm	**lsd**	**lsm**	**lsd**	**lsm**	**lsd**	**lsm**	**lsd**	**s.e[1]**	**s.e[2]**
No of farms	63		35		55		30			
hh size	7.4[b]	0.7	9.9[a]	1.1	8.0[b]	0.5	8.2[b]	0.6	0.3	0.42
hh in agric. (fte)[3]	2.5[b]	-0.1	2.8[a]	0.3	2.7[a]	-0.3	2.4[c]	-0.4[z]	0.1	0.14
hh in livestock (%)	44		38		41		46			
hh off-farm (fte)[4]	1.5[b]	0.1	2.2[a]	1	0.7[c]	0.6[z]	1.8[a]	0.1	0.15	0.21
total farm land (ha)	1.2[b]	0	2.6[a]	-0.1	2.9[a]	0	1.3[b]	-0.4	0.17	0.24
total LU	7.3[b]	-1.6[z]	7.1[b]	-1.6	9.4[a]	-0.2	5.3[c]	-3.5[z]	0.42	0.58
cattle LU										
Jersey	-		0.6[b]	0.1	-		1.6[a]	-1.3[z]	0.08	0.11
Brown Swiss cross	-		-		6.3	-0.1	-		-	0.27
Jersey cross	1.7[a]	-0.2	3.5[b]	-0.4	1.6[a]	0.2	2.2[a]	-0.8	0.22	0.3
Siri	3.7[a]	-0.8	3.0[a]	-1.3	1.3[b]	-0.3	1.4[b]	-1.4[z]	0.25	0.34
Mithun LU										
Jatsum	1.2	-0.3	-		-		-		-	0.12
Yangkum	0.8	-0.3	-		-		-		-	0.09

[a,b,c,d] lsm with different superscripts between study areas are significantly different (P<0.05)
[z]lsd within a study area is significantly different (P<0.05)
[1]s.e of an average between areas; [2] s.e of an average between years within an area
[3]Full time equivalents in agriculture; [4]Full time equivalents in off-farm work.

intensive peri- urban area to 19 in the semi-intensive area; and pigs and horses from 0 in the intensive area to 0.6 in the semi-intensive area. As expected the cattle types had differing dairy performance (Table 3). The average milk off-take per day of lactation of Siri cows ranged from 1.5 to 1.8 kg d^{-1} and that of the Jersey crossbreds from 4.7 to 5.5 kg d^{-1}, approximately a three-fold increase. In all areas the milk off-take of Siri cows was significantly lower than that of the exotic and crossbred cows.

Highest yields (7.6 kg d^{-1}) were observed for pure Jersey in the intensive peri-urban area. Milk off-take for Brown Swiss crossbreds was, on average, 4.8 kg d^{-1}. The higher milk yields of the exotics and their crosses were partially offset by their poor survival. Milk production was further reduced by poor reproductive performance. Figure 2 shows the differences between annual herd calving rates and the critical calving rates in the four areas. Calving rates were low and only in the semi-intensive and intensive peri-urban areas did the Jersey crossbreds have a herd calving rate (29.8% and 32.8%, respectively) higher than the critical calving rates: 4.4 and 4.1 percentage points, respectively.

Table 3. Milk off-take per day of lactation (least square means, lsm) for different cattle breeds in four areas of Bhutan in 2000

Area	Khaling		Dala		Chokhor		Chang	
System	Extensive		Semi-intensive		Intensive		Int. peri-urban	
Cattle breeds	n[1]	lsm	n	lsm	n	lsm	n	lsm
Jersey cross	162	5.5[a]	233	4.7[b]	124	5.1[a]	137	5.5[b]
Brown Swiss cross					264	4.8[a]		
Pure Jersey			60	6.2[a]			129	7.6[a]
Siri	152	1.8[b]	71	1.5[c]	119	1.5[b]	75	1.5[c]
Jatsum	74	2.3[c]						
Yangkum	71	1.2[d]						
s.e[2]		0.1		0.1		0.1		0.3

[a, b, c, d] lsm with different superscripts within a study area are significantly different ($P<0.05$)
[1]number of lactation records
[2]pooled standard error

In the intensive area the herd calving rate of Brown Swiss crossbreds (29.6%) was slightly higher than their critical calving rate. The calving rates of the local breeds were also below their critical calving rates. The annual mortality rates of female cattle (cows, heifers, calves) are included in the calculations of the critical calving rates. The cow mortality of exotic crosses was highest in the extensive area (16%), and in the other areas it ranged from 7 to 9%. Mortality was highest for pure Jersey calves and heifers in the semi-intensive area (31%). On the other hand, the mortality rate for Siri cows and Mithun crosses was low

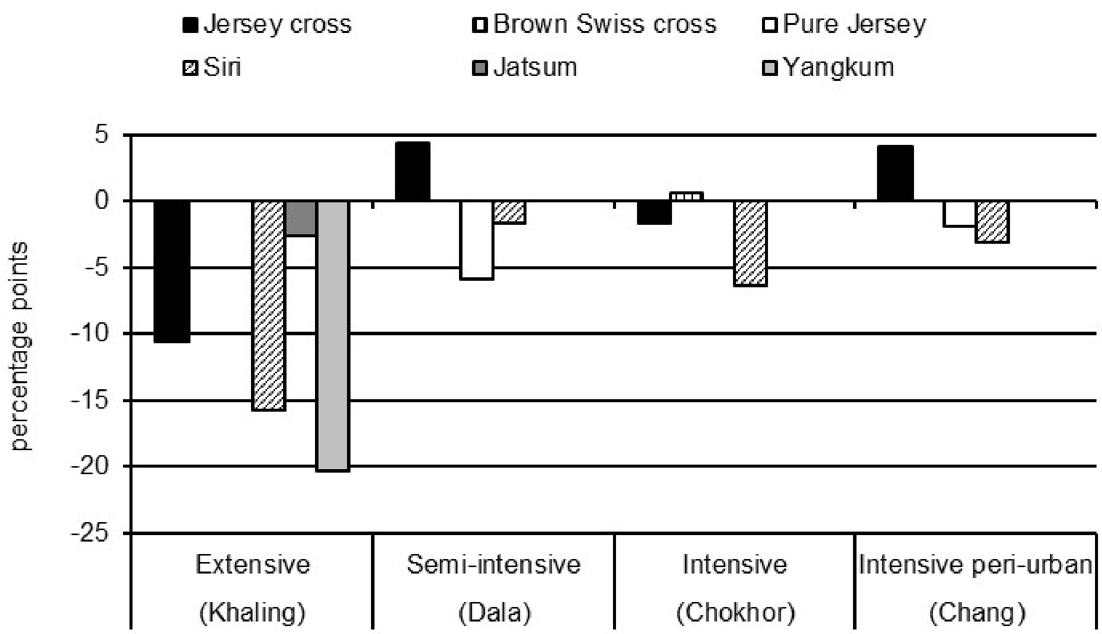

Figure 2. Annual herd calving rates minus critical calving rates in percentage points for different cattle breeds in the four study areas in Bhutan in 2000

(2–7%), except in the extensive area where Siri cows had a mortality rate of 17%, associated with the practice of grazing unproductive cows in the forest. Cows left in the forest usually die due to falling from cliffs or they succumb to predators. In Buddhist areas culling through sale for slaughter is discouraged.

3.3.2 Inputs, outputs and gross margins of the farm systems

The livestock cash inputs differed significantly between the study areas with the intensive peri-urban area having the highest inputs followed by the intensive, the semi-intensive, and the extensive area (Table 4). The highest livestock cash input was for concentrates, other cash inputs were needed for hired labour. The intensive areas had significantly higher cash inputs for crops than the semi-intensive and the extensive area (Table 4). Machinery (hiring tractors and power tillers) was used only in the intensive areas (24–28% of the crop cash inputs).

The intensive areas had significantly higher cash outputs and home consumption than the extensive and semi-intensive areas (Table 4). In the semi-intensive area, cash output from livestock was approximately five times higher than from crops, in the intensive peri-urban area approximately double that from crops, and in the other two areas the cash outputs from crops and livestock were similar. Cash income from cattle off-take and sale of other livestock was low, ranging from 4 to 16% of total livestock outputs.

In 2004 compared to 2000 household consumption of milk and milk products increased significantly in the extensive and semi-intensive areas, while consumption of crop products increased significantly in the semi-intensive and the two intensive areas.

There were significant differences between the areas for GM, off-farm income and total income (Table 5). Farm GM were highest in the intensive peri-urban area, followed by the intensive, semi-intensive, and extensive areas. In the semi-intensive and intensive area the farm GM were significantly higher in 2004. In the intensive area this was due to the significant increase in GM from livestock, while in the semi-intensive area it was due to the increase in GM from crops in 2004. These increases in GM were due both to increased production and the higher prices obtained for the commodities sold. In the intensive peri-urban area there was a significant reduction in Farm GM, due to the reduction in farm sizes and in the number of animals.

Table 4. Cash inputs and outputs, and internal flows in Nu x 100 (US$ 1= Nu 45.3 in 2004) in four areas of Bhutan, averages (least square means, lsm) and change from 2000 to 2004 (least square differences, lsd)

Area	**Khaling**		**Dala**		**Chokhor**		**Chang**			
System	**Extensive**		**Semi-intensive**		**Intensive**		**Int. peri-urban**			
	lsm	**lsd**	**lsm**	**lsd**	**lsm**	**lsd**	**lsm**	**lsd**	**s.e[1]**	**s.e[2]**
farms (n)	63		35		55		30			
external cash inputs										
livestock	28^{a}	-2	56^{c}	-8	94^{b}	13	176^{a}	-45^{z}	6	9
concentrates (%)	100		93		95		88			
crops	36^{b}	-8	53^{b}	-7	157^{a}	13	136^{a}	-62^{z}	7	10
hired bullocks (%)	52		47		22		10			
machinery (%)	0		0		24		28			
hired labour (%)	24		50		31		52			
fertilisers (%)	24		3		23		10			
cash outputs										
livestock	228^{d}	10	507^{c}	24	702^{b}	39	1118^{a}	-246^{z}	38	54
milk products (%)	96		84		95		96			
crops	223^{c}	28	99^{d}	-23	682^{a}	-37	494^{b}	-14	38	55
internal flows										
milk consumed	21^{c}	12^{z}	49^{b}	34^{z}	57^{a}	9	64^{a}	4	5	7
draught	51^{a}	-12	58^{a}	-26	47^{a}	-2	16^{b}	-22^{z}	6	8
manure	49^{a}	-24^{z}	33^{ab}	1	42^{a}	-1	26^{b}	-18^{z}	2	3
crops consumed	151^{c}	17	167^{c}	65^{z}	220^{b}	100^{z}	277^{a}	34	12	17
animal feed	31^{d}	3	58^{c}	-7	110^{a}	9	75^{b}	-14	4	6

[a,b,c,d] lsm with different superscripts between study areas are significantly different (P<0.05)
[z]lsd within a study area is significantly different (P<0.05)
[1]s.e of an average between areas; [2] s.e of an average between years within an area

Table 5. Gross margins (GM) and incomes in Nu x 100 (US$ 1= Nu 45.3 in 2004) in four areas of Bhutan, averages (least square means, lsm) and change from 2000 to 2004 (least square differences 2004-2000, lsd)

Area	**Khaling**		**Dala**		**Chokhor**		**Chang**			
System	**Extensive**		**Semi-intensive**		**Intensive**		**Int. peri-urban**			
	lsm	**lsd**	**lsm**	**lsd**	**lsm**	**lsd**	**lsm**	**lsd**	**s.e[1]**	**s.e[2]**
farms (n)	63		35		55		30			
farm GM	577^{d}	68	1084^{c}	214^{z}	1427^{b}	247^{z}	1652^{a}	-321^{z}	58	82
livestock	290^{c}	-15	533^{b}	48	644^{b}	186^{z}	973^{a}	-220^{z}	36	51
crops	287^{d}	83	551^{c}	165	782^{a}	61	679^{b}	-101	37	53
off-farm income	196^{b}	-34	212^{b}	47	81^{c}	11	303^{a}	86	19	27
total income	773^{d}	34	1296^{c}	261	1508^{b}	258^{z}	1955^{a}	-234^{z}	61	86
total income per capita	104^{c}	-5	130^{c}	12	188^{b}	23^{z}	239^{a}	-22^{z}	8	11

[a,b,c,d] lsm with different superscripts between study areas are significantly different (P<0.05)
[z]lsd within a study area is significantly different (P<0.05)
[1]s.e. of an average between areas; [2]: s.e of an average between years within an area

Off-farm income was lowest in the intensive area. In the semi-intensive area off-farm opportunities exist because of the presence of the hydro-power project. Off-farm income in the extensive area was relatively high as most women had taken up weaving. In the intensive peri-urban area off-farm income was the highest because of the employment opportunities in Thimphu. Overall, total annual income per household was lowest (773 Nu 10^2) in the extensive area and highest (1955 Nu 10^2) in the intensive peri-urban area. The total annual income per capita ranged from 104 (extensive area) to 239 (intensive peri-urban area) Nu 10^2.

3.4 Discussion

3.4.1 Herd compositions and performances

Keeping cattle and extracting milk for home consumption and for sale as butter and cheese have been central to Bhutan's livelihood systems for centuries (Tamang and Dorji 2010). For the last 20 years the sizes of the national population of cattle, Mithun and their crosses have been more or less stable but with a marked shift in composition because of the adoption of Jersey and Brown Swiss crossbreeding. Herd compositions on the study farms (Table 2) reflected the policies promoting dairy crossbreeding in areas with suitable agro-ecological conditions, as well as the preferences of the farmers, strong religious and cultural pressures, and the need for draught animals. Between 2000 and 2004 the proportion of exotic and crossbred dairy cattle increased by only 3, 9, 9 and 11 percentage points in the extensive, semi-intensive, intensive, and intensive peri-urban study areas, respectively. The four-year period might have been too short to capture any significant shifts in breed composition resulting from the change in breeding policy in 1998 which allowed farmers to choose their desired exotic breed irrespective of the agro-ecological zone. The study results showed, however, that, despite the ready availability of Brown Swiss semen and bulls, the breed has not been widely adopted because farmers preferred the Jersey, even in the intensive area where Brown Swiss was promoted strongly. Farmers liked Brown Swiss crosses less than Jersey crosses because of their higher feed requirements. Consequently, in 2007 Bhutan had ten times more Jersey and its crosses than Brown Swiss crosses (DoL 2008). Farmers in the eastern part of the country prefer Mithuns and Jatsums. The number of dairy crossbreds was limited in the extensive area, located in the eastern part, and it is not expected to increase.

Buddhist beliefs against the sale for slaughter of livestock are another major influence on the size, structure and breed compositions of herds. For example, in the intensive areas small numbers of Siri cattle were retained because of religious taboos and societal barriers. Farmers who sell animals for slaughter are looked down upon in society. A recent survey found 18 year-old Siri cows on some farms (Ibrahim, personal communication). More needs to be learnt about how these religious influences affect breeding decisions and herd management practices.

Female cattle do not, generally, contribute the draught power that is integral to Bhutan's smallholder farming systems. In the intensive areas, both machinery and draught bullocks were used for land preparation. The government provides subsidy for the purchase of power-tillers (MoA 2002). In India, the adoption of tractors and power-tillers is affecting livestock type and breed choices (Erenstein et al. 2007). In Bhutan, in the mountainous areas, however, draught cattle are still required as power tillers cannot ply in these areas. Farmers prefer Siri bullocks, but if these are not available crossbred bullocks are used. In the eastern part of the country, the crossbreeding of Siri with Mithun fulfils that important role of providing draught animals (Tamang and Dorji 2010), the eco-region represented by the Khaling study area.

The average milk off-take per cow did not differ much between dairy crossbred types and areas. It was around 5 kg d^{-1}. The pure Jerseys had milk off-takes around 6 to 7.5 kg d^{-1}. These milk production levels are about the same as for smallholder dairy type cows in other countries (Patil and Udo 1997a; Bebe et al. 2003). It seems that the feed resources available on smallholder mixed farms can only support such milk production levels. The Jersey and Jersey and Brown Swiss crosses showed high mortality and low fertility rates. In the semi-intensive and intensive peri-urban areas, the herd calving rates of the Jersey crosses were higher than the critical calving rates, however their herd calving rates in these areas were still only around 30%. It is well documented that in developing countries exotic crossbreds are more susceptible to diseases and high mortality rates and that they require better feeds, veterinary care and management than local cattle (Madalena 1981; Syrstad 1996; Devendra and Sevilla 2002; Bebe et al. 2003). To improve and sustain intensification through dairy crossbreeding requires integrated approaches targeting preventative disease control, improvement of feeding practises and the provision of bulls and effective AI to increase fertility rates.

Recently, such efforts have been initiated in Bhutan (Samdup and Rai 2007). In the extensive area, the calving rates of Jersey crossbreds and local breeds were all below the critical calving rates. This might explain the significant reduction in herd size between 2000 and 2004 in this area.

3.4.2 Impact of crossbreeding

A major objective of dairy crossbreeding was to increase household incomes. Farms in the intensive areas, with mainly crossbreds and pure Jerseys, used 3.8 times more cash inputs for livestock and had 4.0 times higher cash outputs from livestock than farms in the extensive area, with few crossbreds, and 2.6 times more cash inputs and 1.8 times higher livestock cash outputs than farms in the semi-intensive area, with about equal numbers of local and crossbred cattle (Table 4). The livestock GM's were, on average, 1.4–2.4 times higher in the intensive than in the semi-intensive and extensive areas (Table 4). In India's Gujarat state, farms with crossbreds had 1.6 times higher livestock gross margins than farms without crossbreds (Patil and Udo 1997b). In Gujarat, many local cattle breeds are relatively good milk producers, whereas milk off-take levels of Siri cows were small (Table 2).

Crop production was also more intensive in the intensive areas than in the other two areas, resulting in higher crop GM in the intensive areas. The off-farm income was highest in the peri-urban area. All income activities together resulted in a household income per capita that was highest in the intensive peri-urban area followed by the intensive area, the semi- intensive area, and the extensive area. In the extensive area the average per capita income was only slightly above the per capita poverty line of 9723 Nu y^{-1} (the calculated per capita poverty line of 8976 Nu y^{-1} for 2000 (CSO 2001) corrected for the inflation rate). In the semi-intensive area the per capita income was 1.3 times above the poverty line; in the intensive area this was 1.9 times and in the intensive peri-urban area this was 2.5 times. Home consumption of crop and livestock products was also higher in the intensive areas than in the semi-intensive and extensive areas, which indicates a higher standard of living in the intensive areas. This higher standard of living in the intensive areas makes it easier for the farmers to invest in concentrates for dairy crossbreds.

The differences in economic results between 2000 and 2004 were not big. A major difference was the reduction in farm GM, and consequently total income, in the intensive peri-urban area. It is expected that farmers in this area will gradually have to move further interior once the urban infrastructure has been developed or will give up farming and take up other jobs.

A second objective of the crossbreeding programme was to try to reduce the environmental load of cattle by promoting keeping fewer but more productive cattle and reducing grazing in CPR. In each of the four study sites CPR play a major role in the maintenance of the herds by complementing the limited feed resources produced on the farms, mainly crop residues and by-products, and those bought from the market. Our study showed that there was no proof that crossbreeding reduced cattle numbers per farm. Only in the intensive peri-urban area, the cattle herds became markedly smaller between 2000 and 2004, but this was due to the urbanisation in this area. Generally lactating crossbred cows were stall-fed and milked every day. So, crossbreds graze less in the forests and natural grasslands compared to local cattle. Research is required to quantify how the changes in herd compositions, due to crossbreeding, impact on CPR.

A third objective of the crossbreeding programme was to reduce imports of dairy products. Although, crossbreeding policies will have contributed to the 70% increase in local milk production between 2000 and 2005, they did not reduce the gap between supply and demand for dairy products: for the same period imports (in fresh milk equivalents) increased by about 30% (DRC 2001, 2006). Given that imports from India are cheaper than the local dairy products and that both the standard of living and urbanisation are increasing in Bhutan, it is not expected that crossbreeding will reduce dependency on dairy imports in the foreseeable future.

3.5 Conclusions

In Bhutan, dairy crossbreeding has contributed to the higher livestock gross margins in the intensive areas. The benefits of crossbreeding, in terms of milk production per cow, are reduced by poor survival and high reproductive wastage, which should be addressed through integrated management interventions. Farmers preferred Jersey and Jersey crossbreds over Brown Swiss crossbreds. Crossbreeding has not reduced cattle numbers per farm, but it might contribute to reducing grazing pressure on CPR. Crossbreeding has not been able to reduce the gap between supply and demand of dairy products in Bhutan. The promotion of crossbreeding for dairying has not much interfered with cultural values. In the study area with Mithun crossbreds, animals with a high cultural value, the number of dairy crossbreds was small. In the intensive areas small numbers of Siri cattle were retained because of religious taboos against slaughter of cattle and farmers' preference for Siri draught bullocks.

Farmers in the intensive and semi-intensive area will continue to find dairying attractive as a source of regular and reliable income compared to the traditional once-a-year return from crop production. The intensive area had very limited possibilities for off-farm income, but relatively good production and marketing conditions for both livestock and crops. In the semi-intensive area, farmers were more livestock than crop oriented. It is expected that the crossbred population in this area will grow to fulfil the demand for fresh milk, due to the presence of the hydro power project.

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Chapter 4

Livestock intensification and use of natural resources in smallholder mixed farming systems of Bhutan

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Abstract

Bhutan aims to intensify livestock production not only to improve livelihoods of farming households and to meet the increasing demands of livestock products, but also to sustainably use natural resources. This paper assesses the impact and trends of livestock intensification on the use of Common Property Resources (CPR), and how this affects the cattle numbers that can be maintained and the nitrogen (N) and phosphorus (P) flows at the farm. Data on household, cropping and livestock activities were collected through interviewing 183 households in extensive, semi-intensive, intensive, and intensive peri-urban areas in the years 2000 and 2004.

In the extensive and semi-intensive areas, CPR was the most important source of Total Digestible Nutrients (TDN) for cattle. In the intensive areas with a majority of crossbred cattle, the farmers relied less on CPR than in the other two areas, but still about one quarter of the TDN requirements were met by grazing CPR. Grazing in the CPR provided the highest proportion of NP inputs at farm level; without grazing on CPR all four areas would have had highly negative soil nutrient balances. Intensification of livestock production through crossbreeding has not resulted in major reductions in cattle numbers per farm, but it is contributing to reduced use of CPR by farmers. Intensification partly replaces farm nutrient flows from CPR with nutrient inputs through increased use of concentrates, conserved fodder, and fertilisers. More awareness of nutrient management is required among farmers coupled with more research on nutrient assessments.

Keywords: common property resources, livestock, nitrogen and phosphorus flows

4.1 Introduction

A major challenge for livestock intensification in developing countries is to find a balance between human food needs, livelihoods of farming households and the sustainable use of natural resources. Land is such an important natural resource (de Wit et al. 1995). Growing population pressure, fragmentation of land due to inheritance, and land encroachment due to urbanisation all contribute to reducing land sizes per farming household. In Bhutan only about 8% of the land is suitable for arable farming and about 4% is pasture land (LUPP 1997). Therefore, farmers closely integrate livestock and crop production with forestry. The forests are state owned, but farmers do have legal grazing rights in some of the forest areas. Environmentalists and foresters routinely view cattle grazing as a serious threat to biodiversity, through reduction of undergrowth, and change in structure and tree species composition (Rosset 1997). Others argue that quantitative observations do not support these assertions because removal of herbaceous biomass by grazing enhanced conifer species regeneration, though grazing did diminish the number and density of broadleaved species (Roder et al. 2002).

In Bhutan, intensification of livestock production has to consider the fragility of the alpine ecosystems. Crossbreeding for dairy production is the major tool in livestock intensification (Samdup et al. 2010). Concurrent efforts are made to promote and enhance pasture, feed and fodder development programmes (MoA 2002). One of the objectives, next to meeting the demands for dairy products and contributing to the development of rural households, is to reduce grazing in Common Property Resources (CPR) by keeping fewer but more productive cattle. It is expected that crossbreeding will bring the livestock density in line with the carrying capacity of the farm land and CPR (Dorji 1993; Roder et al. 2001). The traditional combination of grazing in the CPR and night feeding near the farmer's house contributes considerably to the maintenance of soil fertility at farm level; on the other hand, it results in continuous export of plant nutrients from the forest (Roder et al. 2002). Intensification of livestock is expected to replace farm nutrient inputs from forest areas with nutrient inputs through increased use of fertilisers and concentrates (Samdup et al. 2010).

Quantitative studies on the impact of livestock on the use of natural resources in Asia are scarce (Pilbeam et al. 2000; Thorne and Tannner 2002). This paper aims to assess the impact of livestock intensification on the use of CPR, and the cattle feed balance and the Nitrogen (N) and Phosphorus (P) flows at the farm level in four geographical areas differing in agro-ecological conditions, infrastructure, market access and consequently crossbreeding implementation.

4.2 Material and methods

4.2.1 Study areas

Bhutan is located in the Eastern Himalayas, bordered by the Tibetan region of China and India. The study areas were in Khaling block in Trashigang district, Dala block in Chukha district, Chokhor block in Bumthang district and Chang block in Thimphu district, located in east, south, central and west Bhutan respectively. A block consists of a number of villages. The Khaling study area represented Bhutan's 'extensive' farming system characterised by mainly local Siri cattle grazing in the forest and on natural grasslands with some night feeding, no crop irrigation, a mild temperate climate, and poor market access (no motorable road, 4-5 h needed by vehicles to reach large markets). The Dala study area represented a 'semi-intensive' farming systems with Siri and crossbred (Siri x Jersey) cattle in equal proportions, mainly grazing with some stall feeding, limited commercial concentrate feeding, some irrigation, and medium market access (no regular transport services, 2 h needed for vehicles to reach large markets). The Chokhor and Chang study areas represented 'intensive' farming systems: Siri x Brown Swiss crossbred cattle in Chokhor and Siri x Jersey crossbreds and Jersey in Chang coupled with stall feeding, high commercial concentrate feeding, use of inorganic fertilisers, and irrigation. The Chang area is close (20-30 min.) to the capital city Thimphu and represents a peri-urban area. Many farmers in the intensive areas were members of dairy groups for the collective marketing of milk.

The soils are mainly clay and clay loam types. The major crops grown were maize and potatoes in the extensive area, maize and rice in the semi-intensive area, buckwheat, potatoes and apples in the intensive area, and rice and apples in the intensive peri-urban area. Cattle provide milk, milk products, manure and draught power. Most cattle graze in the *tsadrogs* (registered grazing land) located near settlements or in forests during the day, and are confined to houses or crop fields at night. Sometimes, crossbred milking cows or those in advanced gestation are kept at the farm during the day. Conservation of fodder (hay and silage) was done in moderate quantities in the intensive areas.

The 1985 national cattle breeding policy differentiated between the agro-ecological zones: it proposed Brown Swiss crossbreeding in the high altitudes; Jersey crossbreeding in other areas with relatively better market access; and using local breeds in remote areas that have harsh environmental conditions. In 1998, in response to farmers' requests, the cattle breeding policy was changed to provide semen and bulls of any breed to all districts based on farmers' demand.

4.2.2 Data collection

A two-phase time series household survey was carried out in which the same households were visited in 2000 and 2004. Data were collected for these two years to capture the impact and trends due to the breeding policy change of 1998. In total, 183 households from 37 villages were selected at random. Based on the 2000 census (DoL 2001), in each block 30-40% of the villages (6, 9, 16 and 6 villages in Khaling, Dala, Chokhor and Chang blocks, respectively) and in each village 5-15% of the households (63, 35, 55 and 30 households in Khaling, Dala, Chokhor and Chang respectively) were visited. Weather conditions were comparable in both survey years.

Recall data covering one year were collected through household interviews by trained enumerators using a pre-tested, semi-structured questionnaire. Individual farmers were interviewed on family background, sources of income, land-use, crop and livestock management practices, crop production, and milk off-take. For each farm, external and internal flows of nutrients N (nitrogen) and P (phosphorus) (Figure 1) were quantified for 2000 and 2004.

4.2.3 Assessment of farm feed balance

In this study, the Farm Feed Balance (FFB) is calculated as the number of standardised tropical livestock units (LU) of 300 kg body weight that can be maintained by the on-farm and off-farm feed resources and grazing in CPR in terms of Total Digestible Nutrients (TDN) requirements (Thapa and Paudel 2000). Cows, bullocks, and bulls were considered as 1 LU, heifers and young bulls as 0.7 LU and calves as 0.2 LU (Samdup 1997; DALSS 2001). A model approach was used to estimate the average FFB in the farms in the four areas based on a comparison of the TDN requirements of the animals with the TDN available from external feed supply, on-farm feed availability, and grazing on CPR and pasture land. A scenario of the FFB without CPR grazing was also analysed to explore the impact of CPR on livestock feeding at farm level.

TDN requirements

The TDN requirements for cattle were taken from Joshi (1988). Table 1 gives the daily maintenance and production requirements in kg TDN for different types of cattle. The TDN requirements were estimated by summing the total nutrient

Table1. Maintenance and production requirements of total digestible nutrients (TDN) in kg per livestock unit (LU) per day

	Type of requirements	TDN (kg)
cows	maintenance	2.36
	gestation	0.7
	production (milk per kg with 3.5% fat)	0.29
	production (milk per kg with 4.5% fat)	0.34
growing animals[1]	maintenance and growth	
	calves	1.9
	heifers and young bulls	2.6
breeding bulls	maintenance and breeding	3.6
	maintenance	2.36
	breeding	1.24
bullocks	maintenance and draft	3.1
	maintenance	2.36
	draft	0.74

[1]heifers; young bulls and calves

requirements for maintenance and production functions. Milk of crossbred and local cattle was estimated to contain 3.5% and 5% fat respectively. Gestation requirements were taken for the last trimester. In the intensive and intensive peri-urban area the average lactation length of cows was obtained from milk recording data, these were 277 days and 289 days, respectively. Such information was not available for the semi-intensive and the extensive area; as such lactation lengths of 277 and 243 days respectively, were estimated based on information by the farmers during the field survey. Concentrates were fed to lactating cows, cows in the last trimester of gestation, breeding bulls, and working bullocks. The survey showed that bullocks worked 27, 41, 21 and 14 days per year in the extensive, semi-intensive, intensive, and intensive peri-urban areas, respectively. Breeding bulls were given additional feed in the extensive area for 90 and in the other areas for 60 days per year.

TDN available

The DM and TDN content of the feeds for cattle were taken from Sen et al. (1978). The annual TDN available was calculated per farm in the four study areas. The annual TDN available from concentrates (Conc $_{TDN\ avail}$) was calculated based on data available from the survey and literature and was estimated as: Conc $_{TDN\ avail}$ = Conc $_{DM\ avail}$ * Conc $_{TDN\ content}$; where Conc $_{DM\ avail}$ is the total dry matter (DM) available from concentrates; Conc $_{TDN\ content}$ is the TDN content per kg DM of concentrates (Singh 2003). The above equation was also used to estimate the annual TDN available from crop residues, fodder tree leaves, and hay and silage.

CPR refers to grazing in the forests and natural grasslands. Farmers generally agreed that CPR provide a large proportion of their animal feed requirements. Based on the interviews with farmers, it was estimated that cattle grazed in the CPR for 365 days in the extensive area, 330 days in the semi-intensive area and 300 days in the intensive areas. Cattle grazed on average, 6.5 h in the intensive areas and 8 h in the semi-intensive and extensive areas.

The grazing practices were similar in 2000 and 2004. Based on estimates of Roder (1990) and RGOB (1994) the proportion of DM maintenance requirements met from grazing in the CPR was taken as 61% in the extensive area, 52% in the semi-intensive area and 44% in the intensive and intensive peri-urban areas.

The annual TDN available from CPR ($CPR_{TDN\ avail}$) was estimated as:

$$CPR_{TDN\ avail} = CPR_{PMR} * MR * CPR_{days} * Grass_{TDN\ content} * LU,$$

where CPR_{PMR} is the proportion of maintenance requirements met from CPR; MR is the DM maintenance requirement per LU in kg d^{-1}, which is estimated as 2 % of the body weight (300 kg); CPR_{days} is the number of days cattle graze in CPR per year; $Grass_{TDN\ content}$ is the TDN content per kg DM of grass

The TDN available from on-farm pasture land ($Pasture_{TDN\ avail}$) was estimated as:

$$Pasture_{TDN\ avail} = Pasture_{DM\ avail} * Pasture_{TDN\ content},$$

where $Pasture_{DM\ avail}$ is the total DM available in the pasture land per year. This was calculated based on the assumption that the average DM available from improved pasture in Bhutan is 4000 kg per ha (Roder et al. 2001) and from local pasture 654 kg per ha (Dorji 1993). $Pasture_{TDN\ content}$ is the TDN content per kg DM of pasture (Dorji 1993).

Nutrient (NP) inputs to livestock sub-system

All NP inputs and outputs were computed on DM basis. The annual NP input into the livestock sub-system was computed in the same way as for the TDN intake. The nutrient inputs were commercial concentrates (ready-made), procured feed ingredients (e.g. maize, rice bran, mustard oil cakes), pasture grazing and crop residues from the crop sub-system. Commercial concentrates were fed to cattle only in the intensive and intensive peri-urban areas. Local concentrates are prepared using locally available feed sources and some procured feed ingredients.

Nutrient outputs from livestock sub-system

The annual NP outputs from the livestock sub-system and crop sub-system were estimated using the equations described below:

The annual NP output of milk ($Milk_{NP\ output}$) was estimated as:

$Milk_{NP\ output} = Milk_{yield} * Milk_{NP\ content}$,

where $Milk_{yield}$ is the quantity of milk per year; $Milk_{NP\ content}$ is the N or P content of milk taken at 0.6 and 0.09%, respectively (Wortman and Kaizzi 1998).

The annual NP output from animals sold ($Animal_{NP\ output}$) was estimated as: $Animal_{NP\ output} = LU_{sold} * LU_{NP\ content}$;

where LU_{sold} is the total LU kg sold per year; $LU_{NP\ content}$ is the NP content of LU taken at 25.3 g N and 7.4 g P per kg body weight (van Eerdt 1994). The same equation was used to derive at estimates for animals that died.

The estimation of the quantity of manure produced was based on the assumption that one LU consumes about 6 kg DM per day (2% of body weight) (Samdup et al. 2010). With an assumed DM digestibility of 60%, it was estimated that the annual manure production was 880 kg DM per LU. With the N, P and K content of manure taken at 1.6%, 0.8% and 1.2% on DM basis, respectively (ICAR 1986), the annual N, P and K content of manure per LU was estimated at 14 kg, 7 kg and 11 kg, respectively. Nutrient losses of NPK during storage were estimated as 50% for N and P and 40% for K (Moore and Garroth 1993). Based on the average number of hours grazed per day in the CPR, it was assumed that 27% to 33% of the manure was deposited on the CPR and the remainder on the farm land.

Nutrient outputs from crop sub-system

The total crop sub-system output is the sum of NP outputs from crops and on-farm pasture land grazing. The annual total NP output of the Crops ($Crops_{NP\ output}$) was estimated as:

$Crops_{NP\ output} = Crop_{yield} * Crop_{NP\ content}$,

where $Crop_{yield}$ is the quantity of grains, crop residues, hay and silage DM from orchard land; $Crop_{NP\ content}$ is the NP content of the crop sub-system outputs. The NP contents of crop products were derived from literature in Bhutan and neighbouring Nepal (Tamang 1988; Roder et al. 2001; Roder et al. 2003). A harvest index of 0.43 for fine grain crops (Pezo 2002; Schiere et al. 2004) and 0.30 for coarse grain crops (Pezo 2002) was used for calculation of the straw:grain ratio.

Pasture land is considered as a part of the crop sub-system. The annual NP output from pasture grazing as an input into the livestock sub-system per farm was estimated as:

$Pasture_{NP\ avail} = Pasture_{DM\ avail} * Pasture_{NP\ content}$,

where $Pasture_{DM\ avail}$ is the total DM available in the pasture land per year (Dorji 1993). $Pasture_{NP\ content}$ is the NP content per kg DM of pasture (Tamang 1988; Roder et al. 2001; Roder et al. 2003).

Estimated ammonia losses and crop harvest losses

Ammonia losses from the application of manure to soil were taken as 18.5% (Van der Hoek 2002). As much as 50% of N and P can be lost from manure through run-off, leaching and mixing with the soil on the plot surface (Tamminga 1992; Moore and Garroth 2003). Since most of the manure in Bhutan is stored in the open, the NP losses were estimated to be 50%. Ammonia losses from inorganic fertilisers through leaching and volatilisation were estimated at 13%, as was reported in the mid hills of Nepal (Singh et al. 1991). Ammonia losses during processing and preservation of the crops to be used as animal feed were estimated at 5% of the total nitrogen content of the crops (de Boer et al. 1997).

Crop harvest losses which remain on the field and go to the soil were estimated as 15% of the total uptake by the crops, and ammonia losses during decomposition of crop harvest losses were estimated at 20% (de Boer et al. 1997).

4.2.4 Nutrient balances

Figure 1 gives the conceptual model used to show the NP flows per farm. The nutrient balances resulted from processes and flows managed by the farmer, so they did not include soil erosion, sedimentation and nitrogen fixation.

The annual NP balances for the crop sub-system ($CSS_{NP\ balance}$) of the farms in the four areas were estimated as:

$CSS_{NP\ balance} = CSS_{NP\ inputs} - CSS_{NP\ outputs}$, where $CSS_{NP\ inputs}$ are the manure inputs from the livestock sub-system to the soil plus fertilisers; $CSS_{NP\ outputs}$ are the outputs of the crop sub-system (crop products, crop harvest to soil, crops and pasture to the livestock sub-system).

The farm nutrient balances ($FS_{NP\ balance}$) are a result of the external nutrient (NP) inputs minus the external nutrient outputs (NP) (Figure 1). This was estimated as: $FS_{NP\ balance} = LSS_{NP\ ext\ inputs} + CSS_{NP\ ext\ inputs} - LSS_{NP\ outputs} - CSS_{NP\ outputs}$, where $LSS_{NP\ ext\ inputs}$ are the external NP inputs into the livestock sub-system

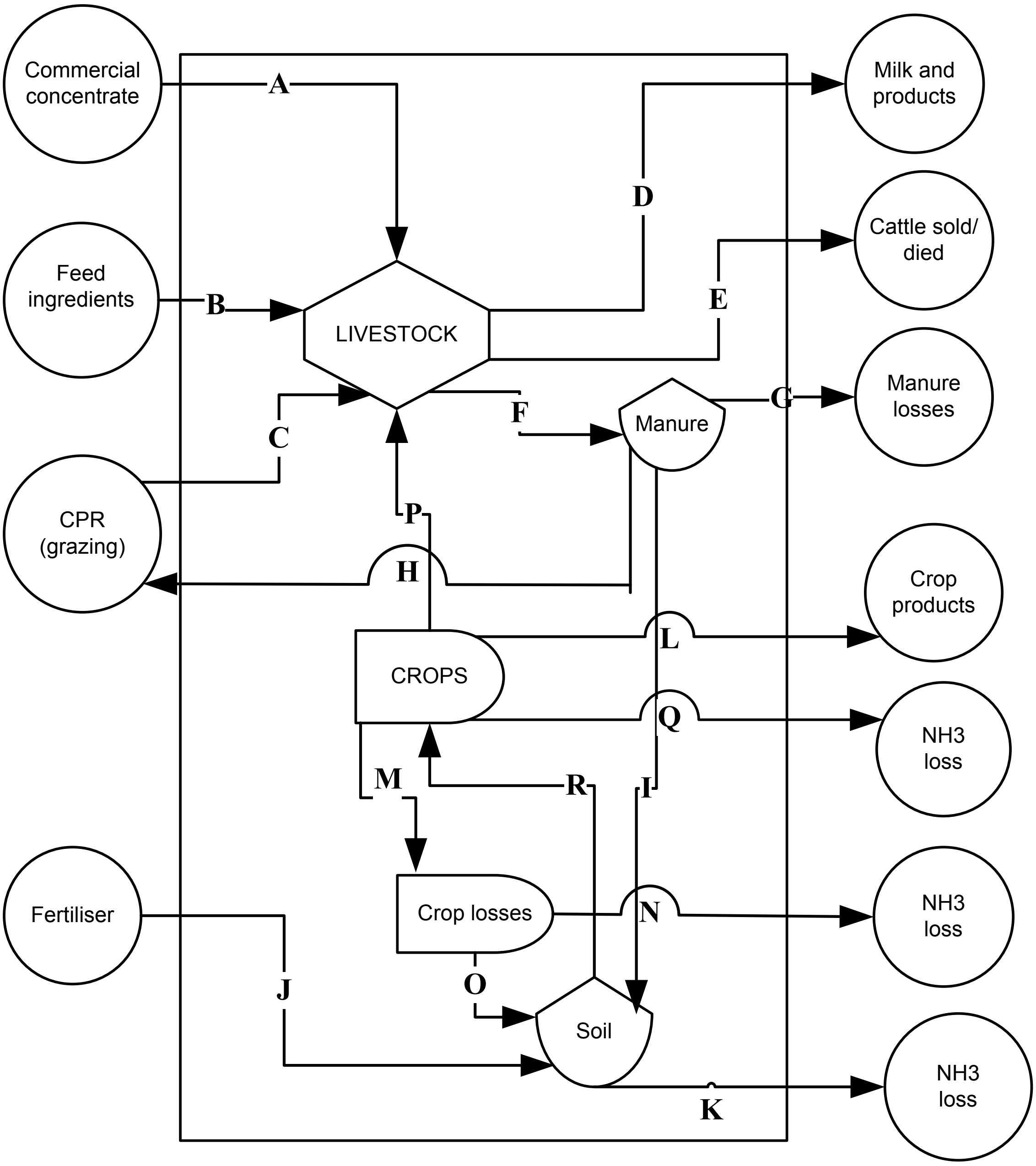

Figure 1. Flow chart of inputs and outputs of Nitrogen (N) and Phosphorus (P) for farms with a crop and livestock sub-system; symbols according to Odum (1983); the labels indicate the flows that are quantified in Tables 3 and 4

(concentrates, feed ingredients and grazing in CPR); $CSS_{NP\ inputs}$ are the external NP inputs into the crop sub-system (inorganic fertilisers); $LSS_{NP\ outputs}$ are the NP outputs of the livestock sub-system going out of the farm system (milk, animal sold or died and manure going to CPR); $CSS_{NP\ outputs}$ are the outputs of the crop sub-system going out of the farm.

4.2.5 Statistical analyses

Least-squares methods (Harvey 1977) were used to explain variation in farm characteristics, and farm inputs and farm outputs between study areas. A nested design was also used with years nested within study areas (least square differences 2004-2000).

4.3 Results

4.3.1 Land use and livestock keeping

Table 2 gives the least square means (lsm) and the change from 2000 to 2004 (lsd) of available farm resources, annual fertiliser use, and annual crop and livestock production in the four areas. The farms were significantly larger in the intensive (2.9 ha) and semi-intensive (2.6 ha) areas compared to the extensive (1.2 ha) and intensive peri-urban (1.3 ha) areas. Land was used mainly for cropping. There was a decline in land area (0.44 ha) in the intensive peri-urban area in 2004 compared to 2000 due to the sale of land for expansion of Thimphu city. This also resulted in a significant decline in herd size in this area. Herd size was highest in the intensive area (9.4 LU). These herds were composed of 85% crossbred cattle, in contrast to the herds in the extensive area which were composed of 23% crossbreds. A significant decline in herd size in the extensive and intensive peri-urban areas in 2004 was seen only for local cattle. The numbers of crossbred cattle did not change between 2000 and 2004.

The annual fertiliser inputs differed significantly between the four areas with the highest fertiliser use in the intensive area (780 kg per farm or 268 kg per ha crop land) and the lowest use in the semi-intensive area (30 kg per farm or 13 kg per ha). In the intensive area the use of fertilisers was significantly higher (21%) in 2004 compared to 2000. Annual rice production was significantly higher in the intensive peri-urban area (1720 kg per farm or 1433 kg per ha crop land) than in the other areas. There was a significant decrease in rice production (48%) in the intensive peri-urban area in 2004 compared to 2000 (Table 2) which was due to the decrease in farm size. In the intensive area there was a significant increase in annual wheat (45%) and buckwheat (61%) production in 2004, probably due to increased use of inorganic fertilisers. In the semi-

Table 2. Farm resources, crop and livestock production in four areas of Bhutan, averages (least square means, lsm) and change from 2000 to 2004 (least square differences, lsd)

Area	Khaling		Dala		Chokhor		Chang			
System	Extensive		Semi-intensive		Intensive		Intensive peri-urban			
	lsm	lsd	lsm	lsd	lsm	lsd	lsm	lsd	s.e[1]	s.e[2]
total land (ha)	1.3[b]	0	2.6[a]	-0.1	2.9[a]	0.01	1.3[b]	-0.37	0.2	0.3
crop land (ha)	1.1[b]	0	2.4[a]	-0.2	2.0[a]	0	1.2[b]	-0.4	0.2	0.2
pasture land (ha)	0.2[b]		0.2[b]	0.1	0.9[a]	0	0.1[b]	0	0.1	0.1
herd size (LU)	7.3[b]	-1.6[z]	7.1[b]	-1.6	9.4[a]	-0.2	5.3[c]	-3.5[z]	0.4	0.6
crossbred	1.7[c]	0	4.2[b]	-0.3	8.1[a]	0.1	4.0[b]	-2.1	0.3	0.5
local	5.7[a]	-1.6[z]	3.0[b]	-1.4[z]	1.4[c]	-0.3	1.4[c]	-1.4[z]	0.3	0.4
inorganic fertiliser (kg x 100)										
urea	1.0[c]	0.4	0.3[d]	0.6	2.7[a]	0.5	1.6[b]	-0.4	0.001	0.001
single superphosphate	0.9[b]	0.1	-	-	5.0[a]	1.0[z]	0.4[c]	-0.1	0.001	0.002
potash	-	-	-	-	0.1[a]	0	0.3[a]	-0.1	0.002	0.001
crop produce (kg x 100)										
rice	-	-	6.3[b]	1.6[z]	-	-	17.2[a]	-11.0[z]	0.002	0.001
wheat	-	-	-	-	2.5[a]	0.9[z]	0.5[b]	0.1	0.002	0.001
barley	-	-	-	-	1.5[a]	0.3	-	-	0.002	0.002
buckwheat	-	-	-	-	20.2[a]	9.4[z]	-	-	0.001	0.001
maize	14.5[a]	1.1	6.5[b]	2.1	-	-	-	-	0.002	0.001
potatoes	27.9[b]	3.5	2.4[c]	0.7	42.6[a]	3.5	3.9[c]	-1.1	0.001	0.001
apples	-	-	-	-	8.2[b]	-0.9	30.2[a]	-0.9	0.002	0.001
livestock produce (kg x 100)										
milk off-take	12.9[c]	-0.2	30.5[b]	3	44.5[a]	11.0[z]	46.0[a]	-14.0[z]	0.002	0.001
butter	0.6[b]	-0.1	0.5[b]	0.2	1.4[a]	0.4[z]	0.5[b]	-0.2[z]	0.002	0.001
cheese	1.1[b]	-0.1	1.0[b]	0.5	2.5[a]	0.7[z]	0.9[b]	-0.3[z]	0.001	0.001

[a,b,c,d]lsm with different superscripts between study areas are significantly different ($p<0.05$)

[z]lsd within a study area is significantly different ($p<0.05$)

[1]s.e of an average between areas, [2]s.e of an average between years within an area

intensive area, there was a significant increase in rice production (21%) in 2004 also due to increased use of inorganic fertilisers.

The intensive areas had significantly higher milk off-take per farm compared to the farms in the extensive and semi-intensive areas. In the intensive area there was a significant increase in milk off-take per farm (28%), and in the intensive peri-urban area a significant decrease in milk off-take per farm (26%) in 2004 compared to 2000. Butter and cheese production was significantly higher in the intensive area than in the other three areas.

4.3.2 Feed resources and farm feed balance

Figure 2 gives the different sources of feed available per farm in kg TDN for the four study areas in 2000 and 2004. In 2000, the contribution of CPR grazing to the TDN available per average farm ranged from 25% in the intensive peri-urban area to 62% in the extensive area. In 2004 the contributions of CPR grazing to TDN available had slightly decreased to 19% in the intensive peri-urban area and 51% in the extensive area. In the intensive and intensive peri-urban areas, concentrates were the next most important source of TDN and contributed 21 and 35%, respectively, to the total TDN available. In the extensive and semi-intensive areas, crop residues were the second most important TDN source, contributing 24 and 34%, respectively, to the total TDN available. Conserved fodder was only fed in the intensive areas. The reasons given for not using conserved fodder in the extensive and semi-intensive areas were the lack of green grass and the additional labour required. This was compensated by more hours of grazing in the CPR. In the semi-intensive area, fodder trees were an important source of feed providing about 20% of the total TDN available.

Figure 3 gives the estimated number of cattle maintained in LU and the excess LU kept in the farms in the four study areas. In 2000, the excess LU reared in relation to the feeds on offer ranged from 2.2 LU or 26% of the total herd size

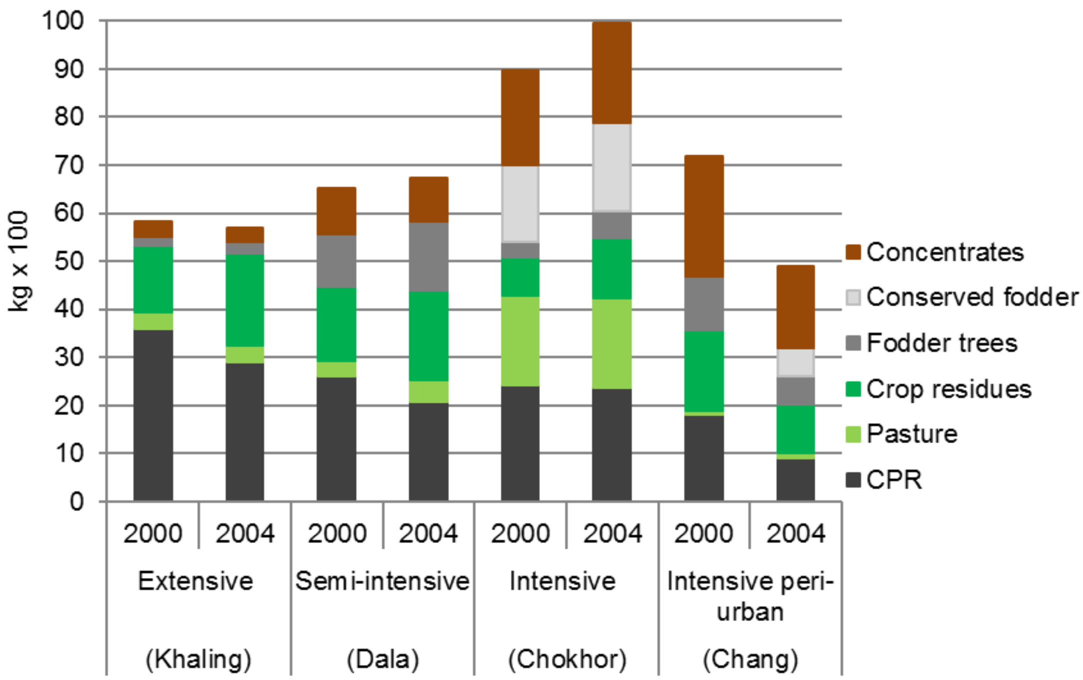

Figure 2. Contribution of Total Digestible Nutrients (TDN) in kg by different sources of feed in the four areas of Bhutan, average in 2000 and 2004

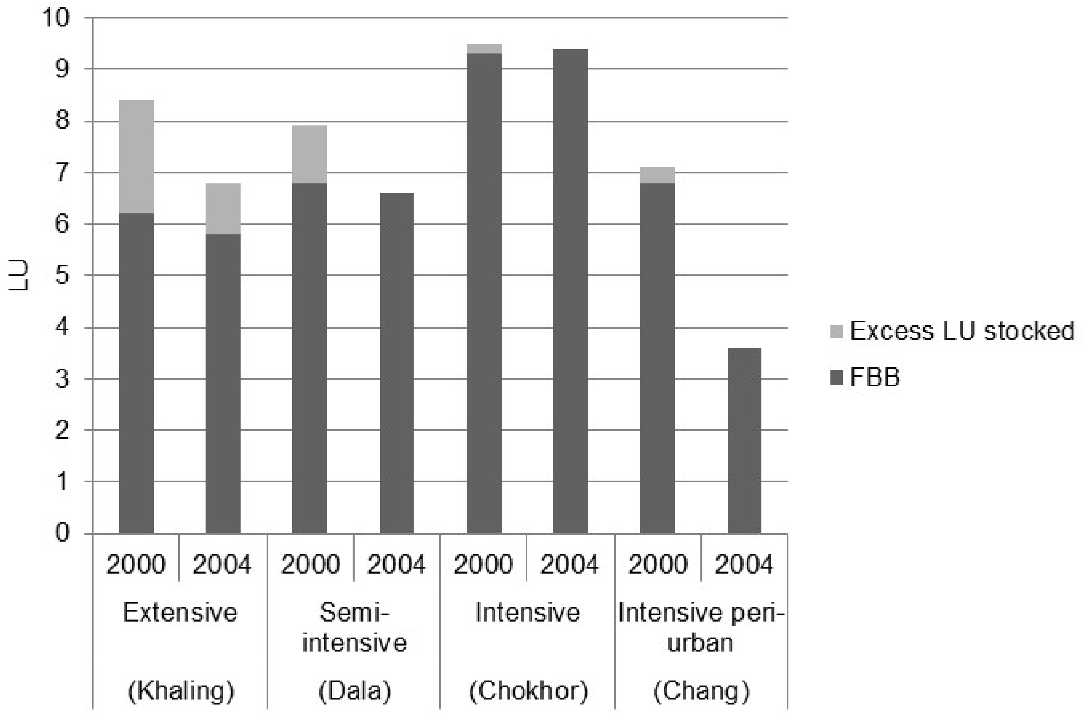

Figure 3. Farm Feed Balance (FFB) and Excess Tropical Livestock Unit (LU) in four areas of Bhutan in 2000 and 2004

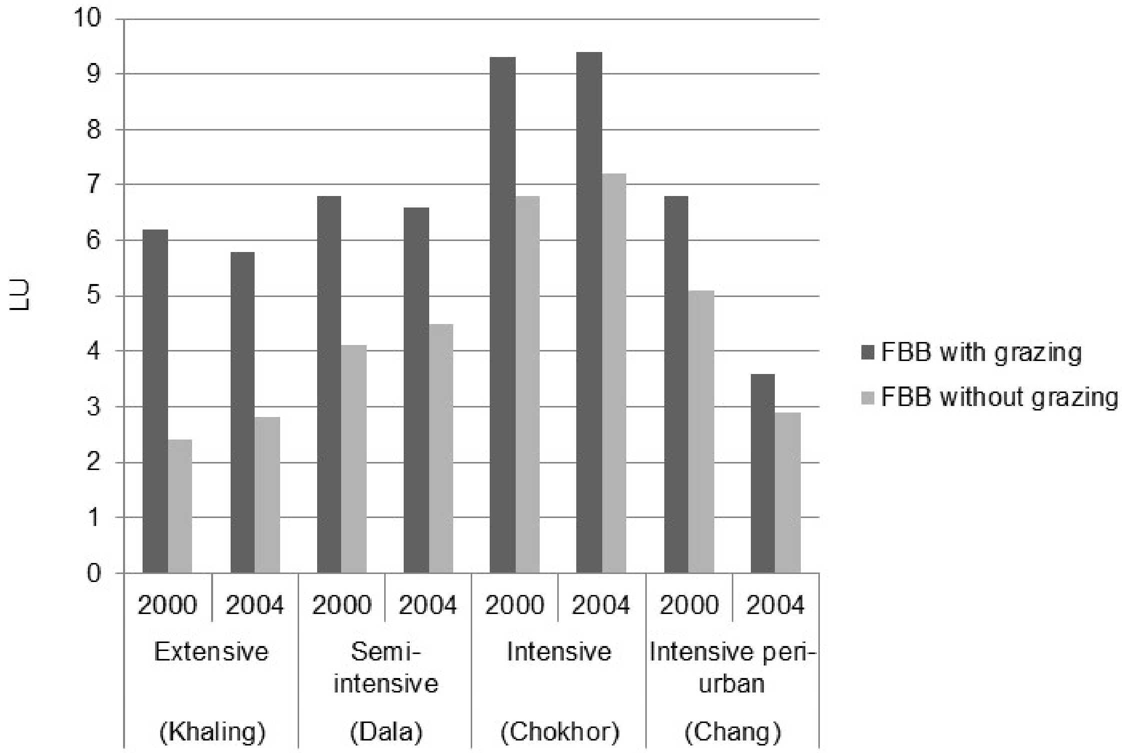

Figure 4. Farm Feed Balance (FFB) with and without grazing in Common Property Resources (CPR) in four areas of Bhutan in 2000 and 2004

(8.4 LU) in the extensive area to 0.2 LU or 2% of the total herd size of 9.5 LU in the intensive area. In 2004, the LU's kept matched the feed resources, mainly due to reductions in local cattle numbers in 2004, only the extensive area had excess of 1 LU (15% of the total herd size).

Figure 4 compares the number of cattle that can be maintained with grazing in CPR and without grazing in CPR. It shows the importance of CPR for feeding cattle. Considering a scenario, where there is no grazing in the CPR, then the number of cattle that can be maintained ranged from only 2.4 LU (extensive area) to 7.2 LU (intensive area).

4.3.3 Nutrient (NP) flows

Tables 3 and 4 give the NP inputs, outputs and balances (in kg y^{-1}) for the farms in the four areas of Bhutan (lsm) and the change from 2000 to 2004 (lsd). Grazing in the CPR provided the highest NP inputs for cattle. They ranged from 66 kg N and 6 kg P (34% of N inputs and 24% of P inputs) in the intensive peri-urban area to 158 kg N and 15 kg P (73% of N inputs and 62% of P inputs) in the extensive area. There was a significant decline in the N inputs from CPR grazing in the extensive, semi intensive and intensive peri-urban areas in 2004 compared to 2000. For P this decline was significant in the semi-intensive and intensive peri-urban areas. The contribution of concentrates and procured feed ingredients to the NP inputs was significantly higher in the intensive and intensive peri-urban areas than in the other areas. Cattle manure was the main input into the crop sub-system. It was highest in the intensive area due to its large herd size. The NP fertiliser inputs were highest in the intensive area and lowest in the semi-intensive area. In 2000, the semi-intensive area did not use inorganic fertilisers at all. There was a significant increase in N inputs from inorganic fertilisers in the extensive area (38%) and intensive area (22%) in 2004 compared to 2000. Only in the intensive area there was a significant increase in P input (11%) in 2004 compared to 2000.

Manure contributed to over 80% of the total NP outputs from the livestock sub-system. The decline in the intensive peri-urban area was due to the decrease in LU in 2004. There were significant differences between the intensive areas and the other two areas for NP outputs from milk, due to the relatively high milk production of crossbred cows in the intensive areas. The NP outputs from animals sold and died declined significantly in the extensive area, and they increased significantly in the intensive peri-urban area in 2004 due to sale of cattle in this area.

Table 3. Nitrogen (N) flows, farm balance (kg) and CSS soil N balance in four areas of Bhutan (kg y^{-1} $farm^{-1}$ and kg y^{-1} ha^{-1}) averages (least square means, lsm) and change from 2000 to 2004 (least square differences, lsd)

Area	**Khaling**		**Dala**		**Chokhor**		**Chang**			
System	**Extensive**		**Semi-intensive**		**Intensive**		**Int. peri-urban**			
Nutrient flows	**lsm**	**lsd**	**lsm**	**lsd**	**lsm**	**lsd**	**lsm**	**lsd**	**s.e[1]**	**s.e[2]**
farm level inputs										
A[3]. com. conc.	-	-	-	-	8.3[b]	2.5	14.1[a]	-3.1	0.8	1.1
B. feed ingredients	8.2[d]	-0.5	21.4[c]	-0.1	27.3[b]	1.1	41.9[a]	-15.3[z]	1.3	1.8
C. CPR[4] grazing	157.5[a]	-33.2[z]	113.5[b]	-25.5[z]	115.5[b]	-2.5	65.7[c]	-43.0[z]	5.1	6.9
J. inorg. fert. to soil	46.0[c]	18.4	13.8[d]	27.6[z]	124.2[a]	23[z]	73.5[b]	-18.2	5.5	7.7
farm level outputs										
D. milk	7.8[c]	0	18.4[b]	1.8	26.7[a]	7	27.5[a]	-8.0	1.0	1.3
E. animal sold/died	7.1[b]	-4.4[z]	7.7[b]	1.6	8.1[a]	-1.5[z]	8.4[a]	2.5[z]	0.2	0.2
H. manure to CPR	59.9[bc]	-6.1	62.7[b]	-1.8	96.4[a]	5.7	47.6[c]	-23.4	3.0	4.2
L. crop products	10.1[c]	3.1	18.2[c]	4.4	45.1[a]	10.6	35.5[b]	-19.1	2.3	3.2
farm balance	126.9[a]	-8	41.6[b]	-3.9	99.1[a]	2.5	76.2[a]	-31.5	9.1	13.0
CSS[5] level inputs										
I. manure to soil	56.9[bc]	-5.8	59.6[b]	-1.8	91.7[a]	5.4	45.3[c]	-22.3	2.9	4.0
J. inorg. fert. to soil	46.0[c]	18.4	13.8[d]	27.6[z]	124.2[a]	23[z]	73.5[b]	-18.2	5.5	7.7
CSS level outputs										
K. volatalisation loss	6[c]	2.4	1.8[d]	3.6[z]	16.1[a]	3[z]	9.6[b]	-2.4	0.8	1.1
L. crop products	10.1[c]	3.1	18.2[c]	4.4	45.1[a]	10.6	35.5[b]	-19.1	2.3	3.2
O. crop harvest to soil	4.1[c]	0.8	5.3[c]	0.8	12.9[a]	3.9	9.5[b]	-4.5	0.5	0.7
P[6] CSS to LSS[7]	48.8[d]	9.1	100.2[b]	22.7[z]	204.9[a]	23.2[z]	73.0[c]	-22.2	1.0	6.5
CSS balance	40[a]	-0.4	-50.3[c]	-2.2	-47.1[c]	-9.2	0.8[b]	5.4	7.8	9.3
CSS balance/ha	30.8[a]	-0.3	-19.3[c]	-0.8	-16.2[c]	-3.2	0.6[b]	4.2	6.5	8.1

[a,b,c,d] lsm with different superscripts between study areas are significantly different $p<0.05$).
[z] lsd within a study area is significantly different ($p<0.05$).
[1] s.e of an average between areas, [2] s.e of an average between years within an area,
[3] refers to the flows in Fig. 1; flow R is not in the table, this flow denotes I+J+O-K,
[4] common property resources, [5] crop sub-system,
[6] includes N flows from crop products, crop residues, fodder trees, conserved fodder and grazing on pasture land, [7] livestock sub-system

Crop residues were the main NP outputs from the crop sub-system to the livestock sub-system and was significantly highest (Tables 3 and 4) in the intensive area (205 kg N y^{-1} $farm^{-1}$ and 20 kg P y^{-1} $farm^{-1}$). Similarly, NP outputs from crop products were significantly highest in the intensive area (45 kg N y^{-1} $farm^{-1}$ and 23 kg P y^{-1} $farm^{-1}$) since there were a variety of cereal crops grown in this area with significantly higher crop production compared to the other areas.

The soil N balances of the crop sub-system were negative in the semi-intensive (-50 kg y^{-1} $farm^{-1}$ or -19 kg y^{-1} ha^{-1}) and intensive (-47 kg y^{-1} $farm^{-1}$ or -16 kg y^{-1}

Table 4. Phosphorus (P) flows, farm balance (kg) and CSS soil P balance in four areas of Bhutan (kg y^{-1} $farm^{-1}$ and kg y^{-1} ha^{-1}) averages (least square means, lsm) and change from 2000 to 2004 (least square differences, lsd)

Area	**Khaling**		**Dala**		**Chokhor**		**Chang**			
System	**Extensive**		**Semi-intensive**		**Intensive**		**Int. peri-urban**			
Nutrient flows	**lsm**	**lsd**	**lsm**	**lsd**	**lsm**	**lsd**	**lsm**	**lsd**	**s.e[1]**	**s.e[2]**
farm level inputs										
A[3]. com. conc.	-	-	-	-	1.7^{b}	0.5	2.8^{a}	-0.6	0.2	0.3
B. feed ingredients	1.7^{d}	0	4.0^{c}	0.1	5.6^{b}	0.2	9.2^{a}	-3.4^{z}	0.3	0.4
C. CPR[4] grazing	15.2^{a}	-3.2	10.9^{b}	-2.5^{z}	11.2^{b}	-0.3	6.4^{c}	-4.1^{z}	0.6	0.9
J. inorg. fert. to soil	13.1^{b}	1.5	-	-	75^{a}	15^{z}	6.0^{b}	-1.5	2.7	3.6
farm level outputs										
D. milk	1.2^{c}	0	2.8^{b}	0.3	4.0^{a}	1	4.1^{a}	-1.2	0.1	0.2
E. animal sold/died	2.1^{b}	-1.3^{z}	2.2^{b}	0.5	2.4^{b}	-0.4	2.5^{a}	0.7^{z}	0.1	0.1
H. manure to CPR	6.4^{b}	-0.1	6.9^{b}	-0.2	10.6^{a}	0.9	5.9^{b}	-3.1	0.5	0.7
L. crop products	7.8^{b}	1.6	13.1^{c}	2.6	23.1^{a}	3.1	8.2^{b}	-2.7	1	1.5
farm balance	12.5^{b}	-2.0	-10.1^{d}	-5.6	53.5^{a}	10.9^{z}	3.6^{c}	-3.3	9.1	13
CSS[5] level inputs										
I. manure to soil	7.5^{b}	-0.1	8.1^{b}	-0.2	12.3^{a}	1.1	6.9^{b}	-3.6	0.6	0.8
J. inorg. fert. to soil	13.1^{b}	1.5	-	-	75^{a}	15^{z}	6.0^{b}	-1.5	2.7	3.6
CSS level outputs										
L. crop products	7.8^{b}	1.6	13.1^{c}	2.6	23.1^{a}	3.1	8.2^{b}	-2.7	1	1.5
O. crop harvest to soil	1.2^{b}	0.3	1.5^{b}	0.2	4.4^{a}	1.8	1.7^{b}	-0.8	0.2	0.3
P[6] CSS to LSS[7]	3.9^{c}	0.5	5.1^{b}	1.2	19.7^{b}	5.5^{z}	7.3^{a}	-3.3^{z}	1	1.5
CSS balance	7.7^{b}	-1	-11.7^{d}	-4.3	40.2^{a}	5.6^{z}	-4.2^{c}	1.7	7.8	9.3
CSS balance/ha	5.9^{b}	-0.8	-4.5^{c}	-1.6	13.9^{a}	1.9^{z}	-3.2^{c}	1.3	6.5	8.1

[a,b,c,d] lsm with different superscripts between study areas are significantly different $p<0.05$).
[z] lsd within a study area is significantly different ($p<0.05$).
[1] s.e of an average between areas, [2] s.e of an average between years within an area,
[3] refers to the flows in Fig. 1; flow R is not in the table, this flow denotes I+J+O-K,
[4] common property resources, [5] crop sub-system,
[6] includes P flows from crop products, crop residues, fodder trees, conserved fodder and grazing on pasture land, [7] livestock sub-system

ha^{-1}) areas. This was attributed mainly due to low inorganic fertiliser inputs in the semi-intensive area and the high crop outputs to the livestock sub-system in the intensive area (Table 3). The crop sub-system P balance was significantly highest in the intensive area (40 kg y^{-1} $farm^{-1}$ or 14 kg y^{-1} ha^{-1}) which was attributed to the high usage of single super phosphate (SSP) (Table 4).

The overall farm N balance was positive in all areas. It was significantly higher in the extensive (127 kg y^{-1} $farm^{-1}$ or 98 kg y^{-1} ha^{-1}) and intensive area (99 kg y^{-1} $farm^{-1}$ or 34 kg y^{-1} ha^{-1}) than in the semi-intensive area (42 kg y^{-1} $farm^{-1}$ or 16 kg y^{-1} ha^{-1}). CPR grazing was the main contributor to the positive N balances in the extensive and semi-intensive areas (Table 3). The overall farm P balance was significantly the highest in the intensive area (54 kg y^{-1} $farm^{-1}$ or 18 kg y^{-1} ha^{-1}) in 2004 due to the significant increase in use of SSP. In the semi-intensive area the P balance was negative (-10 kg y^{-1} $farm^{-1}$ or -4 kg y^{-1} ha^{-1}) in 2004 mainly due to a significant decrease in P input from CPR grazing (Table 4).

4.4 Discussion

4.4.1 Impact of intensification on CPR use for feeding cattle

In the Himalayan area, the livestock population exceeds the carrying capacity of land resources (ICIMOD 1985). Studies on the livestock carrying capacity and the use of CPR in Bhutan mentioned that that the bulk of the livestock population were underfed and was highly dependent on CPR, and that these CPR were heavily overgrazed (Dorji 1993; Moktan et al. 2008). In this study, in all four study sites CPR played a major role in the maintenance of the herds by complementing the limited feed resources produced on the farms, mainly crop residues and by-products, and those bought from the market. However, in the intensive areas with a majority of crossbred animals, the farmers rely much less on CPR than in the other two areas. Farmers with crossbred cattle feed more concentrates and conserved fodder. Nevertheless, in the intensive area about one quarter of the TDN requirements were met by CPR. Without CPR about one quarter less animals can be kept by individual farms in the intensive area, while in the extensive and semi-intensive areas it is about one half less (Figure 4), or more concentrates and on-farm produced animal feed crops are needed. So, though crossbreeding has not resulted in major reductions in cattle numbers per farm, it has contributed to reducing use of CPR by farmers (Tables 2, 3 and 4). The number of farms with crossbred cattle was more or less the same in 2000 and 2004 (Samdup et al. 2010). The urban development in the intensive peri-urban area shows that urbanisation had a much bigger impact on herd sizes and on the FFB than crossbreeding and promoting on-farm feed resources. In the intensive peri-urban area in four years' time the average farm area and herd size were reduced by 27% and 49%, respectively.

The comparison of the TDN available and the requirements per LU for the actual production levels at farm level showed that in 2000, the herd sizes did not match the feed sources; in particular the extensive area had a 26% excess of LU (Figure 3). In 2004, only the extensive area still had an excess of 15% LU (Figure 3). The slight reduction in number of local cattle per farm was a reason for this, or it could be that we underestimated the TDN consumed in this area. In the extensive area, Jersey crossbreds had a high mortality of 16%, while in the other areas mortality ranged from 7-9%. The herds in the extensive area were generally weak and the calving rates of local cattle and Jersey crossbreds were all below the calving rates needed to maintain the herds (Samdup et al. 2010). This information together with field observations supported the conclusion that there is a feed shortage in this area. This can be addressed by increasing crop production and bringing associated feed residues from outside (equivalent to about 2770 kg TDN per farm per year would be needed) on farm or by reducing the herd sizes. In this area, crushed maize seeds and maize straw are the main crop by-products fed, so cultivation of improved varieties of maize could make more feeds available to some extent. Therefore crossbreeding in extensive areas without adequate access to markets and feed resources is not advisable.

4.4.2 Impact of intensification on farm nutrient (NP) flows

Cattle play an important role as agents of nutrient cycling especially for transfer of biomass from the CPR to the farms. Without CPR grazing there would be a considerable decline in NP flows from the livestock sub-system to the crop sub-system and all four areas would have had highly negative crop sub-system NP balances. Even with CPR grazing the crop sub-system N balance was positive only in the extensive area (31 kg y^{-1} $ha^{-1)}$ (Table 3), while the P balance was positive only in the intensive area (14 kg y^{-1} ha^{-1}) (Table 4). In the intensive areas farmers practise indigenous methods to optimise use of the limited P pools by burning the top soil to increase availability of P, and burning manure to reduce its bulk and speed up release of P (Roder et al. 2003). They also used SSP mainly for potatoes which contributed to the positive crop sub-system P balance. Roder et al. (2001) and Norbu and Floyd (2004) mention that soils in Bhutan generally exhibit low pH and also low fertility in terms of N due to high soil erosion potential and limited soil depth of organic matter. Farmers normally intuitively decide how much fertiliser to apply which may cause such NP imbalances. More awareness on nutrient management is required among farmers. Nutrient balance studies can help to serve as indictors for the magnitude of losses of nutrients and to identify causes for such losses. The interpretation of nutrient balances can be further improved by linking the farm nutrient budgets with total soil nutrient stocks (Van den Bosch et al. 1998), but this was beyond the scope of the present study and more research is required.

4.4.3 Methodology

The period of comparative study in a span of four years (mid of the 9th Five year plan to mid of the 10th Five year plan and change-over in crossbreeding policy) could be argued to be too short to evaluate the impact of the livestock intensification policies, but it does provide a perspective and methodology of such studies which are rare in Bhutan. Although this study was mainly based on field surveys the nutrients contents of plants and animal products were based on available literature. Soil samples could also not be analysed for their N and P content since the facilities were not available. Nevertheless, the results indicate the diversity and resilience of smallholder farm systems and the crucial role of CPR in these systems in Bhutan.

4.4.4 Future developments

Though Bhutan is a small country, the diversity of smallholder farmers livestock rearing and farm management practices indicates that there can be no single recommendation on livestock and farm management practices. Though livestock intensification has not resulted in major reductions in cattle numbers per farm, but it has contributed to reduced use of CPR. Intensification also partly replaces farm nutrient inputs from CPR with nutrient inputs through increased use of concentrates, conserved fodder, and fertilisers. While there is potential for intensification in the intensive areas, such practices may not be feasible in the extensive and semi-intensive areas. Though there is very high demand and good prices for livestock products in the intensive areas, the increasing costs of concentrates and fertilisers could be a major challenge. The current government policies promote local produce and are aimed at reducing imports, via strict financial and monetary regulation for imports. These measures will have an impact mainly in the intensive areas. They should be accompanied with appropriate extension services and market availability. Finally, in the process of livestock intensification, its impact on the quality or conservation of the CPR will also need to be assessed; such studies could also serve as a useful analytical tool for natural resources management planning.

4.5 Conclusion

In Bhutan, dairy crossbreeding has contributed to reducing grazing pressure on CPR in areas where there is accessibility to markets and feed resources. However, even in the intensive area with a high proportion of crossbred cattle, CPR still met about one quarter of the feed requirements. Additional feed can be made available through intensification of crop production and making more crop residues available, and growing fodder trees for livestock feeding. Such interventions could alleviate feed shortages, but may not be able to replace grazing in CPR given the limited farm land sizes and resources. So, CPR will remain an essential feed source, also for farms with crossbred cattle. Grazing in the CPR provided the majority of the N inputs at farm level. If there would be no CPR grazing then farms in all four areas would have negative N balances. More awareness needs to be created among farmers on nutrient management, in particular appropriate use of fertilisers.

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Chapter 5

Refining the Gross National Happiness concept to smallholder farm level in Bhutan

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Submitted

Abstract

Intensification of livestock production through crossbreeding for dairying is a major Gross National Happiness GNH development effort to enhance rural livelihoods in Bhutan. The objectives of this study were to refine the GNH concept to farm level and to show major temporal and spatial trends in development in rural areas differing in agro-ecological conditions and adoption of crossbreeding. The study areas are described as extensive, semi-intensive, intensive and intensive peri-urban. Technical, societal, economic and environmental data of 183 households in the four areas were collected in 2000, 2004 and 2015. Participatory methods were used for selecting the most relevant issues and associated indicators at farm level from these data. The issues identified during field workshops in the four areas could be grouped as societal, economic and environmental. Next, indicators were aggregated to economic, societal and environmental indices. The selected societal issues were rural-urban migration, farm labour shortage, literacy rate, access to piped drinking water and household living standard. The economic issues were annual income, farm GM (gross margin), off-farm income, milk yield per cow per day and GM livestock per LU (livestock unit). The environmental issues were excess LU reared, livestock CPR (common property resources) grazing practices, soil N balance, soil P balance and soil erosion on crop land. In 2000 and 2004 the intensive peri-urban area showed the highest performance for the economic and societal indicators. In 2010, livestock farming was prohibited in this area, despite its potential for dairying, due to expansion of the capital Thimphu. The dynamics in the indicators in the other three areas indicated that the societal and economic indices were the highest in the intensive area followed by the semi-intensive area and the extensive area. This could partly be attributed to differences in implementation of crossbreeding in these areas. In the period 2004-2015, the societal indices declined which could be attributed to an increase in rural-urban migration and farm labour shortages. There were no major changes in the environmental indices within the research areas in the monitoring periods. The present methodological approach based on participatory identification of societal, economic and environmental issues and indicators along with reference values for selected indicators and an integral assessment can complement the implementation of the GNH philosophy in rural areas in Bhutan.

Keywords: sustainability, socio-economics, environmental impact, indicators, cattle, crossbreeding, smallholder farmers

5.1 Introduction

Bhutan's Gross National Happiness (GNH) development philosophy is discussed mainly at the national level. Linkages of GNH with other system levels (e.g. district, community, and farm level) have not received much attention yet (Samdup et al. 2014). About two-third of the Bhutanese population are smallholder farmers growing crops and keeping livestock (NSB 2007). The major concerns of these smallholder farmers are related to the socio-economic and environment GNH pillar; the issues for the other two GNH pillars, i.e. culture and good governance, remain rather vague for farmers (Samdup et al. 2014).

A main GNH development effort for rural areas is directed at livestock intensification. Cattle are the most dominant livestock with over 78% of the rural households owning cattle. Promotion of intensification of dairy production through crossbreeding of local Siri cattle with Jersey or Brown Swiss is seen as a way to enhance rural livelihoods (MoA 2009). Bhutan's large variation in altitude, climate and market access, however, is expected to affect the possibilities for intensification of dairy production. Before 1998, for example, crossbreeding was promoted only in areas with suitable agro-ecological conditions. From 1998 onwards, farmers were allowed to choose their desired cattle breed irrespective of the agro-ecological conditions. No empirical studies are conducted so far to what extent intensification has contributed to development from a GNH perspective in farming communities in different agro-ecological areas.

Methods to assess development efforts are generally based on identifying and monitoring relevant indicators (Becker 1997; Singh et al. 2009; de Olde et al. 2016). In Bhutan, the Centre for Bhutan Studies (CBS) uses 33 indicators to build the GNH index which reflects the development of the degree of happiness of people across the country (CBS 2012). Hardly any of the indicators, however, can be used to assess the impact of intensification efforts at farm level.

The objectives of this study were to refine the GNH concept to farm level by selecting the most relevant issues and associated indicators, assessing the indicators in four agro-ecological areas in 2000, 2004 and 2015 and aggregating the indicators to indices showing major temporal and spatial trends in development in rural areas in Bhutan. The year 2000 was chosen, since this was the year when crossbreeding of cattle was intensified with the revision of the

1998 cattle breeding policy, and in 2004 and 2015 we assessed the medium and long term changes at farm level in the four areas.

5.2 Materials and Methods

5.2.1 Study Areas

Bhutan is a small, land-locked country in the Eastern Himalayas. Its large variation in altitude results in a wide range of climate zones: from alpine, cool temperate, warm temperate, dry sub-tropical, humid sub-tropical to wet sub-tropical (FAO 2005). For this study four areas were selected varying in terms of climate zone, cattle breeds kept by smallholders, cattle management practices, and market access. The selected study areas were Khaling geog (geog: a number of villages in a district) in the district Trashigang (eastern part of Bhutan, warm temperate zone), Dala geog in the district Chukha (southern part of Bhutan, sub-tropical zone), Chokhor geog in the district Bumthang (central part of Bhutan, cool temperate zone) and Chang geog in the district Thimphu (western part Bhutan, cool and warm temperate zone). Details on the four study areas are described in Samdup et al. (2010). The four areas were classified as extensive (Khaling) with mainly local Siri cattle, grazing in forests and communal lands, no motorable road and walking distances to local markets of 30 minutes to 1 h; semi-intensive (Dala) with Siri and Jersey crossbred cattle, mainly grazing in forests and communal lands, no regular local transport services and walking distances to local markets of 1 to 2 h; intensive (Chokhor) with mainly Brown Swiss and Jersey crossbred cattle, mainly stall-feeding, and no regular local transport services and walking distances to local markets of 30 minutes to 1 h; and intensive peri-urban (Chang) with mainly Jersey crossbreds and pure Jerseys, mainly stall feeding, and located close to the capital.

Crossbreeding is implemented via exotic breeding bulls in communities or the supply of semen of exotic bulls to artificial insemination (AI) centres throughout the country. AI is provided at no costs for farmers. The breeding policy promotes producing animals with 25:75 ratios of Siri and Brown Swiss or Jersey genes in the intensive and intensive peri-urban areas, and a 50:50 ratio of Siri and exotic genes in other areas (MoA 2009).

5.2.2 Methodology

Key steps in the methodology applied were 1) participatory field workshops with farmers and other stakeholders in the four areas to select issues at farm level; 2) a national workshop with experts to finalise the issues and select relevant indicators; 3) assessment of the indicators based on collection of technical, societal, economic and environmental data; and 4) an integral assessment of the indicators. The field workshops with farmers and other stakeholders were organised in 2000. Collection of a large volume of technical, societal, economic and environmental data started in the same year and was repeated in 2004. Part of these data was used to analyse and describe technical and economic performances and the use of natural resources (Samdup et al. 2010; Samdup et al. 2013). The selection of the most relevant issues and indicators for the present study was done 2002 in a national level workshop with experts and farmers' representatives. Empirical assessment of the selected indicators was based on the data available from the 2000 and 2004 data collection and on data collected in 2015. The data were used to characterise the farms and to assess the indicators selected for the present study in the four study areas. An integral assessment, combining the societal, economic and environmental indicators into respective indices was developed to communicate progress in GNH development in the four areas.

5.2.2.1 Selection of issues and indicators

In 2000, in each study area a field workshop was organised to identify the main GNH issues (Samdup et al. 2014). In total 120 farmers who were the locally elected farmers' representatives, a private retailer (dealing with crop and livestock products), and 28 government stakeholders who were the agriculture, forest and livestock extension officers, and representatives from the veterinary office of each district and the national dairy centre based in Thimphu, participated in the workshops. The government stakeholders helped in facilitating the workshops and provided their views when asked. The issues identified during the field workshops were grouped into societal, economic and environmental issues (Samdup et al. 2014).

To further select issues and subsequently to identify indicators for the present study, a national level workshop was held in the capital Thimphu in 2002. Participants were the livestock, agriculture and forestry officers from each of the four study areas, a farmer representing each study area, a livestock production specialist, a social science expert, a veterinarian, and a policy and a planning officer (in total 20 people). The moderator briefed this multidisciplinary expert group about the various issues derived from the four field workshops and the resulting problem tree analysis (see Samdup et al. 2014 for details). It was decided to separate the socio-economic GNH pillar into societal and economic issues because these issues were the main resulting concerns from the field workshops and needed to be addressed explicitly

(Samdup et al. 2014). So, the final list of the identified issues for the present study was based on the views of the farmers on their most pertinent societal, economic and environmental issues complemented with suggestions of the expert group and literature review.

5.2.2.2 Empirical assessment

Data collection

The empirical assessment was done through a household survey in 2000, 2004 and 2015. A household in this study refers to adults and children who are living together and are registered officially. In each area 30-40% of the villages were selected: 6 villages in the extensive area Khaling, 9 villages in the semi-intensive area Dala, 16 villages in the intensive area Chokhor and 6 villages in the intensive peri-urban area Chang. Second, in each village 5-15% of the households were selected randomly resulting in 63, 35, 55 and 30 households in the extensive, semi-intensive, intensive and intensive peri-urban areas respectively. In 2000 and 2004 the same households were visited. In 2015 only 47, 29 and 47 of the same households in the extensive, semi-intensive and intensive areas were visited, as the remaining households had migrated to other areas of Bhutan in particular to Thimphu. In Chang, all households identified in 2000 have given up farming since their villages came under the Thimphu city corporation area in 2010. In such urban areas rearing of livestock is not permitted anymore.

Household interviews were done by trained enumerators using a pre-tested questionnaire. These enumerators were the two extension officers (from the national livestock and agriculture departments) in each district and regional livestock officers in the respective districts who had experience in collecting field data. Individual farmers were interviewed on family background, sources of income, land-use, crop and livestock practices and production and financial results. For each farm nitrogen (N) and phosphorus (P) flows were quantified by computing the NP inputs and outputs of the livestock and crops.

Data analysis

The data sets were screened and analysed for household and farm characteristics and the selected societal, economic and environmental indicators. For the economic indicators the monetary values were expressed in Ngultrum (Nu). In 2000 we calculated the nominal values for the economic indicators (US$ 1 = Nu 43.8). In 2004 and 2015 we corrected the nominal values with an inflation rate of 2.7% (RMA 2005) and 9.1% (RMA 2016) respectively.

Continuous indicators that met assumptions of normality were analysed with the least-squares method (Harvey 1977) to explain variation between the study areas within the three monitored years and between the monitored years within study areas.

Qualitative indicators were transformed into qualitative ordinal data (QOD) (de Wit et al. 1995; Hardi et al. 2000). The qualitative indicators were categorised as bad (1), poor (2), medium (3), ok (4) and good (5) by the enumerators. Sometimes they also used halves (e.g. 1.5, 2.5, 3.5 and 4.5). Indicators that did not meet assumptions of normality and ordinal data were analysed with the Kruskall Wallis test to find the overall effects of years (2000, 2004 and 2015) and area (extensive, semi-intensive, intensive and intensive peri-urban). Depending upon significant effects, post-hoc analysis was conducted with Wilcoxon two-sample test to make pair wise comparisons between areas within a particular year and between years within a particular area. A p-value<0.05 was considered to indicate a significant difference.

5.2.2.3 Integral assessment

An ‘integral assessment’ was developed to visualise and communicate progress in GNH development in the four areas. This concept is based on Prescott-Allen’s barometer of sustainability (Prescott-Allen 1997). The idea behind this integral assessment is to standardise indicators by establishing a performance value range for five performance categories of each identified indicator. Based on the expert group discussion and literature (CSO 2001), the five performance categories were derived by dividing the scale of each indicator into five sectors of 20 points each over a total scale of 1-100. This results in a set of performance measurements for the indicators using the same scale. The five sectors are described as: bad sector (from 1 to 20 points on the 1-100 scale); poor sector (from 21 to 40); medium (from 41-60); ok sector (from 61-80) and good sector (from 81-100) (Prescott-Allen 1997). The standardised societal, economic and ecological indicator values are combined in a respective societal, economic or ecological index. All indicators were considered as equally important by the expert group.

The starting point in the definition of the performance value ranges for the quantitative indicators selected in the present study was the medium performance value range. Prescott-Allen (1997) states that a medium performance value range can be based on performances that have been experienced in the past and could be achieved in the foreseeable future. Based on this reference performance value range, ranges for the other performance value ranges were derived by incremental increase or decrease or based on the opinion of the expert group. The qualitative indicators are already scored in the bad, poor, medium, ok and good sectors.

The standardised value (SV) for each indicator was calculated as follows:

$SV = (SV_i * \text{multiplier of 20 for the sector}) + \text{base value of that sector}$

Where $SV_i = (Y_i - Min_i)/(Max_i - Min_i)$; Y_i is the actual value of indicator (i); Min_i is the minimum performance value of the indicator (i) on its specific sector; Max_i is the maximum performance value of the indicator (i) on its specific sector. For the qualitative ordinal indicators Min_i is the minimum and Max_i is the maximum performance value of indicator (i). The base value of the sector is Min_i in the sector (Prescott-Allen 1997).

Illustration of a SV calculation: Let's assume the literacy rate in an area is 49%. Performance value ranges for literacy rate are determined at 31-40% for the bad sector, 41-50% for the poor sector, 51-60% for the medium sector, 61-80% for the ok sector and 71-80% for the good sector. Then the actual value (49%) falls within the poor sector. The poor sector is scaled from 21-40 on the 1-100 scale. This gives the following values for the components of the formula:

$SV_i = (49-41)/9 = 0.89$

Base value of the poor sector = 21

SV for literacy rate in this area = 0.89*20 + 21 = 38

The societal, economic and environmental indices were calculated simply by taken the averages of the societal, economic or environmental SVs. The indices were categorised over a scale of 1-100 with the categories bad sector (from 0 to 20 points on a 1-100 scale); poor sector (from 21 to 40); medium sector (from 41-60); ok sector (from 61-80) and good sector (from 81-100) as for the standardised indicators.

5.3 Results and Discussion

5.3.1 Description of issues and selection of indicators

Table 1 gives definitions of the selected indicators for the societal, economic and environmental issues. The reasons for choosing these indicators are given below. Table 2 gives the description of the qualitative indicators transposed into qualitative ordinal data.

Table 1. Selected indicators and their definitions

Indicators	Definition
Societal	
rural-urban migration (%)	number of household members that migrated to other areas as percentage of total number of household members in a study area
farm labour shortage (% of hh)	number of households that expressed farm labour shortages as percentage of total number of households
literacy rate (%/hh)	number of household members that are literate as percentage of total number of household members. Literacy is defined as the proportion of the population aged 15 years and over that can read and write a simple short statement related to their daily life (FAO 2005)
access to piped drinking water (QOD[1])	quantitative ordinal indicator data (QOD) ranging from bad (0-1) to good (4.5-5) based on access to clean piped drinking water with personal taps/common taps or having to fetch water from other sources
household living standard (QOD)	a QOD ranging from bad (0-1) to good (4.5-5) based on household living standards in terms of availability of basic needs of food, clothing, shelter and household luxuries (details in Table 2)
Economic	
annual income (Nu)	the sum of the farm GM[2] (livestock and crop GM) and the off-farm income
farm gross margin (GM) (Nu/y)	the sum of the livestock and crop GM
off-farm income (Nu/y)	the sum of income earned from non-farm activities for e.g. part time labour in other farms/ construction sites/ hotels and weaving
milk yield/cow/day (kg)	the average milk off-take (kg) per cow per day
GM (livestock)/LU (Nu)	the GM of livestock sub-system per LU[3]
Environmental	
excess LU reared	the numbers of "excess livestock (LU)" relative to the feed resources available (on-farm, bought plus grazing CPR[4])
soil N balance (kg/ha)	the partial nutrient balances of N kg per ha of land
soil P balance (kg/ha)	the partial nutrient balances of P kg per ha of land
livestock CPR grazing practices (QOD)	a QOD ranging from bad (0-1) to good (4.5-5) based on whether the cattle are accompanied by a herder while grazing in the CPR, and whether the cattle are allowed to wander or controlled grazing is practised (details in Table 2)
soil erosion of crop land (QOD)	a QOD ranging from bad (0-1) to good (4.5-5) based on level of water runoff and soil erosion (details in Table 2)

[1]qualitative ordinal data; [2]GM is the outputs minus the inputs (variable costs); [3]one LU is defined as an adult animal weighing 300 kg; cows, bullocks and breeding bulls are 1 LU, heifers and young bulls 0.7 and calves 0.2; [4]Common Property Resources

Societal issues and indicators

An emerging issue in Bhutan is migration to urban areas, therefore rural-urban migration defined as the total number of household members who migrated from the study area (as percentage of all household members in an area) was

Table 2. Description of the qualitative indicators to transpose them into qualitative ordinal data (QOD) for five sectors in 1-100 scale

Sector	**Bad (0-20)**	**Poor (21-40)**	**Medium (41-60)**	**Okay (61-80)**	**Good (81-100)**
Ordinal scale	**1**	**1.5 to 2**	**2.5 to 3**	**3.5 to 4**	**4.5 to 5**
Indicators					
access to piped drinking water[1]	more than 30 minutes walking to fetch water	between 15 minutes to 30 minutes to fetch water	no personal tap water, common taps available, water supply erratic	personal tap, but water not very clean and erratic supply	personal tap with clean water available at all times
household living standard[1]	basic needs of food, clothing and shelter not met	shortages in food, basic clothing and shelter are met	basic needs all met; no access to other household luxuries	basic needs all met; some access to other household luxuries	basic needs all met, access to other household luxuries (e.g. fridge, radio, television)
livestock CPR[2] grazing practices	no herder with the cattle	occasionally a herder with the cattle	cattle accompanied by herder, some control on cattle wandering to other areas	cattle accompanied by herder, cattle not allowed to wander, rotate occasionally	cattle accompanied by herder, controlled grazing, rotation to different areas
soil erosion of crop land [3,4]	very high runoff and surface erosion along with high down-ward movement of soil	high runoff and high surface erosion	moderate surface erosion	mild surface erosion	no surface erosion or water runoff

[1]based on expert group view; [2]Common Property Resources
[3]in-situ land degradation (physical) on sloping farm land due to agricultural practices;
[4]Norbu and Floyd (2004),

selected as indicator. Due to the rapid rural-urban migration and with a decreasing rural population the expert group suggested to quantify the issue of labour shortage with the indicator farm labour shortage (defined as the percentage of households in the study area that expressed farm labour shortages). The expert group mentioned literacy as an important issue to enhance development progress, therefore *literacy rate* (percentage of household members that were literate) was selected as an indicator. Accessibility to amenities and services, e.g. schools, extension services, drinking water supply, is an important societal issue in developing regions (Moorse et al. 2001; Zhen and Routray 2003). Farmers mentioned that an important accessibility concern for them was access to piped drinking water. Good access to drinking water implies that members of the household do not have to spend a disproportionate part of the day fetching water and it is of fundamental significance to lowering child mortality (FAO 2005). The expert group therefore suggested to include the indicator *access to piped drinking water*, ranging from bad access (fetch from other sources) to good access (personal or common taps). No feasible indicator was found to evaluate the water quality and quantity. The expert group proposed to include the issue of quality of rural life expressed by the indicator *household living standard,* ranging from bad when basic needs (food, clothing, shelter) were not met to good when all basic needs are met and households had access to household luxuries (e.g. fridge, radio, television).

Economic issues and indicators

For the economic issues the field workshops indicated that low farm income, low crop yield, low milk yield and limited alternative sources of income were major concerns. Several authors proposed *farm gross margin* (on a yearly basis) as economic indicator (Tellarini and Caporali 2000; Zhen and Routray 2003). The experts also selected *off-farm income* (on a yearly basis) and total *annual income* as economic indicators to obtain an overview of the off-farm and on-farm income sources. Since milk and milk products are important sources of cash income the *milk yield per cow per day* was taken as an indicator. The expert group expressed concerns about the productivity of livestock farming practices and proposed to use the economic indicator *GM livestock per LU (LU: livestock unit)*. Details of the calculations of these economic indicators for 2000 and 2004 are given in Samdup et al. (2010).

Environmental issues and indicators

For the environmental issues the field workshops confirmed that lack of knowledge on livestock carrying capacity of their farms was a concern. Therefore, *excess LU reared* relative to the feeds on offer was selected as environmental indicator. The calculation of this indicator was based on the comparison of the total digestible nutrients available from the different feeds with the requirements of the LUs present on a farm (Samdup et al. 2013). In Bhutan, cattle are often blamed for overgrazing and damage to forest vegetation (Roder et al. 2001). The expert group proposed therefore to include the indicator *livestock CPR grazing practices*, ranging from bad to good based on whether the cattle are accompanied by a herder in the CPR, and whether the cattle are allowed to wander or controlled grazing is practised.

In Bhutan, the soils on the mountain slopes inherently exhibit low fertility, and the low availability of N and P is a major soil fertility concern, while the soil parent materials are generally rich in potassium (K) (Roder et al. 2001; Norbu and Floyd 2004). For the present study the partial nutrient balances of N (*soil N balance*) and P (*soil P balance*) as environmental indicators were included (de Wit et al. 1995; Zhen and Routray 2003). The details of the calculation of these environmental indicators (annual N and P inputs minus N and P outputs of the livestock and the crops, not including soil erosion, sedimentation and N fixation) are described in Samdup et al. (2013). In mountain areas there is high soil erosion potential due to heavy rains (Yunlong and Smit 1994; de Wit et al. 1995), therefore, the expert group proposed to include *soil erosion of crop land* as indicator, ranging from bad with very high water run-off and surface soil erosion, to good with no water run-off and surface erosion.

5.3.2 Performance value ranges for individual indicators

Table 3 gives the results of the discussions with the expert group on the performance value ranges for the societal, economic and environmental indicators.

Societal indicators

In the past Bhutan's internal migration rate was estimated at around 6% per year (HDR 2009), and taking this rate as a reference value the expert group categorised a performance value range of 6-10% of household members migrating for the medium sector of *rural-urban migration.* Although labour shortage on farms in Bhutan is viewed as a concern, data available on this issue were limited. The expert group recommended a performance value range of 11-15% of households per study area for the medium sector of *farm labour shortages*. Based on a *literacy rate* of 53% in Bhutan in 2000 (CSO 2001) the expert group suggested a *literacy rate* of 51-60% per household as performance value range for the medium sector. The indicators *access to piped drinking water* and *household living standards* were categorised as bad (1), poor (1.5 or 2), medium (2.5 or 3), ok (3.5 or 4) and good (4.5 or 5).

Economic indicators

The performance value range for *annual income* was based on the estimated monthly household consumer expenditure of Nu 1097 per capita with an average household size of 5.5 in 2000 (CSO 2001). This coincides with an *annual income* of Nu 91,000 to Nu 120,000 for the medium sector. In the absence of other literature in Bhutan, the expert group recommended to take the values of Samdup (1997) corrected for inflation rates as reference values for the medium sector of the remaining four economic indicators. Therefore the *farm GM*

Table 3. Performance value ranges (Minimum, Min) and (Maximum, Max) for five sectors in a 1-100 scale of the societal, economic and environmental indicators

Sector	**Bad (0-20)**		**Poor (21-40)**		**Medium (41-60)**		**OK (61-80)**		**Good (81-100)**		**Reference**
Performance value ranges	**Min (0)**	**Max (20)**	**Min (21)**	**Max (40)**	**Min (41)**	**Max (60)**	**Min (61)**	**Max (80)**	**Min (81)**	**Max (100)**	
societal indicators											
rural urban migration[1] (%)	25	21	20	11	10	6	5	3	2	0	HDR (2009), expert group
farm labour shortage[1] (% hh)	40	21	20	16	15	11	10	6	5	0	MoA (2005), expert group
literacy rate (%/hh)	31	40	41	50	51	60	61	70	71	80	CSO (2001), expert group
access to piped drinking water (QOD[2])	0	1	1.1	2	2.1	3	3.1	4	4.1	5	NSB (2013), expert group
household living standard (QOD)	0	1	1.1	2	2.1	3	3.1	4	4.1	5	expert group
economic indicators											
annual income (Nu[3] x 1000)	31	60	61	90	91	120	121	150	151	210	Samdup (1997)
farm gross margin (GM) (Nu x 1000)	31	50	51	80	81	110	111	150	151	190	Samdup (1997)
off-farm income (Nu x 1000)	0	5	6	10	11	20	21	30	31	50	Samdup (1997)
milk yield/cow/ day (kg)	1	2	2.1	4	4.1	6	6.1	8	8.1	10	Samdup (1997)
GM (livestock)/ LU[4] (Nu x 1000)	1	2	3	5	6	10	11	20	21	30	Samdup (1997)
environmental indicators											
excess LU reared[1]	2.5	2.1	2	1.6	1.5	1.1	1	0.6	0.5	0	expert group
soil N balance (kg/ha)	-81	-60	-61	-40	-41	-20	-21	20	19	32	van Keulen (1996)
soil P balance (kg/ha)	-30	-19	-20	-11	-10	-3	-2	2	3	15	van Keulen (1996)
livestock CPR[5] grazing practices (QOD)	0	1	1.1	2	2.1	3	3.1	4	4.1	5	expert group
soil erosion of crop land (QOD)	0	1	1.1	2	2.1	3	3.1	4	4.1	5	expert group

[1]lower "performance value range" is better (Min.); [2]qualitative ordinal data;
[3]ngultrum (US$ 1 = Nu 43.8 in 2000; Nu 45.3 in 2004 (RMA, 2005); Nu 65 in 2015 (RMA 2016));
[4]Livestock Unit; [5]Common Property Resources

(Nu 81,000 to Nu 110,000) per year; *off-farm income* per farm (Nu 11,000 to Nu 20,000) per year; *milk yield per (exotic crossbred) cow per day* (4.1 to 6 kg) and *GM livestock per LU* (Nu 6000 to Nu 10,000) were taken as the performance value ranges of the medium sector for these indicators.

Environmental indicators

The performance value range for *excess LU reared* in relation to the feeds on offer per household was based on the opinion of the expert group who proposed that a range between 1.1 to 1.5 excess LU per household could be categorised in the medium sector (Table 3). Due to absence of literature in Bhutan and the experts could not advice on this, we took the performance value range for *the soil N balance* and *soil P balance* kg per ha of land based on Van Keulen et al. (1996) who mention that -20 kg to 20 kg N per ha, and -2 kg to 2 kg P per ha is not considered a problem and therefore the expert group proposed these performance value ranges for the ok sector and the ranges of -41 to -20 kg N per ha and -10 to -3 kg P per ha for the medium sectors. Table 2 gives the descriptions of the medium scoring for the qualitative indicators *livestock CPR grazing practices* and *soil erosion of crop land.*

5.3.3 Household and farm characteristics

Table 4 shows least square means of household members, farm sizes, cattle herd sizes, and percentages of crossbreds on a farm in the study areas for 2000, 2004 and 2015. The number of household members declined in the monitoring period in the semi-intensive, intensive and intensive peri-urban areas. This decline is due to migration to urban areas. Average farm size was smallest in the extensive area due to its difficult farming conditions (Samdup et al. 2010). Average cattle herd size has declined in the monitoring period, mainly due to decline in local cattle numbers per farm. In the intensive area the average proportion of crossbred cattle per household was the highest, but had not changed in the monitoring period. In the extensive, and semi-intensive areas

Table 4. Least square means (lsm) for the numbers of household members, farm sizes, herd sizes (LU), and percentages of crossbreds in a herd for four areas in 2000, 20004 and 2015

Area	Khaling				Dala				Chokhor				Chang		
System	Extensive				Semi-intensive				Intensive				Int.peri-urban		
	2000	2004	2015	p	2000	2004	2015	p	2000	2004	2015	p	2000	2004	p
house-hold size	7.1	7.8	7.5	0.10	9.4	10.5	6.7	0.02	7.8	8.3	7.0	0.04	7.9	8.5	0.04
farm size (ha)	1.2	1.2	1.2	0.12	2.6	2.5	2.4	0.15	2.9	2.9	2.8	0.20	1.5	1.1	0.03
herd size (LU[1])	8.4	6.8	6.4	0.04	7.3	7.1	5.9	0.02	9.5	9.3	7.5	0.03	7.2	6.6	0.03
crossbr. cattle (%/hh/y)	20	25	34	0.04	59	59	71	0.03	84	88	89	0.07	70	83	0.04

[1]One livestock unit is defined as an adult bovine weighing about 300 kg, cows, bullocks and breeding bulls were considered as 1 LU, heifers and young bulls as 0.7 LU and calves as 0.2 LU.

the average proportion of crossbred cattle per household had increased. So, adoption of crossbreeding strongly differs still between the areas.

5.3.4 Empirical assessment of the GNH indicators

Tables 5, 6 and 7 give the least square means for the continuous societal, economic and environmental indicators, and medians for the non-parametric indicators for the four study areas in the monitoring years 2000 (5), 2004 (6) and 2015 (7). *Rural-urban migration* and *farm labour shortage* are presented only as overall percentages per area. Table 8 summarises the results per area per year. The main trends in the indicators between areas and between years are presented below.

Societal indicators

The societal indicators differed considerably between the study areas, in particular in 2000 (Table 5) and 2004 (Table 6). *Farm labour shortage* was highest in the extensive area in 2000 and 2004. In 2015 the *rural-urban migration* and *farm labour shortage* were high in all areas. In 2000 and 2004 *literacy rate* was higher in the intensive peri-urban area than in the other areas. In 2015 the *literacy rates* were similar in the three remaining areas. *Access to piped drinking water* and *household living standards* were higher in the two intensive areas than in the semi-intensive and extensive areas in all three monitoring years.

The changes in the societal indicators over the monitoring years (Table 8) showed the increase in *rural-urban migration* and *farm labour shortage* in 2015. The *literacy rate* increased in the extensive area from 2000 onwards. In the extensive and intensive areas the *access to piped drinking water* and *household living standards* improved from 2000 to 2004 and from 2004 to 2015. In the intensive peri-urban area *household living standard* had improved from 2000 to 2004.

Economic indicators

The differences in the economic indicators between the study areas were rather consistent over the monitoring period. *Annual income*, *farm GM*, *milk yield per cow per day* and *GM(livestock) per LU* were the highest in the intensive peri-urban area followed by the intensive, semi-intensive and extensive area in 2000 and 2004. In 2015, the intensive area showed the highest *farm GM* (Table 8). *Off-farm income* remained lower in the intensive area compared to the other areas over the whole study period. In this area there are less possibilities for off-farm work, e.g. because of limited construction work for buildings and roads as most

Table 5. Least square means (lsm) and medians for the societal, economic and environmental indicators for the four areas in 2000

Year	2000								
Area	Khaling (n=63)		Dala (n=35)		Chokhor (n=55)		Chang (n=30)		
System	Extensive		Semi-intensive		Intensive		Int.peri-urban		
societal indicators									
rural urban migration (%)	2		0		0.9		0		
farm labour shortage (% hh)	14.2		5.7		5.4		6.7		
	lsm	se	lsm	se	lsm	se	lsm	se	p
literacy rate (%/hh)	47.9^{b}	2.6	49.9^{b}	3.5	53.2^{b}	2.8	69.6^{a}	3.8	0.001
	median	min-max	median	min-max	median	min-max	median	min-max	
access to piped drinking water	2.0^{z}	2.0-3.0	3.0^{y}	2.0-5.0	3.0^{x}	3.0-4.5	4.0^{r}	2.0-4.0	0.001
household living standard	2.0^{z}	1.5-3.0	3.0^{y}	2.0-3.5	3.0^{x}	2.0-4.0	3.0^{r}	2.0-4.0	0.001
economic indicators	lsm	se	lsm	se	lsm	se	lsm	se	
annual income (Nu[1] x 1000)	75.6^{c}	7.8	116.6^{b}	10.5	137.7^{b}	8.3	207.2^{a}	1.1	0.001
farm gross margins (GM) (Nu x 1000)	54.3^{d}	73.8	97.7^{c}	9.8	130.3^{b}	7.8	181.2^{a}	10.6	0.001
milk yield/cow/day (kg)	3.0^{c}	0.22	5.0^{b}	0.2	4.9^{b}	0.2	7.0^{a}	0.2	0.001
GM (livestock)/LU[2] (Nu x 1000)^	4.9^{d}	0.8	9.9^{c}	1	6.6^{b}	0.8	18.8^{a}	1.1	0.001
	median	min-max	median	min-max	median	min-max	median	min-max	
off-farm income (Nu x 1000)	21.0^{r}	0-72	15.0^{r}	0-76	3.5^{x}	0-36	18.0^{r}	0-90	0.001
environmental indicators									
	lsm	se	lsm	se	lsm	se	lsm	se	
excess LU reared	2.1^{a}	0.1	1.1^{b}	0.2	0.2^{c}	0.1	0.2^{c}	0.1	0.001
soil N balance (kg/ha)	30.9^{a}	1.3	-18.2^{c}	1.7	-17.8^{c}	1.4	1.5^{b}	1.8	0.001
soil P balance (kg/ha)	6.3^{b}	0.6	-3.7^{c}	0.8	13.8^{a}	0.7	-3.9^{c}	0.9	0.001
	median	min-max	median	min-max	median	min-max	median	min-max	
livestock CPR[3] grazing practices	2.0	1.0-3.5	2.0	1.0-4.5	2.0	2.0-3.5	2.0	2.0-3.0	0.090
soil erosion of crop land	3.0	2.5-4.0	3.0	2.0-4.0	3.0	3.0-4.0	3.0	2.5-4.0	0.867

[1]ngultrum (US$ 1 = Nu 43.8 in 2000 and Nu 45.3 in 2004 (RMA 2005) and Nu 65 in 2015 (RMA 2016);
[2]livestock unit; [3]common property resources;
^analysis was conducted on log transformed data;
[a,b,c,d] lsm with different superscripts between study areas are significantly different ($p<0.05$);
[r,x,y,z] medians with different superscripts between study areas are significantly different ($p<0.05$) (Kruskal Wallis and Wilcoxon rank sum tests)

Table 6. Least square means (lsm), (%) and medians for the societal, economic and environmental indicators for the four areas in 2004

Year	2004								
Area	**Khaling(n=63)**		**Dala (n=35)**		**Chokhor (n=55)**		**Chang (n=30)**		
System	**Extensive**		**Semi-intensive**		**Intensive**		**Int.peri-urban**		
societal indicators									
rural urban migration (%)	5.5		0.0		2.0		0.0		
farm labour shortage (% hh)	15.9		8.6		7.3		6.7		
	lsm	se	lsm	se	lsm	se	lsm	se	p
literacy rate (%/hh)	52.8^{bc}	2.6	51.1^{c}	3.5	55.1^{b}	2.8	69.1^{a}	3.7	0.001
	median	min-max	median	min-max	median	min-max	median	min-max	
access to piped drinking water	2.5^{y}	2.0-3.5	3.0^{x}	2.5-4.0	3.5^{r}	3.0-4.0	4.0^{r}	2.0-4.0	0.001
household living standard	2.5^{y}	2.0-3.5	3.0^{x}	2.0-3.5	3.5^{r}	2.0-4.0	3.5^{r}	2.0-4.0	0.001
economic indicators	lsm	se	lsm	se	lsm	se	lsm	se	
annual income (Nu[1] x 1000)	79.0^{c}	6.8	142.7^{b}	9.1	164.2^{ab}	7.3	183.8^{a}	9.8	0.001
farm gross margins (GM) (Nu x 1000)	61.1^{c}	6.5	119.1^{b}	8.8	155.5^{ab}	7	149.2^{a}	9.5	0.001
milk yield/cow/day (kg)	3.1^{c}	0.2	5.6^{b}	0.2	5.6^{b}	0.2	7.3^{a}	0.3	0.001
GM (livestock)/LU[2] (Nu x 1000)^	4.9^{c}	0.9	10.7^{b}	1.2	8.6^{b}	0.9	24.6^{a}	1.2	0.001
	median	min-max	median	min-max	median	min-max	median	min-max	
off-farm income (Nu x 1000)	15.0^{x}	0-60	13.5^{rx}	0-88	6.0^{y}	0.0-39	30.0^{r}	0-135	0.001
environmental indicators									
	lsm	se	lsm	se	lsm	se	lsm	se	
excess LU reared	1.1^{a}	0.1	0^{b}	0.1	0^{b}	0.8	0^{b}	0.1	0.001
soil N balance (kg/ha)	30.7^{a}	1.3	-19.7^{c}	1.7	-14.6^{d}	1.3	2.7^{b}	1.9	0.001
soil P balance (kg/ha)	5.5^{b}	0.6	-5.3^{d}	0.9	15.5^{a}	0.7	2.6^{c}	0.9	0.001
	median	min-max	median	min-max	median	min-max	median	min-max	
livestock CPR[3] grazing practices	2.0	1.0-3.5	2.0	2-4.5	2.5	2.0-3.5	2.0	2.0-3.0	0.070
soil erosion of crop land	3.0	2.5-4.0	3.0	2-4.0	3.0	2.5-4.0	3.5	3.0-4.0	0.090

[1]ngultrum (US$ 1 = Nu 43.8 in 2000 and Nu 45.3 in 2004 (RMA 2005) and Nu 65 in 2015 (RMA 2016);
[2]livestock unit;
[3]common property resources;
^analysis conducted on log transformed data;
^{a,b,c,d} lsm with different superscripts between study areas are significantly different ($p<0.05$);
^{r,x,y,z} medians with different superscripts between study areas are significantly different ($p<0.05$)(Kruskal Wallis and Wilcoxon rank sum tests)

Table 7. Least square means (lsm), (%) and medians for the societal, economic and environmental indicators for the three areas in 2015

Year	2015						
Area	**Khaling (n=47)**		**Dala (n=29)**		**Chokhor (n=47)**		
System	**Extensive**		**Semi-intensive**		**Intensive**		
societal indicators							
rural urban migration (%)	14.0		23.3		12.4		
farm labour shortage (% hh)	23.4		17.2		36.2		
	lsm	se	lsm	se	lsm	se	p
literacy rate (%/hh)	58.8	3.2	55.6	4.1	58.9	3.2	0.790
	median	min-max	median	min-max	median	min-max	
access to piped drinking water	3.0^{z}	2.0-4.0	3.5^{y}	2.0-5.0	4.0^{x}	3.0-4.5	0.001
household living standard	3.0^{z}	2.5-4.0	3.0^{y}	2.0-5.0	4.0^{x}	2.5-5.0	0.001
economic indicators	lsm	se	lsm	se	lsm	se	
annual income (Nu[1] x 1000)	93.7^{b}	11.4	148.2^{a}	14.6	170.6^{a}	11.4	0.001
farm gross margins (GM) (Nu x 1000)	75.4^{b}	10.8	123.8^{a}	13.7	161.9^{c}	10.8	0.001
milk yield/cow/day (kg)	3.6^{c}	0.1	6.0^{a}	0.2	4.2^{b}	0.1	0.001
GM (livestock)/LU[2] (Nu x 1000)^	12.6^{b}	1.9	23.4^{a}	2.5	12.3^{b}	2.0	0.042
	median	min-max	median	min-max	median	min-max	
off-farm income (Nu x 1000)	12.0^{r}	0-60	12.0^{r}	0-88	3.0^{x}	0-39	0.004
environmental indicators	lsm	se	lsm	se	lsm	se	
excess LU reared	1.2^{a}	0.1	0.1^{b}	0.1	0^{b}	0.1	0.001
soil N balance (kg/ha)	24.6^{a}	0.9	-7.1^{b}	1.2	-5.5^{b}	0.9	0.001
soil P balance (kg/ha)	4.6^{b}	0.7	-3.9^{c}	0.8	10.3^{a}	0.7	0.001
	median	min-max	median	min-max	median	min-max	
livestock CPR[3] grazing practices	2.5^{z}	2.0-4.0	3.0^{yz}	1.0-4.5	3.5^{xy}	1.0-4.5	0.001
soil erosion of crop land	3.5^{z}	3.0-4.0	3.5^{xy}	2.0-4.5	4.0^{x}	3.0-5.0	0.040

[1]ngultrum (US$ 1 = Nu 43.8 in 2000 and Nu 45.3 in 2004 (RMA 2005) and Nu 65 in 2015 (RMA 2016);
[2]livestock unit;
[3]common property resources;
^analysis conducted on log transformed data;
[a,b,c] lsm with different superscripts between study areas are significantly different ($p<0.05$);
[x,y,z] medians with different superscripts between study areas are significantly different ($p<0.05$)(Kruskal Wallis and Wilcoxon rank sum tests)

Table 8. Least square means (lsm) and medians for the societal, economic and environmental indicators within an area

Area System	Khaling/ Extensive				Dala/ Semi-intensive				Chokhor/ Intensive				Chang/ Int.peri-urban		
	2000	2004	2015	p	2000	2004	2015	p	2000	2004	2015	p	2000	2004	p
societal indicators															
rural urban migration (%)	2.0	5.5	14.0		0.0	0.0	23.3		0.9	2.0	12.4		0.0	0.0	
farm labour shortage (% hh)	14.2	15.9	23.4		5.7	8.6	17.2		5.4	7.3	36.2		6.7	6.7	
literacy rate (%/hh)	47.9^{c}	52.8^{b}	58.8^{a}	0.027	49.9	51.10	55.6	0.207	53.2	55.1	58.9	0.395	69.6	69.1	0.912
access to piped drinking water	2.0^{z}	2.5^{y}	3.0^{x}	0.001	3.0	3.0	3.5	0.237	3.0^{z}	3.5^{y}	4.0^{x}	0.001	4.0	4.0	0.189
household living standard	2.0^{z}	2.5^{y}	3.0^{x}	0.001	3.0	3.0	3.0	0.093	3.0^{z}	3.5^{y}	4.0^{x}	0.001	3.0^{y}	3.5^{x}	0.001
economic indicators															
annual income (Nu x 1000)	75.6^{b}	79.0^{b}	93.7^{a}	0.014	116.6	142.7	148.2	0.146	137.7	164.2	170.6	0.09	207.2	183.8	0.198
farm gross margin (Nu x 1000)	54.3^{b}	61.1^{b}	75.4^{a}	0.001	97.7	119.1	123.8	0.204	130.3	155.5	161.9	0.098	181.2	149.2	0.069
milk yield/cow/day (kg)	3.0^{b}	3.1^{b}	3.6^{a}	0.006	5.0^{b}	5.6^{ab}	6.0^{a}	0.006	4.9^{b}	5.6^{a}	4.2^{c}	0.001	7.0	7.3	0.598
GM (livestock)/LU[2] (Nu x 1000)^	4.9^{b}	4.9^{b}	12.6^{a}	0.001	9.9^{b}	10.7^{b}	23.4^{a}	0.004	6.6^{b}	8.6^{b}	12.3^{a}	0.001	18.8^{a}	24.6^{b}	0.017
off-farm income (Nu x 1000)	21.0	15.0	12.0	0.459	15.0	13.5	12.0	0.992	3.5	6.0	3.0	0.953	18.0	30.0	0.264
environmental indicators															
excess LU	2.1^{a}	1.1^{b}	1.2^{b}	0.001	1.1^{a}	0.0^{b}	0.1^{b}	0.001	0.2^{a}	0^{b}	0^{b}	0.004	0.2^{a}	0^{b}	0.003
soil N balance (kg per ha)	30.9^{a}	30.7^{a}	24.6^{b}	0.001	-18.2b	-19.7^{b}	-7.1^{a}	0.001	-17.8^{b}	-14.6^{b}	-5.5^{a}	0.001	1.5^{b}	2.7^{a}	0.001
soil P balance (kg per ha)	6.3^{a}	5.5^{a}	4.6^{b}	0.001	-3.7	-5.3	-3.9	0.532	13.8^{b}	15.5^{a}	10.3^{b}	0.001	-3.9^{b}	2.6^{a}	0.001
livestock CPR[3] grazing practices	2.0^{z}	2.0^{y}	2.5^{x}	0.001	2.0	2.0	3.0	0.275	2.0^{z}	2.5^{yz}	3.5^{x}	0.001	2.0	2.0	1.00
soil erosion of crop land	3.0^{z}	3.0^{y}	3.5^{x}	0.001	3.0^{z}	3.0^{yz}	3.5^{xy}	0.017	3.0^{z}	3.0^{y}	4.0^{x}	0.001	3.0	3.5	0.075

[1]ngultrum (US$ 1 = Nu 43.8 in 2000 and Nu 45.3 in 2004 (RMA 2005) and Nu 65 in 2015 (RMA 2016);

[2]livestock unit;

[3]common property resources;

[a,b,c] lsm with different superscripts between years are significantly different ($p<0.05$);

^analysis was conducted on log transformed data;

[x,y,z] medians with different superscripts between years are significantly different ($p<0.05$) (Kruskal Wallis & Wilcoxon rank sum tests);

For the number of households (n) and standard errors (se) of lsm and min-max values of medians (please refer to tables 5, 6, 7) of these had been completed before 2000. *Milk yield per cow per day* was lowest in the extensive area in the three monitoring years. In 2000 and 2004, it was highest in the intensive peri-urban area. *Milk yield per cow per day* is about three times higher in crossbred cows than in local Siri cows (Samdup et al. 2010). So milk yields and economic results of cattle keeping are higher in areas with large numbers of crossbreds on the farms as in the intensive areas. In 2015, however, *milk yield per cow per day* was higher in the semi-intensive area than in the extensive area and the intensive area. In 2015, the *GM (livestock) per LU* in the semi-intensive area was higher compared to the other two areas. This was partly due to the higher milk off-take.

Only in the extensive area there was an increase in *annual income* and *farm GM* in 2015 compared to 2000 and 2004. There were no changes over the years for these two indicators in the other areas. *Off-farm income* remained the same in all areas over the years. Despite the large numbers of crossbred cattle in the intensive area *milk yields per cow per day* have decreased between 2004 and 2015. In 2015 an outbreak of FMD (foot and mouth disease) in this area will have negatively affected the *milk yields per cow per day*. Main reasons for the slowly increasing or even stagnant *milk yields per cow per day* are the lack of systematic breeding programmes and the poor quality of the feeds available (Samdup et al. 2010). Despite the lower *milk yield per cow per day* the *GM (livestock) per LU* increased between 2004 and 2015 in the intensive area. Also in the extensive and semi-intensive areas the *GM (livestock) per LU* increased significantly between 2004 and 2015. A reason for the increases in *GM (livestock) per LU* could be the decreases in LUs per farm.

Environmental indicators

The environmental indicators *excess LU reared* and *soil N balance* were higher in the extensive area than in the other areas in all three monitoring years. The *soil N balance* was (relatively) high in the extensive area probably because of the large N input into the farms from manure through CPR grazing. The semi-intensive and intensive area showed a negative *soil N balance* which was probably due to higher outputs from the crop sub-system (Samdup et al. 2013). The *soil P balance* was higher in the intensive area than in the other areas in all the monitoring years probably because of the high use of single super phosphate (SSP) fertilisers for cropping, especially for potatoes (Samdup et al. 2013). The *CPR grazing practices* and *soil erosion on sloping land* did not differ significantly between the study areas in 2000, but in 2004 and 2015 they were better valued in the intensive area than in the other areas due to more awareness of farmers, created via extension efforts, about grazing practices and erosion. There was a significant decline in the *excess LU reared* in 2004 and 2015 compared to 2000 in all the study areas probably because of smaller numbers of animals per farm due to sales, so the LU were more in balance with the feeds available in 2004 and 2015 than in 2000. The *soil N and P balances* reduced in 2015 due to more prudent use of the fertilisers compared to the other monitoring years, except for the *soil P balance* in the semi-intensive area which remained slightly negative over the years.

5.3.5 The integral assessment

Table 9 gives the Standardised Indicator Values (SVs) of the individual societal, economic and environmental indicators and their average index values per study area for 2000, 2004 and 2015. The performance value ranges (Table 3) were used to calculate the SV's.

Overall, the extensive area had the lower societal and economic indices than the other areas. This indicates that this area has witnessed lower societal and economic progress than the other areas. Remote locations such as the extensive area have been less effectively addressed by development efforts (Rinzin et al. 2007). Adoption of crossbreeding is slow due to the difficult topography and, consequently, long distances to input and output markets in this area. In 2015 the economic index had moved from the poor sector in 2000 and 2004 to the medium sector. This was due to the increase in all the economic indicators in this area, except *off-farm income* (Table 8). So, farming is giving slightly better economic results in 2015 compared to the earlier years partly due to a slowly increasing crossbred cattle population (Table 4).

In the semi-intensive area the economic index moved from the medium sector in 2000 to the ok sector in 2004 and 2015, with *farm income* moving from the ok to the good sector. Major reasons for this change were increased milk sales. In the intensive area *farm income* was relatively high. The good income opportunities from farming are the result of the large numbers of crossbred cattle in this area and the higher livestock GMs from crossbred cattle than from local cattle, and crop GMs from potatoes (Samdup et al. 2010). The off-farm income was categorised in the bad sector in this area, due to the very limited off-farm possibilities.

A striking finding was that the societal index declined in the semi-intensive and intensive areas by 19 and 18 scale points between 2004 and 2015. Increased

Table 9. The Standardised Values[1] (SV) and average index values (0 to 100) of the societal, economic and environmental indicators for the four areas during 2000, 2004 and 2015

Area	Khaling			Dala			Chokhor			Chang	
System	Extensive			Semi-intensive			Intensive			Intensive peri-urban	
	2000	2004	2015	2000	2004	2015	2000	2004	2015	2000	2004
farms (n)	63	63	47	35	35	29	55	55	47	30	30
societal indicators											
rural-urban migration	93	61	34	100	100	19	97	93	39	100	100
farm labour shortage	45	42	17	83	68	35	84	75	4	78	78
literacy rate	36	45	58	39	41	51	46	50	59	81	81
access to piped drinking water	41	50	61	61	61	70	61	70	81	70	81
household living standard	41	50	61	61	61	61	61	70	81	61	70
average societal index	51	49	46	69	66	47	70	71	53	78	82
economic indicators											
annual income	31	33	43	59	76	80	73	86	89	100	94
farm GM	24	32	46	68	88	83	97	100	100	100	100
off-farm income	61	50	43	50	44	41	9	21	6	72	85
milk yield per cow per day	21	22	27	51	57	61	50	57	43	61	64
GM (livestock) per LU[2]	40	39	64	61	61	86	44	54	64	76	89
average economic index	36	35	45	58	65	70	54	64	60	82	86
environmental indicators											
excess LU reared	20	61	56	41	100	100	97	100	100	95	100
livestock CPR[3] grazing practices	41	41	50	41	41	61	41	50	70	39	39
soil erosion of crop land	61	61	70	59	59	70	61	59	81	59	70
soil N balance	99	83	90	62	62	75	63	64	69	71	73
soil P balance	94	97	84	59	47	44	99	102	93	57	82
average environmental index	63	69	70	52	62	70	72	75	83	64	73

[1]SV (higher the SV means it is better, for e.g this also refers to the rural-urban migration, farm labour shortages and excess LU reared)

[2]livestock unit; [3]common property resources

rural-urban migration and *farm labour shortage* are responsible for this decline. In this study the *rural-urban migration* calculations, which were based on the percentages of migrated family members, only involved the households present for the survey. However, compared to 2000 and 2004, in 2015 the number of households declined in our survey by 25%, 17% and 14% of the initial households in the extensive, semi-intensive and intensive areas, respectively. All members of the missing households had moved to other areas. Whether this was to other rural areas or urban areas is not known, but the rural-urban in 2015 could be higher than the 2015 results indicate since we did not include the households that had moved to other areas with all family members. Rural-urban migration and consequently farm labour shortages keep on increasing in Bhutan (Gosai 2009; Gosai and Sulewski 2013). The main reasons are better employment opportunities in urban areas and accessibility to cash income, and escape from drudgery of farm work (MoA 2005). Though rural households receive cash remittances, most farmers adapt by shifting to farming practices which require less labour such as orchards, vegetables, keeping fewer cattle, backyard poultry farming, and non-farm activities such as weaving (MoA 2005).

In Bhutan, environmental conservation is considered to be equally important as socio-economic development, but there was not much progress in environmental issues over the period 2000-2015. The environmental indices for the study areas remained in the ok sector over the whole study period, except in the semi-intensive area where it started in the medium sector in 2000 and in the intensive area where it had moved to the good sector in 2015. Encouraging was that the number of LU reared was in line with the feeds available, based on the existing production levels (shown by the good sector for *excess LU reared*), in the semi-intensive and intensive areas. Farmers are not aware of some of the issues behind the environmental indicators used, such as whether their *CPR grazing practices* are good or bad for biodiversity in forest areas. But farmers are well aware that CPR grazing is an important source of feed for their cattle (Samdup et al. 2013).

The intensive peri-urban area had the highest societal and economic indices in 2000 and 2004. All economic indicators were higher in this area compared with the other areas in both years. The large majority of the cattle kept were crossbreds which will have contributed to economic results from the cattle component of these farms (Samdup et al. 2010). Despite the considerable potential for dairying due to availability of inputs and close proximity to the market, farmers had to stop dairying as Chang was demarcated as an urban area and therefore rearing of cattle was allowed anymore from 2010 onwards. The farmers in this area considered this as a blessing in disguise, as the value of land increased ten times.

5.3.6 Strengths and weaknesses of the methodological approach

A main difference between our approach to assess development progress in rural areas and the CBS GNH index is that we focused only on two of the four GNH pillars and used fewer and other indicators than the 33 indicators in the GNH index (CBS 2012). The GNH index aims to guide policy makers in formulation of annual and five-year planning of the development activities. Our approach zooms in on the issues of farmers in different agro-ecological areas. In future such efforts can complement the GNH development efforts since real life issues of the farmers are sometimes underscored at the macro level of planning.

The selection of the indicators we used and the identification of the performance value ranges for the bad to good sectors of the indicators was very much based on judgements and values of the experts. A different composition of the expert group, for instance by including experts from other fields of expertise might have yielded a different list of selected indicators. The determination of the performance value ranges was a challenge due to absence of official standards for the indicators selected. More research is needed to develop 'less arbitrary' performance value ranges. Nevertheless, our approach is a first attempt to define benchmarks for development targets for rural areas in Bhutan.

For the integrative assessment we considered the indicators to be of equal importance. The weighing of indicators in composite indices is discussed widely (Blanc et al. 2008; Rowley et al. 2012). Rowley et al. (2012) state that it is important to choose an approach that fits the user's information needs. The present approach, based on equal weights of the indicators, is in line with the fundamental idea of GNH that all domains in the GNH concept are equally important. For ease of communication with policy makers and extension officers the societal, economic and environmental indices were established. Several authors (e.g. Mollenhorst 2005; DEFRA 2009) state that aggregating indicators into a single index may not improve understanding of the system and could mask the details. However, others (e.g. Singh et al. 2009; UNCSD 2012) argue that composite indices are increasingly recognised as a useful tool for communication of findings. The level of aggregation depends very much on the potential users. Policy makers need a rather high level of aggregation, whereas scientists or development practitioners might be interested in the trends of the individual indicators. The present approach also presents the trends in empirical and standardised values of the different indicators; these can explain the dynamics in the indices.

To obtain views on our integral assessment methodology from potential users, we presented the concepts and results during a meeting with some of the officials of the GNH Commission Secretariat of Bhutan in 2016. This institution is responsible for planning and coordinating the government's five year planning processes and also allocates budget to the different government agencies. The officials in general appreciated the idea of studying development trends and problem areas at farm level by societal, economic and environmental indicators and indices but did not yet make any specific comment. It is hoped that the methodology presented could be adapted and the results be used while framing future policies for rural areas.

5.4 Conclusions

The present methodological approach based on participatory identification of societal, economic and environmental issues and indicators along with reference values for selected indicators coupled with an integral assessment using societal, economic and environmental indices, can complement the implementation of the GNH philosophy in Bhutan. It may re-enforce more awareness amongst policy makers and other stakeholders for necessary interventions. So, informed decisions can be made to benefit the largely agrarian population. The integral assessment indicated that more equitable social and economic development is required. The intensive peri-urban and intensive areas showed the highest performance in all monitoring years for most of the societal and economic indicators and consequently the respective indices. Between 2004 and 2015 the societal indices declined in the semi-intensive and intensive areas. Policy interventions are required to address especially rural-urban migration and farm labour shortages.

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Chapter 6

General discussion

6.1 Introduction

Bhutan's GNH concept and the GNH index aim to guide policy makers to address a question like "how to increase the national well-being of the population?" and to track changes in well-being over time (CBS 2015). The GNH index, however, is developed initially at the national level, and lacks measuring issues which are especially important for smallholder farmers. Therefore, there is a need to have a methodology to derive GNH issues and indicators which are important for rural farmers, while at the same time keeping in mind the national interests over different spatial and temporal dimensions.

Many smallholder farmers in rural areas in Bhutan live in poverty (MoA 2002). As in many developing countries (Delgado et al. 2001; Tulachan et al. 2002; Udo et al. 2011), crossbreeding of local cattle with exotic dairy breeds is promoted as a key strategy to increase livestock production, or in other words to improve the well-being of rural smallholders. The objective of this study, therefore, is to evaluate whether crossbreeding of dairy cattle has benefited rural farmers from a GNH perspective across time and space.

To this end, Chapter 2 first describes the evolving GNH concept and various issues relevant for smallholder farmers in rural areas. Subsequently, Chapters 3 and 4 describe the analysis of the impact of crossbreeding on farming practices, economic results, and the use of natural resources. In Chapter 5, finally, a pragmatic approach for an integrated GNH assessment at farm level is presented. This chapter starts with a reflection on the methodological challenges of an integrated GNH assessment at farm level (section 6.2). Subsequently, the future perspectives of crossbreeding in Bhutan are discussed (section 6.3). Finally, future prospects of the GNH concept for rural areas are discussed (section 6.4).

6.2 Reflection on methodological challenges

6.2.1 The setting

National and international conferences on GNH have emphasised the need for its operationalisation by way of practical indicators and the development of practical policies. Also outside Bhutan, a wide range of concepts and tools have been developed to support decision-making regarding improvement of well-being or sustainable development of societies (Caspari 2004). Recently, the Food and Agricultural Organisation (FAO) developed a framework for Sustainability Assessment of Food and Agriculture Systems (SAFA), with large similarity with

GNH (FAO 2014). SAFA characterises food and agricultural systems by four dimensions of sustainability: good governance, environmental integrity, economic resilience and social well-being. So, far before the development of SAFA, the GNH concept already identified governance as an important aspect of sustainable development, in addition to the currently well-acknowledged pillars of sustainability: the domain of people, planet, and profit. In Chapter 2, I argue that governance should be the foundation for the three pillars of GNH, since good governance is vital to actually improve well-being of people. Furthermore, both SAFA and Bhutan's GNH index use indicators to measure progress of issues in the domain of people, planet and profit. SAFA determines 116 indicators and aggregates them to 21 indicators, which are presented in a polygon. The GNH index uses 33 indicators and aggregates them in nine domains and combines these in one index. The present study complements the GNH index methodology, by including issues relevant for smallholder farmers. It uses a combination of an empirical and integral assessment with separate indices for societal, economic and environmental issues. It is hoped that the proposed procedures and criteria elucidated will provide a basis for GNH assessment at the smallholder farm level, and subsequent dissemination. Figure 1 gives a schematic presentation of the integral GNH assessment at farm level. Key aspects in this methodology are: (1) participatory stakeholder meetings to

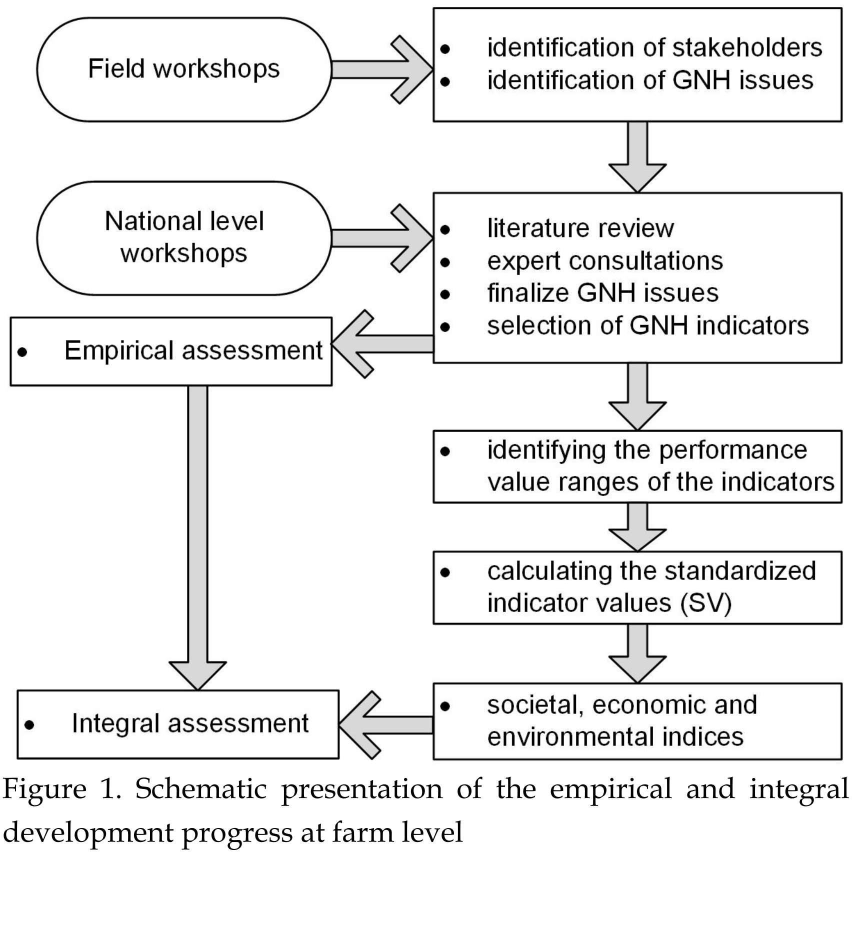

Figure 1. Schematic presentation of the empirical and integral assessment of GNH development progress at farm level

identify GNH issues; (2) identification of indicators; (3) quantifying the GNH indicators and (4) computation of an integrated assessment.

6.2.2 Operationalisation of the methodology

Key points for future implementation

It is generally acknowledged that in order to assess development at farm level, we need a participatory approach to include opinions and perceptions of all relevant stakeholders, in particular the farmers (Zhen and Routray 2003; Mollenhorst 2005). Our participatory workshops enabled us to structure views on real life problems (issues) of the farmers, including causes and consequences of these problems in a relatively short space of time (Chapter 2). The national level workshop, with the participation of a multidisciplinary expert group, was useful to understand national level issues, which had relevance for the rural areas. This expert group consisted of 20 persons: a livestock production specialist, a social scientist, a veterinarian, a policy and planning officer, three district officers (i.e. one for livestock, agriculture and forestry) from each of the four study areas, and a farmer representing each study area. From the discussions in this national workshop, we learned to include more farmers' representatives, more officials at the regional level, and experts in the field of economy or environment. This would have been useful, as the discussions were dominated by policy makers and technical experts. If the expert group would have, for example, also consisted of an environmentalist or an economist, other issues could have been tabled, such as the impact of cattle husbandry on climate change, biodiversity, and trade and marketing issues.

Once relevant issues are selected, we need to identify an indicator for each issue, a(n aggregated) parameter that measures the state of that issue. The various technical, economic and environmental indicators analysed in Chapters 3 and 4, and the CBS GNH indicators were evaluated by the expert group for their relevance in the integral assessment, considering generally used criteria for indicator selection, such as relevance, simplicity, validity and the availability of performance/target values (Bell and Morse, 2003).

Collection of appropriate data based on the identified critical issues is crucial for final selection of indicators, and hence the operationalisation of this methodology. Obtaining data for the quantitative indicators was not a major problem. Each of the 205 geogs in Bhutan has a livestock, agriculture and forestry extension officer. These extension officers were used as enumerators, since they have experience in collecting data from the field. Also in future, extension officers can be used for data collection. They are in close contact with the farmers.

One of the challenges was the subjectivity around the qualitative indicators used for the issues household living standards, livestock CPR grazing practices and soil erosion on sloping crop land (Chapter 5). Kemp and Martens (2007) argue that subjectivity in quantifying qualitative indicators is unavoidable, and must be managed rather than eliminated. Subjectivity in the present qualitative indicators was managed by transposing them into quantitative ordinal data, by scoring them between 1 (bad) to 5 (good) (Chapter 5, Table 3). We were unable to include a qualitative indicator for incidence of wildlife conflicts, which was mentioned to be relevant during the field workshops. This indicator could not be selected because of the varied views of the farmers and expert group and lack of reliable information.

The progress in societal, economic and environmental indicators was assessed by establishing performance value ranges for five sectors on a scale of 1-100 (bad, poor, medium, ok and good) of each identified indicator (Chapter 5, Table 3). There is a need to draw up more reliable performance value ranges for the identified indicators. This can be achieved by the government encouraging more studies at farm level, followed by consultative meetings and publishing a compendium of the agreed performance value ranges.

To monitor progress in the selected indicators, we conducted surveys in 2000, 2004 and 2015, in four different locations. Performing surveys along such a long time frame, however, has it challenges, such as identifying the same households and farmers. Future studies, moreover, could be done in a five-year time frame, which coincides with the five year planning process of the government.

Institutional implementation

One of the challenges of the use of the GNH concept is its policy relevance, i.e. a close and practical link to policy recommendations or measures which are credible for key stakeholders (Hilden and Rosenstrom 2008). Concerted efforts will be made to create awareness amongst policy makers and other stakeholders in Bhutan to disseminate the outputs of the present study. The outcomes of this thesis will be presented to policy makers and researchers under the Ministry of Agriculture and Forests (MoAF) of Bhutan, which is a mandatory requirement especially after completion of post graduate studies

(RCSC 2012). Progressive awareness creation of the study outputs will also be done through periodic meetings with extension workers and farmers.

To pursue the pragmatic implementation of GNH development progress in rural areas, MoAF should take a catalytic role as they have the mandate of policy interventions, and research and extension development for the largely rural population. MoAF's Department of Livestock (DoL) conducts already an annual census on livestock population and livestock production (by the livestock extension workers); the census questionnaires could be further elaborated, including other relevant GNH indicators. Researchers in DoL and other researchers under the MoAF can convey the overall assessment to the policy makers of the MoAF. MoAF can include the implementation in the five year planning process in Bhutan. The 12th five year plan begins in July 2018.

Political commitment has already been made to enhance the smallholder dairy sector through crossbreeding during the coming five year plan period, since cattle are the most important livestock for farmer's livelihoods as they provide a regular and reliable income compared to the traditional once-a-year return from crop production. Hence, a critical assessment of the crossbreeding practices is required.

6.3 Consequences of crossbreeding for dairying

Crossbreeding for dairying is expected to have direct linkages with the socio-economic and environmental pillars of GNH, in terms of its potential to increase household incomes, to reduce the unproductive cattle population and so, reducing the environmental impact on CPR, and to integrate farmers in a reliable market chain (MoAF 2012).

In 1985 Bhutan's Ministry of Agriculture started crossbreeding in areas with suitable agro-ecological conditions, whereas in 1998 the Ministry of Agriculture lifted the zonation in the promotion of crossbreeding. Chapters 3 and 5 indicated that the impact of crossbreeding on economic and environmental issues appeared promising in the initial period of this research (2000-2004), but its impact was relatively modest between 2004 and 2015. Before I will elaborate on the future of crossbreeding, I first present the dynamics in cattle numbers, crossbreeding and milk production in the following sections.

6.3.1 Spatial and temporal dimensions in adoption of crossbreeding

National cattle population dynamics

Table 1 gives the cattle population from 2000 to 2015 in Bhutan. The total number of cattle remained relatively stable at about 300,000, with a peak around 2008. The proportion of crossbred cattle increased from 11% in 2000 to 30% in 2015. Crossbreeding was implemented via artificial insemination (AI) of local cattle with semen from exotic bulls. The number of AI centres increased from 45 in 2000 to 106 in 2015 (NDDC 2016). In 2000, from 4894 inseminations only 1851 calves were born (i.e. 38% success rate), while in 2015 from 8710 inseminations, 4370 calves were born (i.e. 50% success rate). This relatively low AI coverage and poor success rate could be attributed to the low number of staff properly trained in AI and the huge area coverage in one geog for one inseminator. Each inseminator also had other extension duties, related to animal health and livestock production.

Table 1. Cattle population (nos. x 1000) during 2000 to 2015

	2000	2004	2008	2012	2015
Crossbred	33	44	62	72	92
Local	264	252	249	227	210
Total	297	296	311	299	303

Source: MoA (2001); DoL (2005, 2009, 2013, 2016)

Crossbreeding was also implemented by supplying bulls from the nucleus breeding farms for natural mating. In 2015, the Department of Livestock supplied 5 breeding bulls (3 purebred Jersey and 2 Brown Swiss crossbred) in the intensive area (Chokhor), 1 pure Jersey bull in the semi-intensive area (Dala) and 3 pure Jersey bulls in the extensive area (Khaling) for natural mating (NDDC 2016). These breeding bulls were born in the Brown Swiss breeding farm in Bumthang and the Jersey breeding farm in Samtse. The poor AI coverage and the limited pool of good quality breeding bulls will have contributed to the slow increase in the crossbred cattle population (MoA 2012).

Adoption of crossbreeding in the study areas

The adoption of crossbreeding varied strongly amongst the four study areas, with low percentages of crossbreds in the extensive area and high percentages in the intensive areas (Chapter 3, Table 2 and Chapter 5, Table 4). Roger (2003)[1] defined five categories of potential adopters of technologies.

Roger (2003)[1] defined innovators, early adopters, early majority, later majority and laggards as adopters of technologies.

In the extensive area the majority of the farmers have not adopted crossbreeding at all. Such so-called laggards could be attributed to the farmers being sceptical towards the innovation and its outcomes. In general, farmers in the extensive area were initially reluctant in adopting crossbreeding, because of their perception that very good animal husbandry practices are required for crossbred cattle and risks, such as untimely availability of inputs. However, in 2015, a few farmers in the extensive area achieved economic progress with crossbred cattle. It is expected, therefore, that the success of these few farmers will influence the adoption of crossbreeding by other farmers in this area.

From 2000-2004, farmers with crossbreds in the semi-intensive area could be categorised as early majority adopters. The revitalisation of the dairy farmers' group in this area in 1999 has helped these farmers to start with crossbreeding. The objectives of these dairy groups are to collectively deliver their milk at the milk collection centre on a regular basis, and sell it collectively as fresh milk or as butter and cheese. Part of the milk and milk products are contracted to middlemen. Between 2004 and 2015, the crossbred cattle population per household gradually increased; the late majority adopters in this area had changed over to crossbreeding because they saw the good income opportunities from the early adopters.

The farmers in the intensive area could be categorised as innovators and early adopters of crossbreeding, already in 2000 and 2004. They took the risk of an unsure innovation since they could cushion on income from crops and apples to cover the initial expenses of crossbreeding, such as costs of crossbred heifers and cows, a dairy shed and concentrate feed. These farmers were also thought to live in a more favourable environment in terms of climate, markets and accessibility to livestock extension services. The HELVETAS Brown Swiss crossbreeding project supported crossbreeding from the late 1980's until 2000. The government still operates the Brown Swiss nucleus breeding farm, but the demand for Brown Swiss crossbred bulls has been declining since then.

Farmers in the intensive peri-urban area were also innovators and early adopters, due to their accessibility to the markets, good quality Jersey cattle and good feeding and management practices (Chapter 3). The potential for dairying in the peri-urban intensive area was also the reason that The Netherlands peri-urban dairy project was active here since the late 1990s. Although the farmers in Chang had to give up dairying, the main activities of the project such as AI and animal health services are still a part of the government programmes in nearby geogs.

Hence, factors which discouraged farmers to take up crossbreeding were many, e.g. the risks related to an unfavourable environment, in particular in remote areas, with no easy access to inputs such as AI and extension services, and also the inability to feed the animals properly in the absence of better quality feed resources. Favourable conditions for adoption of crossbreeding were support by projects, especially in terms of monetary subsidies for procurement of cattle, functioning farmers' groups, and accessibility to urban markets, AI and extension services.

6.3.2 Milk Production Trends

National dairy production

Table 2 gives the domestic production of milk and milk products from 2000 to 2015. In 2000, the domestic milk production was estimated at 25,000 tons (t); it declined to 20,000 t in 2004. There are no clear and documented reasons for this decline. It could be due to accuracy of data collection; in 2000 data collection was done by free-lance enumerators without much experience in conduction surveys. Compared to 2004, milk production increased by about 33% in 2012 and 50% in 2015. The doubling of the crossbred cattle population between 2004 and 2015 may have contributed to the increased milk production from 2004 onwards (Table 1). Of the total milk produced, most of the milk is processed into dairy products (Table 2).

Table 3 gives the import of milk and milk products from 2000 to 2015. The import of cheese and milk powder increased from 2000 to 2015, whereas the import of fresh and tetra pack milk only increased until 2012, and decreased afterwards.

Table 2. Domestic production of milk, butter and cheese (kg x 1000) during 2000 to 2015

Products	2000	2004	2008	2012	2015
milk produced	24,837	19,928	22,883	29,625	39,844
fresh milk consumed	3726	NA[a]	3690	3366	3768
fresh milk sold	497	NA[a]	2051	2913	4969
fresh milk processed	20,615	NA[a]	17,142	23,346	31,107
butter	1316	1553	1348	1207	1629
cheese	2173	4791	4463	2300	3471

Source: MoA (2001); DoL (2005, 2009, 2013, 2016); [a]not available

Table 3. Milk and milk products imported (kg x 1000) by Bhutan during 2000 to 2015

Products	2000	2004	2008	2012	2015
milk	95	703	971	1357	141
tetrapack	NA[a]	NA[a]	NA[a]	248	624
butter	199	236	235	289	214
cheese	79	250	534	913	1005
milk powder	726	1189	1469	2034	1692

Source: (NSB 2015; DoL 2016)
[a]NA: data not available

In summary, despite the crossbreeding efforts, Bhutan will continue to be dependent on imports of dairy products especially milk powder from India (Chapter 3). However, Bhutanese in general prefer local dairy products, although they are more expensive than imported dairy products (Wissink 2004). Consumers, for example, pay Nu 62 (approximately US$ 1) for 1 kg of Indian tetra pack milk,, while local fresh milk is sold for about Nu 90 (US$ 1.5). Bhutanese generally prefer fresh milk. Off-late, there has also been an increased market for fresh milk from Bhutan in India near the border with Bhutan, as the milk sold from Bhutan cannot be adulterated and is strictly monitored by the Bhutan Agriculture and Food Regulatory Authority (BAFRA).

Milk production per lactation day

At the start of this research in 2000, crossbred cows produced about three times more milk per lactation day than Siri cows (4.8-5.5 kg for crossbreds vs 1.5-1.8 kg for Siri) (Chapter 3, Table 3). In the extensive area, the higher milk production (milk off-take used for human consumption, so excluding the milk for the calf) of crossbreds is reflected in a marginal increase in average milk production per lactation day per cow per farm from 3 kg in 2000 to 3.6 kg in 2015, with the proportion of crossbred cows increasing from 20% to 34% in this period (Chapter 5, Tables 4 and 8). In the other areas, the average milk production per cow per lactation day remained more or less at the same level or even decreased between 2004 and 2015. In the semi-intensive area, there was a marginal increase in daily milk production per cow per farm from 5 kg in 2000 to 5.6 kg in 2004 to 6 kg in 2015. However, in the intensive area there was a decline in milk production per cow per farm from 5.6 kg in 2004 to 4.2 kg in 2015 (Chapter 5, Table 8). The outbreak of foot and mouth disease in 2015 was an important reason for the low milk production in the intensive area in 2015. Studies in other developing countries, such as India, Kenya showed similar average milk production levels of crossbred or exotic dairy cows in smallholder farms as in the present study (Patil and Udo 1997; Bebe et al. 2003; Udo et al. 2011). Two main reasons for the modest milk production levels at smallholder farms are that no systematic breeding practices seem to develop after the initial crossbreeding and the available feed resources do not support higher milk production levels. Below, these major limitations are discussed in the Bhutanese context.

6.3.3 Breeding practices

Current practices

A major criticism on crossbreeding is that it is often based on unsystematic breeding practices and applied without considering the agro-ecological and socio-economic settings (Wollny 2003). In Bhutan, DoL recommends Brown Swiss or Jersey 50% to 75% crossbreds for the intensive areas, and Jersey 50% crossbreds for the semi-intensive and extensive areas (DoL 2012). Farmers, however, are free to choose which male breed to use for crossbreeding (Jersey or Brown Swiss) and also whether pure or crossbred semen is used. The National Research and Development Centre (NRDC), Thimphu supplies semen to all the districts as per the requisitions received from the districts. Consultations with farmers in the beginning of this research indicated that farmers preferred Jersey and Jersey crossbreds over Brown Swiss crossbreds, because of the smaller body size and associated lower feed requirements (Chapter 4). According to Rai (2017 personal communication), farmers still mainly ask for semen of pure Jerseys or 75% Jersey crossbreds in all areas. Hence, crossbreeding of cattle in Bhutan is still unsystematic largely due to free availability of semen. Continuous upgrading reduces the crossbred element which is essential for adaptability and easier management and feed requirements. Policy interventions need to be framed and awareness needs to be created among farmers for more systematic future crossbreeding.

Way forward

The current policy of enabling farmers to choose any semen or available breeding bulls at the livestock centre or in the community needs further introspections. While this is a democratic choice, there is a need to consider the scientific and practical perspectives. There are two alternative crossbreeding strategies that could be considered: *inter se* mating of F_1 Jersey or Brown Swiss crossbreds or rotational crossbreeding schemes. Syrstad (1996) suggested that *inter se* mating of crossbreds is the most practical breeding strategy for smallholder dairying. The main advantage of this crossbreeding system is that after the initial crosses cattle are mated *inter se* to form an F_2 generation, and so on. Other crossbreeding strategies require an efficient identification and registration (I&R) system, so that farmers know the crossbred generation of their female stock and can decide to continue crossbreeding with the desired male stock. Major investments are needed for an efficient I&R system to implement a well-planned crossbreeding and selection programme (Widi 2015; Ojango et al. 2016). In Bhutan, there is no I&R system as in most developing countries. A National Dairy and Research Development Centre in Western Bhutan started in 2015. This might offer a possibility to strengthen the identification and recording systems in future.

Rege et al (2011) concluded that major questions in animal improvement for smallholders are what breed resources exist, where to get the breeding bulls, and how they can be delivered to the farmers. In Bhutan efforts have been made to address such concerns with the establishment of the Jersey breeding farm and the Brown Swiss breeding farm. The selection programmes are limited to these government breeding farms. These farms supply 30-40 breeding bulls to farmers at the national level annually. The sale of crossbred heifers and cows to farmers is very limited and done only occasionally when the farms have excess animals. Importing crossbred cattle from neighbouring countries is also very difficult since many of them have a policy of not exporting live germplasm.

For a sustainable cattle breeding strategy, given the limited resources, the most practical way forward is to pursue *inter se* mating of the Jersey crossbreds. Currently Jersey crossbred bulls are procured from contract bull breeders based on their breeding data, phenotype and semen test results. Though the Brown Swiss was a choice in the 1990's, however most farmers now prefer the Jersey crossbreds. For farmers interested in local cattle breeding the two regional Mithun breeding farms in central and east Bhutan and the national Siri breeding farm in east Bhutan provide breeding bulls (DoL 2017b).

6.3.4 Feeding and the use of CPR

The quality of the feed sources available is a major limiting factor in smallholder dairying (McDermott 2010; Udo et al. 2011). Also in Bhutan the availability of adequate quality feeds is one of the most important challenges for livestock development (NFFDP 2006; Chapter 4). In the semi-intensive and intensive areas, the excess total livestock units (LU) reared and their present production performances more or less matched the feeds on offer. The extensive farms had, on average, excess LU of 2.1, 1.1 and 1.2 in 2000, 2004 and 2015 respectively indicating underfeeding (Chapter 5, Table 8). The average contribution of CPR grazing to the total digestible nutrients (TDN) available per average farm ranged from 900 kg (19% of TDN available per farm) in the intensive areas to 2900 kg (51%) in the extensive area in 2004 (Chapter 4, Figure 2). So, in all four study sites CPR played a major role in the maintenance of the herds. The herds in the extensive area were generally weak and the calving rates of local cattle and Jersey crossbreds were all below the calving rates needed to maintain the herds (Chapter 3, Figure 2). Other studies also mention that the majority of the cattle are underfed and that the CPR are heavily overgrazed in most of the areas (Dorji 1993; Moktan et al. 2008).

Although, in the intensive areas with a majority of crossbred animals, the farmers rely much less on CPR than in the extensive and semi-intensive areas, the use of CPR will continue to be an important feed resource for dairy farmers all over Bhutan. The government is recognizing this and has committed itself to allow the use of CPR for cattle grazing in the 12th five year plan (2018-2023) (DoL 2017b).

An emerging challenge on the use of CPR for livestock is the local cultural practice of *tshethar* by animal welfare groups, wherein they buy unproductive animals, such as yaks, cattle, goats, that were bound to be slaughtered, and then release them into the forest. Such practices contribute to forest overgrazing and diseases outbreaks. To address these issues the DoL has drafted a *tshethar* guideline, wherein animals procured for *tshethar* will have to have a certificate of vaccination against notifiable diseases in Bhutan, such as foot and mouth disease and anthrax, and have to be housed and fed properly by a caretaker and cannot be released into the forests (DoL 2017a).

Studies on limiting factors in smallholder cattle systems generally conclude that only small step feed improvements are possible (Owen et al. 2012). It seems that the same conclusion is valid for Bhutan. More high quality feeds are required to increase milk production and herd fertility levels. In the intensive and intensive peri-urban areas concentrates were the second most important providers of TDN (Chapter 4, Figure 2). Bhutan currently has four commercial feed mills; their main customers are the government farms and poultry and pig farmers. Therefore advocating the feeding of commercial concentrates may not be a feasible option, given the costs involved and their poor accessibility, but feeding some locally made compound feeds (based on buck wheat husks and bran and turnips for milking cows may be a possibility (Chapter 3).

Acute feed shortages are mainly experienced in winter in the temperate areas. To address this, there is a need to integrate forage production in the cropping and horticulture systems. Turnips are an option; these are partly used as vegetable and partly as winter feed for livestock. Oat (*Avena sativa)* is promoted as a winter fodder for cattle in some of the temperate areas. A temperate pasture mixture consisting of cocksfoot (*Dactylis glomerata*), Italian ryegrass (*Lolium multiflorum*) and white clover (*Trifolium repens*) proved to be successful in the temperate environment at elevations of 2300-3100 m asl (Wangchuk and Dorji 2008). However, the limited land holdings have been the main impediment to upscale these innovations.

Agroforestry, the integration of trees and agriculture, has been traditionally used in Bhutan and accounts for about 20% of fodder requirements especially in the sub-tropical and tropical areas (NFFDP 2006; Samdup et al. 2013). While there are lots of tree fodders grown in the sub-tropical and tropical areas of Bhutan there is a dearth of fodder trees in the temperate areas. According to Roder (1992) options for temperate areas in Bhutan are willow trees (*Salix babylonica*) and oak trees (*Quercus semicaroifolia* and *Euonimus spp)*. Willow is the only fodder tree planted by farmers and its use is limited as farmers mention that animals do not consume it readily. Roder (1992) and Smith et al. (2014) concluded that willow trees should be valued as a multifunctional land use approach that balances the production of commodities (food, feed, fuel, live fencing) with non-commodity outputs such as environmental protection (protection of river banks, prevention of soil erosion), and cultural and landscape amenities.

6.4 GNH: Future Prospects

Bhutan will continue with its implementation of the GNH concept. GNH-oriented policies have initiated many development projects in the areas of tourism, agriculture and hydro-power (Hoy et al. 2016). Whether or not GNH has been the major driving force for its development cannot be said for certain, but compared to most other countries in the South Asia region, Bhutan is performing relatively well in the international indicators (Hoy et al. 2016). In the 1980s, Bhutan's GDP per capita was one of the lowest in South Asia, now it has the highest GDP. In 2015, the following GDPs per capita in nominal values in current US$ were determined: Bhutan 2843, India 1617, Bangladesh 1287 and Nepal 751; these countries ranked 129, 144, 154 and 168 respectively amongst 195 nations (IMF 2016). The present HDI (Human Development Index) of Bhutan is more or less comparable to its neighbouring countries in South Asia. In 2015, the following HDIs were determined: Bhutan 0.607, India 0.624, Nepal

0.558, Bangladesh 0.579; these countries were ranked 132, 131, 144 and 139 respectively out of 188 countries (HDR 2016).

Figure 2 shows how results of the integral assessment can be communicated with policymakers and other relevant stakeholders. This assessment shows that two of the main challenges in the implementation of the GNH concept in rural areas are the decline in the societal indices in 2015 compared to 2000 and 2004 and the need for equitable socio-economic development. The 2015 indicator and index results (Chapter 5, Table 9) show that the main societal problems in all areas are the increases in the indicators for rural-urban migration and farm labour shortage. These issues are strongly related. To at least arrive at the medium index scale the *farm labour shortages* should considerably reduce from the present 23 (extensive area), 17 (semi-intensive area) and 36 (intensive area) percent of all households experiencing farm labour shortages to at the most 15 percent. *Rural-urban migration* in 2015 varied from 12% in the intensive area to 23% in the semi-intensive area. These percentages should be reduced to at the most 10 percent to get them in the medium sector (Table 4). These changes will be very difficult to achieve. Farm labour shortages are mainly experienced in crop farming, but do also occur in livestock keeping. Rural-urban migration is a general problem in Bhutan. Addressing this requires political commitment by making farming and in general rural life more attractive. Initiatives to reduce rural-urban migration include improvement of farm road connections to a main road and basic facilities such as hospitals, schools and transportation facilities (power tillers), income generation programmes and easier access to credit facilities.

The economic indicators and the economic indices were the lowest in the extensive area. In this area *annual income*, *farm GM* and *off-farm income* were in the medium sector, whereas *milk yield per cow* was in the poor sector. In Chapter 3 it was shown that crossbreeding was not much practiced in the extensive area in the early period of this research, however, the 2015 data show that crossbreeding is gradually increasing in this area. Crossbreeding could contribute to reducing rural-urban migration and increasing milk yields and farm income, but then it should not be limited to only providing exotic semen or exotic breeding bulls. Critical government interventions that need to be strengthened in close collaboration with the farmers include dairy farm group formation, product diversification, processing and market research, health services and credit facilities. In east Bhutan (where the extensive area is located) a project is initiated called Commercial Agriculture and Resilient Livelihood

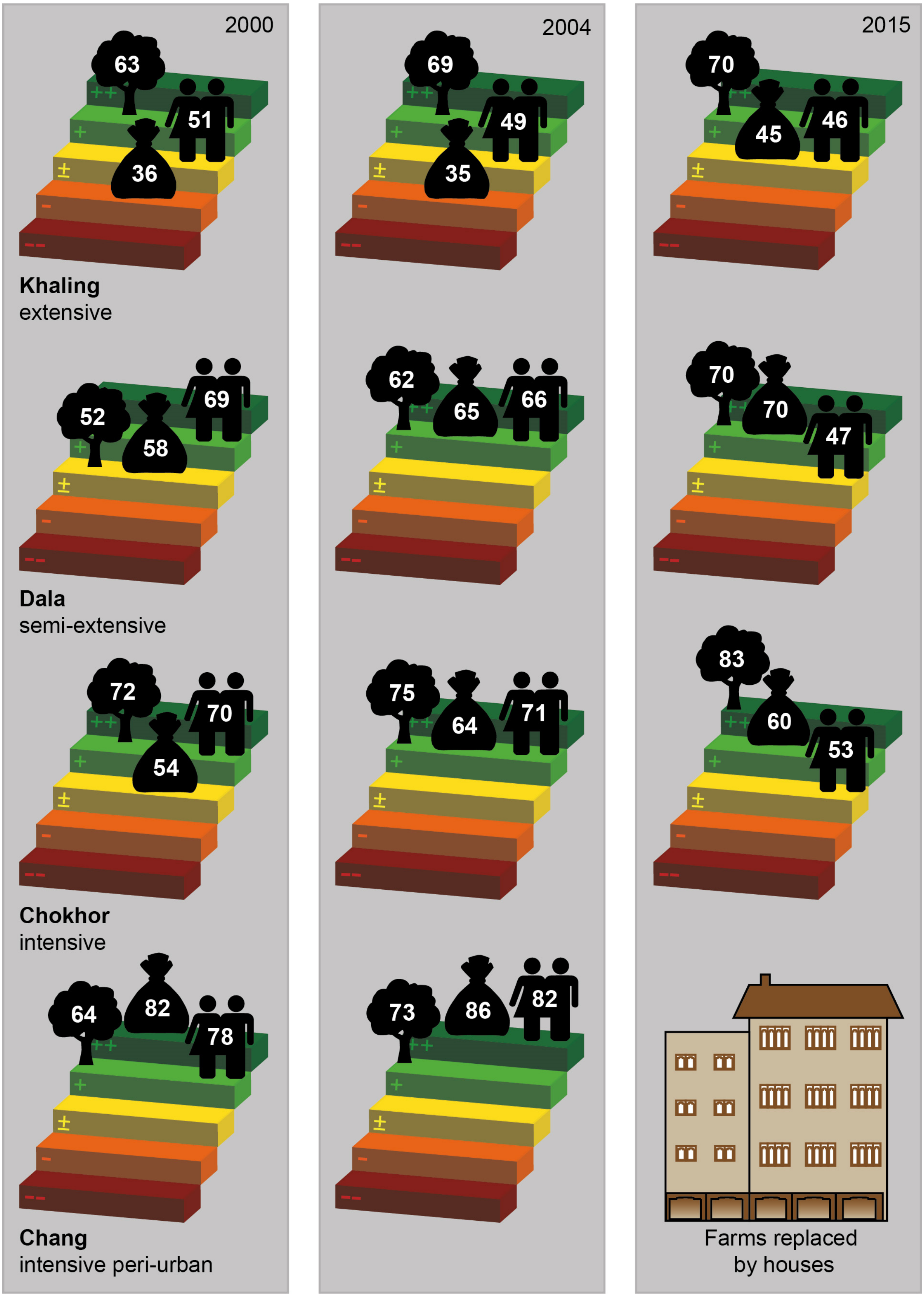

Figure 2. Integral assessment of index values of the societal, economic and environmental indicators per study area for 2000, 2004 and 2015

Enhancement Programme (CARLEP), wherein provisions are incorporated for developing infrastructure such as milk collection centres, market outlets, artificial insemination and supply of breeding bulls, along with training on cattle husbandry and clean milk production practices (DoL 2013). So, crossbreeding is expected to increase in future. Dairy products can be marketed in the nearest urban area of Trashigang town.

A striking finding was the stagnant economic situation in the intensive area, whereas the economic indices in the extensive and semi-intensive areas gradually improved between 2000 and 2015. There is hope for more interventions in dairy development as in the 12th five year plan (GNHC 2016) there will be more focus on strengthening and consolidating existing farmers' groups and supporting emerging groups on dairy in this area. Smallholder farmers operating in groups are able to help each other through volume of supply and therefore marketing advantages and also exchange of knowledge and experiences, and through the increased bargaining power in the purchase of inputs. Consumers are also benefiting from dairy farmers groups through steady supply of farm products (Wangchuk and Dorji 2008; DoL 2016).

There are no large-scale commercial dairy farms in Bhutan. The promotion of dairying is exclusively aiming at improving the livelihoods of the smallholder farmers and has to contribute to the GNH objectives and so, to equitable socio-economic development.

6.5 Conclusions

- The GNH (Gross National Happiness) development philosophy is widely discussed at different hierarchical levels, however, more efforts are required to address and incorporate the concerns and issues of smallholder farmers who comprise over two-thirds of the Bhutanese population. Farmers consider equitable social and economic development as their main concerns. Environmental preservation has high priority at national level.
- A practical implementation of GNH for rural areas is cattle crossbreeding for dairying because it increases livestock GMs, reduces cattle grazing on CPR (Common Property Resources), and it might have potential for reducing rural-urban migration.
- The proportion of crossbred cattle in the total cattle population is slowly increasing, however, the adoption of crossbreeding varied strongly between areas with high percentages of crossbred cattle in intensive

areas and low percentages in the extensive area. Favourable conditions for adoption of crossbreeding were support by projects, functioning farmers' groups, access to urban markets and access to AI and extension services. Farmers in the intensive areas find livestock intensification through crossbreeding attractive as a source of regular and reliable income.

- CPR will remain an essential resource for cattle feeding, also for farms with crossbred cattle.
- Maintaining the momentum of crossbreeding is challenging. Poor functioning of the AI services contributes to the overall slow increase in the crossbred cattle population. The current breeding practices are unsystematic. Farmers are mainly choosing pure Jersey or Jersey 75% crossbred semen or breeding bulls. *Inter se* mating of crossbreds might be the most practical breeding strategy to prevent upgrading to too high levels of Jersey crossbreeding.
- Crossbreeding has not been able to reduce the gap between supply and demand of dairy products; Bhutan will continue to be dependent on imports of dairy products from India.
- Main societal problems in all areas are rural-urban migration and farm labour shortage. Economic indicators were the lowest in the extensive area, although the economic indicators and indices gradually improved in this area between 2000 and 2015, just as in the semi-intensive area. The economic index did not increase between 2004 and 2015 in the intensive area. There were no major changes in the environmental indices within the research areas in the period 2000-2015.
- The present methodological approach based on participatory identification of societal, economic and environmental issues and indicators along with reference values for selected indicators coupled with an integral assessment using societal, economic and environmental indices, can complement the implementation of the GNH philosophy in rural areas in Bhutan. This can best be done in a five year time frame coinciding with the five year planning process of the government.

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Summary

Gross National Happiness (GNH), the overarching development philosophy of Bhutan, comprises of four pillars: sustainable and equitable socio-economic development, environmental preservation, preservation and promotion of culture and promotion of good governance. A major challenge is to translate it into reality, in particular in rural areas. About two-thirds of the Bhutanese population are smallholder farmers growing crops and keeping livestock. Cattle are the most dominant livestock, with over 78% of the rural households owning cattle. Intensification of livestock production through crossbreeding for dairying is a major GNH development effort, which aims at enhancing rural livelihoods, meeting the increasing demand for livestock products and reducing the impact of cattle grazing on common property resources (CPR), in particular the forests. Bhutan's large variation in altitude, climate and market access is expected to affect the possibilities for crossbreeding. Before 1998, for example, crossbreeding local Siri cows with Brown Swiss or Jersey bulls or semen was promoted only in areas with suitable agro-ecological conditions. From 1998 onwards, farmers were allowed to choose their desired cattle breed irrespective of the agro-ecological conditions.

National and international conferences on GNH have emphasized the need for its operationalisation by way of practical indicators and the development of practical policies. The Centre for Bhutan Studies uses 33 indicators to build a GNH index, which reflects the development of the degree of happiness of people across the country. There is a need to have a methodology to derive issues and indicators which are important for farmers. The objective of this study was to evaluate whether crossbreeding of dairy cattle has benefited farmers from a GNH perspective across time and space.

As the potential for crossbreeding is expected to differ across agro-ecological zones, four geographical areas of Bhutan were selected: the Khaling area representing Bhutan's extensive farming systems characterised by mainly Siri cattle, grazing CPR with some night feeding, and poor market access; the Dala area representing the semi-intensive farming systems with Siri and crossbred cattle, grazing CPR and stall-feeding, and medium market access; the Chokhor area representing the intensive farming systems with mainly crossbred cattle, mainly stall-feeding, and good access to markets; and the Chang area representing intensive peri-urban farming systems with mainly crossbred cattle,

stall-feeding, and good access to the market in the capital Thimphu. In 2000, in each area participatory field workshops with farmers and other stakeholders were organised to select issues at farm level. In total 120 farmers and 28 other stakeholders participated in the field workshops. Data on households, and cropping, livestock and off-farm activities were collected by trained enumerators through interviewing 183 households in 2000 and 2004. In 2015 only 123 of the same households in the extensive, semi-intensive and intensive areas could be visited; the other households had migrated to other areas or had given up farming as rearing of livestock was no longer permitted in the intensive peri-urban area from 2010 onwards. In 2002 a national workshop with 20 experts, farmers' representatives, and livestock, agriculture and forestry extension officers was organised to select issues and their indicators for developing a pragmatic methodology to study major temporal and spatial trends in development in rural areas.

Chapter 2 presents the participatory methodology to identify GNH issues which are important at farm level. Socio-economic development was identified as the top concern by all stakeholders in the four study areas; this was followed by environmental preservation. Issues for the other two GNH pillars remained rather vague for the farmers. It was found that the indicators used for the GNH index do not address several of the relevant issues at farm level. Most of the identified issues were experienced in all four study areas, however, their levels of intensity varied, depending for instance on access to markets and services. It was decided to separate the socio-economic GNH pillar into societal and economic issues, because these need to be addressed explicitly.

Chapter 3 addressed technical and economic performances of the livestock sub-system and the whole farm system in the four areas in 2000 and 2004. Herd compositions reflected the initial policy of promotion of crossbreeding in areas with suitable agro-ecological conditions, as well as the preferences of the farmers for specific cattle types. The change in livestock breeding policy in 1998 had no apparent impact on the breed composition of the herds. Crossbred cows had 2.4–4.6 times higher milk off-takes than local cows. The livestock gross margins were 1.4–2.4 times higher in the intensive than in the semi-intensive and extensive areas. It was concluded that crossbreeding has contributed to the higher livestock gross margins in the intensive areas. However, crossbreeding has not yet been able to reduce the gap between supply and demand of dairy products in Bhutan.

Chapter 4 was stimulated by the concern that farmers need to sustainably use natural resources. It evaluates feed availability, use of CPR and the flows of macro nutrients at farm level in the four study areas. In the extensive and semi-intensive areas, CPR was the most important source of total digestible nutrients for cattle. Even in the intensive area with a high proportion of crossbred cattle, CPR still met about one quarter of the feed requirements. Feed resources in the extensive area did not meet the nutrient requirements of the cattle kept. Grazing in the CPR provided the majority of the nutrient inputs at farm level. In the intensive and intensive peri-urban areas concentrates and conserved fodders partly replace farm nutrient flows from CPR. It was concluded that CPR will remain an essential resource for cattle feeding, also for farms with crossbred cattle.

The objectives of Chapter 5 were to refine the GNH concept to farm level and to show major temporal and spatial trends in development in the four study areas over the period 2000-2015. Participatory methods were used for selecting the most relevant societal, economic and environmental issues and associated indicators at farm level from the technical, societal, economic and environmental data collected in the three monitoring years. Next, the assessed indicators were standardised by establishing a performance value range for five performance categories of each identified indicator. The standardised indicators were aggregated to an economic, societal and environmental index to communicate progress in GNH development in the four areas. The selected societal issues were rural-urban migration, farm labour shortages, literacy rate, access to piped drinking water and household living standard. The economic issues were annual income, farm GM (gross margins), off-farm income, milk yield per cow per day and GM livestock per LU (livestock unit). The environmental issues were excess LU reared, livestock CPR grazing practices, soil N balance, soil P balance and soil erosion on crop land. The associated indicators for these issues were assessed for 2000, 2004 and 2015. In 2000 and 2004 the intensive peri-urban area showed the highest performance for the economic and societal indicators. In 2010, livestock farming was prohibited in this area, despite its potential for dairying. The dynamics in the indicators in the other three areas indicated that the societal and economic indices were the highest in the intensive area followed by the semi-intensive area and the extensive area in all three monitoring years. This could partly be attributed to the differences in implementation of crossbreeding in these areas. In the period 2004-2015, the societal index declined in the semi-intensive and intensive areas, which could be attributed to an increase in rural-urban migration and farm labour shortages.

There were no major changes in the environmental indices within the research areas in the monitoring periods.

Chapter 6 discusses core aspects of the methodology to evaluate GNH development at farm level, and the future of crossbreeding and the GNH concept. The developed methodological approach can complement the implementation of the GNH philosophy in rural areas. It may re-enforce more awareness amongst policy makers and other stakeholders to address pertinent GNH issues at the farm level, while keeping in mind the national level issues. Favourable conditions for adoption of crossbreeding were support by projects, functioning farmers' groups, access to urban markets and access to AI and extension services. Factors which discouraged farmers to take up crossbreeding were the risks related to an unfavourable environment, in particular in remote areas, with no easy access to inputs such as artificial insemination (AI) and extension services, and also the inability to feed the animals properly. Maintaining the momentum of crossbreeding is challenging. Poor functioning of the AI services contributes to the overall slow increase in the crossbred cattle population. The current breeding practices are unsystematic. The integral assessment shows that the main challenges in the implementation of the GNH concept in rural areas are the increases in rural-urban migration and farm labour shortages and the need for more equitable socio-economic development.

Acknowledgements

This PhD journey has been long but rewarding. I savour those moments that culminated to this thesis. I have frequently been informed by my colleagues that my PhD thesis was rather ambitious; it covered four different agro-ecological areas over three temporal dimensions in 2000, 2004 and 2015. I must admit that I could take upon these challenges only with the whole hearted support and critical guidance of my promotor and co-promotor from the Animal Production Systems group of Wageningen University & Research.

I would like to express my sincere gratitude to the visionary guidance and whole hearted support by Prof. Imke de Boer and Prof. Akke van der Zijpp. To Prof. Imke de Boer, your constant encouragement and guidance have been the key determinants to the completion of this thesis. I would like to re-iterate that your intellectual leadership, scientific rigor and supervisory skills have truly inspired and motivated me. I would like to mention that dr Henk Udo's pivotal role as my co-promoter, teacher, guide and friend need to be explicitly highlighted. I was dr Udo's student during my MSc programme at Wageningen University and his valuable guidance greatly enabled me to pursue my career in a competitive world. Further, his consent to guide me through the PhD was phenomenal. Though dr Henk Udo experienced several health and domestic related inconveniences during the PhD supervision programme, he continued to provide time, guidance and personal perseverance to me, without which the completion of this thesis would have still remained a distant dream. The result of this thesis aims to provide empirical information to enable policy makers and relevant stakeholders to make informed decisions for the development of smallholder farmers.

I would like to also acknowledge the valuable comments and support of many persons associated with my thesis from the Animal Production Systems group, especially dr Eddie Bokkers, dr Karen Eilers, Prof. M.N.M Ibrahim, dr Simon Oosting, Mr Theo Viets, dr Wiebe Koops and to many of my PhD colleagues. To ing. Mrs. Fokje Steenstra, who also co-supervised my MSc thesis, a special thanks to you for all your suggestions to the various chapters and also for the support in formatting the thesis for printing. My sincere thanks go to Ms. Ymkje Tamminga for organising my stay in The Netherlands and assisting me meticulously with the various administrative formalities.

I would like to convey my thanks to dr Bill Thorpe, Prof. Mike Grossman, dr René Kwakkel, Mr. Jan Roest, Mrs. Jannie Roest, ir Nico van Wageningen and Gitti for their warm friendship and unfailing support. Thanks are due to Doortje Udo, dr Hans Schiere and Rinske Schiere for their support and to my Dutch friends Ymke Koperberg and Thijs Wissink who have been very supportive.

Back at home, in Bhutan, I am extremely indebted to the Chairperson and Commissioners of the Royal Civil Service Commission (RCSC) of Bhutan, and to the Honourable Minister and Secretary, Ministry of Agriculture and Forests and to all my colleagues from the erstwhile Council of Renewable Natural Resources Research of Bhutan (CoRRB). Thanks to Mr. Namgay Dorji and dr Kesang Wangchuk and all my colleagues in the Department of Livestock for all their support which enabled me to synchronize my study without compromising any of our official job responsibilities till date. Further, the field work in Bhutan would not have been possible without the dedicated technical and logistic support from many of my field colleagues. I am confronted with the fact that I cannot acknowledge all individually by names, but I will do it personally.

As my PhD study comes to an end, I feel relieved and satisfied, but I also reminiscence the sacrifices that my near and dear ones have made for me. My family provided a constant source of inspiration throughout these years, and I especially need to thank my mother, my wife Gem Lham who is also my best friend, and my children Palden, Kalden, Lhaki and Dechen Samdup for their support and sacrifices.

Last but not the least, I would like to express that this thesis is also a small tribute to Bhutan’s pursuit of Gross National Happiness. I thank all the farmers in the four study areas for accepting me in their midst during my field visits, for their hospitality, cooperation and for providing me the opportunity to learn more about the intricacies of their farming systems, so as to contribute in a small way to pave a path for a better tomorrow for smallholder farmers.

Thimphu (Bhutan)

Tashi Samdup

About the author

Tashi Samdup was born on September 1, 1967 in Thimphu, Bhutan. He obtained the BVSc & AH degree from Kerala Agricultural University, India in January 1991 and the MSc degree in Animal Science with distinction from Wageningen University, The Netherlands in January 1997 and was also honored with the Professor Henk Van der Plas Award for the most outstanding MSc thesis.

Tashi's professional working career started as a civil servant for the Royal Government of Bhutan in April 1991 and till April 2000. He worked in the field in Bhutan in different capacities, such as Veterinary Surgeon; Veterinary Parasitologist; Manager of the National Brown Swiss and Horse Farm; Officer in-charge of the National Jersey Breeding Centre. From 2003 till September 2007, he worked as the Chief Livestock Officer of the Livestock Production Division, Department of Livestock (Directorate) in Thimphu. During this period he was also a member of the European Commission livestock project formulation team and member of the Government of India livestock project formulation team.

In October 2007, he was selected though the national open competition by the Royal Civil Service Commission (RCSC) as the Director of the Council for Renewable Natural Resources Research of Bhutan (CoRRB). Besides, his given terms of reference as Director of CoRRB, he held additional responsibilities; some of which were: Board Director to the Druk Seed Corporations of Bhutan, SAARC Focal Person on the Technical Committee on Science and Technology, Board Director to the Bhutan Development Bank Limited, and Chairperson of the Board of Directors of Bhutan Agro-Industries Ltd. In the international arena he was the Executive Committee member to the Asia Pacific Association for Agriculture Research Institutes ARAARI) and the Permanent Representative of Bhutan to the World Meteorology Organization.

From October 2013 till date he has been serving as the Director General of the Department of Livestock in Thimphu. During this period, besides serving as a board Director of several organizations in Bhutan, he was the Chairperson of the Animal Production and Health Commission of Asia & Pacific (APHCA) based in Bangkok from January 2014 till February 2015 and is the Permanent Delegate of Bhutan to the OIE (World Organization for Animal Health) from

November 2013 till date. More recently he was elected as the Chief Veterinary Officer (CVO) of the SAARC region during the 6th SAARC CVO's meeting in April 2017 in Thimphu. He was also elected as the Vice President of the OIE Regional Commission of the OIE for Asia, the Farm East and Oceania during the 85th Session of the General Session of the World Assembly of Delegates of the World Organization for OIE in May 2017 in Paris.

Tashi's research interest includes farming systems analysis and related domains such as animal production, animal health, socio-economics and livestock bio-diversity.

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Publication list

Articles in peer reviewed scientific journals

Samdup T., H.M.J. Udo, and A.J. van der Zijpp. 2014. A participatory framework to identify Gross National Happiness issues for the development of smallholder mixed farming systems in Bhutan. Asian Journal of Agriculture and Development 11 (1): 1-20.

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Cannon P.F., L.H.J. Nigel, N. Maczey, L. Norbu, Tshitila, T. Samdup, and P. Lhendup. 2009. Steps towards sustainable harvest of *Ophiocordyceps sinensis* in Bhutan. Biodiversity Conservation 18: 2263–2281.

Abstracts in conference proceedings and other publications

Samdup T., and N. Wangchuk. 2014. Dairy farming in Bhutan: The achievements, challenges and future potentials. Paper for discussion at the regional workshop on breeding for milk production in tropical/non-temperate environments, Chiang Mai, Thailand, 3-7th November 2014.

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Samdup T. 2010. Options and opportunities in crop, livestock, fishery and agro-industries to face the challenges of food insecurity and climate change. Technical conference on agricultural biotechnologies in developing countries, Guadalahara, Mexico, 1-4 March 2010.

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Samdup T. 1997. The performance of Brown Swiss crossbred types & the impact of crossbreeding at farm level in Bumthang, Bhutan, MSc Thesis, Wageningen University, Wageningen.

Samdup T. 1994. Gid disease in Yaks in Bhutan. Journal of Animal Husbandry Vol.1, 1994, Thimphu, Bhutan.

Completed training and supervision plan[1]

Basic package (11.1 ECTS)

- WIAS Introduction course, Wageningen (2001)
- Supervisors training programme, Queensland University of Technology (2009)
- Bhutan Executive Services Training (2016)

International conferences (14.7 ECTS)

- Animal Science Congress, AAAP, Kuala Lumpur, Malaysia (2004)
- APAARI, Suwon, Republic of Korea (2010)
- Global Conference on Women in Agriculture, New Delhi, India (2012)
- General Assembly OIE, Paris, France (2014)
- International conference on Yak, Lanzhou, China (2014)
- General Assembly OIE, Paris, France (2015)
- Global conference on Biological Threat Reduction, Paris, France (2015)
- Global Elimination of Dog-Mediated human Rabies, Geneva, Switzerland (2015)
- General Assembly OIE, Paris, France (2016)
- Global conference on Animal Welfare, Guadalajara, Mexico (2016)
- General Assembly OIE, Paris, France (2017)

Seminars and workshops (14.1 ECTS)

- Inception Workshop, Bangladesh Livestock Research Institute and FAO (2003)
- FAO Regional TCP Project National demonstrations (2004)
- SAARC conference on science, ICAR (2008)
- Seminar, Royal Civil Service Commission and SNV (2008)
- International symposium on climate change and food security in South Asia (2008)
- Consultation Meeting, SAARC Agriculture Centre (2010)
- Inception Meeting, ICIMOD (2010)
- International Workshop, WMO and FAO a.o. (2010)
- APAARI General Assembly (2010)
- HKH-HYCOS Regional Steering Committee Meeting (2010)
- Expert Consultation, APAARI (2011)
- FICCI & NESTLE Meeting (2012)
- ICAR-APAARI Expert Consultation (2012)
- General Assembly, APAFRI (2012)
- International Symposium, ITTO (2012)
- Network Meeting, SATNET Asia (2013)
- High-Level Policy Dialogue, SATNET Asia (2013)
- Bhutan Symposium, Columbia University (2013)
- Meeting of the Thailand-Bhutan JAWG (2014)
- Dairy Asia Writeshop (2015)

Presentations (8 ECTS)

- SAARC Regional Conference, Islamabad, Pakistan (2012)
- Dairy Asia meeting, Bangkok, Thailand (2015)
- Dairy Asia meeting, Saraburi, Thailand (2016)
- SAARC Chief Veterinary Officers Meeting, Nagarkot, Nepal (2016)
- One Health Economic and Policy Regional Workshop South Asia & Thailand (2016)
- FAO APHCA/OIE regional workshop antimicrobial resistance in Asia Pacific (2016)
- Sub Regional GF-TAD meeting for South Asia (2017)
- SAARC Chief Veterinary Officers Meeting (2017)

In-depth studies (11.1 ECTS)

- Livestock- Environment Interaction, Wageningen, The Netherlands (2002)
- WIAS Advanced Statistics Course: Design of Animal Experiments (2000)
- Training course on Basic GIS and Remote Sensing Training for Natural Resource Management, Thimphu, Bhutan (2013)
- Basic Database Course on Access 2000, Digital Shangrila, Thimphu, Bhutan (2003)

Professional skills support courses (7.2 ECTS)

- Techniques for Writing and Presenting a Scientific Paper, Wageningen Graduate Schools, The Netherlands (2005)
- Training on Statistical Analysis using SPSS and End Note Programme, CoRRB, Bhutan (2010)
- Training Seminar in EC Procurement and Payment Procedures, Bhutan (2005)
- Didactic skills course, Wageningen University, The Netherlands (1996)
- FAO High-Level Policy Learning Programme: Addressing long-term development challenges from short – lived interventions to lasting achievements FAO, Italy (2011)
- Corporate Governance Training at AIT, Thailand (2012)
- Dairy Asia: Writeshop, Thailand (2015)

Research skills training (12.6 ECTS)

- Preparing own PhD research proposal (2001)
- Advisor to the Bhutan Journal of Animal Sciences (2017)
- Asia-Pacific workshop on surveillance, prevention and control of zoonotic influenza, Paro, Bhutan (2016)
- Consultative training on Veterinary services cum workshop, Chukha, Bhutan (2016)
- Local supervisor in Bhutan for 2 MSc students of APS, Wageningen, The Netherlands (2004-2006)
- Local supervisor in Bhutan for 2 PhD students of Charles Stuart University, Australia (2011-2016)

Management skills training (7.4 ECTS)

- Advisory Board Member to the Ugyen Wangchuk Institute of Environment Sciences, Bhutan, May 2009 – Jan. 2013
- Board Director to the Druk Seed Corporations of Bhutan from Oct. 2007 – Dec. 2011
- Interim Permanent Representative of Bhutan to the World Meteorology Organization, Feb. 2008 – Sep. 2012
- Chairperson of Board of Directors of Bhutan Agro-Industries Ltd, Jul. 2010-Jun. 2012
- Permanent Delegate of Bhutan to the OIE, Nov. 2013 till date
- Chairperson of the World Food Day Celebration in Bhutan, Aug. 2011 – Oct. 2013
- Board Director of National Water Resources Board of Bhutan, Sep. 2011–Oct. 2013
- SAARC Focal Person on Technical Committee on Science and Technology, Feb. 2009 – Nov. 2013
- Executive Committee member to the Asia Pacific Association for Agriculture Research Institutes (APAARI), Bangkok. Oct. 2012 – Dec. 2013
- Board Director to the Bhutan Development Bank, Sep. 2010 – Mar. 2014
- Chairperson of Audit Committee of Bhutan Development Bank, Jan. 2011- Mar. 2014
- Chairperson of Animal Production and Health Commission of Asia & Pacific (APHCA), Bangkok, Jan. 2014 – Feb. 2015
- Board Member of the Bhutan Medicines Board, Feb. 2014 till date
- Board Member of Bhutan Ecological Society, Jan. 2014 till date
- Chairperson of Koufiku Dairy International Limited, Druk Holding Investment, Royal Government of Bhutan, Mar. 2017 till date
- Chairperson of Bhutan Livestock Development Corporation, Royal Government of Bhutan, Apr. 2017 till date

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Total: 86.2 ECTS

[1]With the activities listed, the PhD candidate has complied with the requirements set by the Graduate School of Wageningen University of Animal Sciences (WIAS). One ECRS equals a study load of 28 hours.

Colophon

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Cover design by Fokje Steenstra. Pictures were taken by Choidup and Namgay Dorji.
Front cover: The background picture is the campus of the Tashi cho Dzong (fortress) area in Thimphu, the capital city of Bhutan. This area houses many government Ministries and Departments. The scenic background and architectural aspects of the houses gives an indication of the Gross National Happiness (GNH) concept, wherein environmental conservation and cultural preservation are vital tenets of the GNH concept. The picture of the crossbred cattle refers to the fact that Bhutan is still largely agrarian, wherein livestock plays a vital role for the rural livelihoods. The introduction of crossbreeding policies has enabled farmers to rear adapted crossbred cattle, which has resulted in enhancing farmers income and is also contributing to reduced overgrazing of the fragile land resources.
Back cover: This picture shows that as a result of rearing crossbred cattle, the milk production has increased and with the enhanced volume of milk production, farmers now use improved technologies to process the milk into products in the remote areas of Bhutan.

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