Intensification of smallholder livestock production, is it sustainable?

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ABSTRACT: This paper discusses sustainability perspectives of intensification of different types of smallholder livestock production. A main sustainability issue of intensification is its contribution to household incomes. Smallholder dairying substantially increases incomes, despite pressing technical sustainability issues. Trade-offs are that it is not an option for the really resource-poor households, and its impact on different environmental and societal sustainability issues. Intensification of small animal systems appears to have a low potential to substantially increase incomes. Livestock intensification strategies have to meet the environmental and societal demands.

Key words: intensification, livestock, smallholders, sustainability, livelihoods, environment

INTRODUCTION

Worldwide, livestock production systems are rapidly changing. The increasing demand for animal source food is a major driving force for these changes. The growth in consumption of animal products in emerging and developing countries will remain strong, despite the present economic crisis. In these countries, increases in livestock production occur mainly outside the traditional rural sector (FAO, 2005), at the same time, large numbers of smallholders keep livestock in support of their livelihoods. Many countries promote the intensification of livestock production to meet the increasing demands and to reduce imports of livestock commodities. Countries are not only supposed to be concerned about the increased demands of the wealthier consumers of animal foods, they are expected to remain committed to poverty alleviation too. It is expected that the increase in demand for animal foods can help smallholder crop-livestock farmers to engage in market-oriented economic activities and that this can help them to improve their livelihoods (Delgado et al., 2001).

Intensification, the increased use of inputs and services to increase the output quantity and/or value per unit input, requires cash inputs. This does not fit the risk avoidance strategy of smallholders. It requires that smallholders have to become more market-oriented. This will lead to increased competition with other smallholders and with large-scale operators. Is it feasible for the poorer households to invest their scarce resources in more intensive livestock systems?

Livestock intensification is also promoted to reduce the environmental burden of livestock production (Steinfeld et al., 2006). Environmental challenges vary from exhaustion of resources to environmental pollution. At present, the impact of livestock on climate change is widely discussed. Steinfeld et al. (2006) state that reducing animal numbers, improving feed quality and increasing production levels are needed to mitigate detrimental effects of livestock on the environment. Reducing animal numbers interferes with the multiple objectives of smallholder livestock keeping. Livestock do not only produce food, they provide manure and draught power to support crop production, and they are a capital asset, in particular in areas lacking reliable financial institutions.

The potential benefits and trade-offs of livestock intensification place livestock on the sustainability agenda. Sustainability is defined in many different ways. In short, sustainable agricultural production has to be economically viable, ecologically sound and socially just, at farm, regional and global system levels. This paper discusses the sustainability perspectives of the current changes in smallholder livestock production. It draws on the results of case-studies on village poultry, integrated agriculture-aquaculture systems, small ruminants and dairy cattle in Ethiopia, Vietnam, Indonesia, India, Bhutan, and Kenya, respectively.

CASE STUDIES

Village Poultry

The majority of rural households keep poultry in their farmyard. In Tigray, Northern Ethiopia, Aklilu (2007) explored the role of village poultry, their marketing and consumption, and possibilities for their improvement. The main benefits derived from village poultry were income from sale of eggs and sale of birds, followed by egg and meat consumption in the family, and strengthened social relationships. Poultry were seen as a very important resource for the very poor. Female-headed households often only kept poultry, whereas male-headed households had a wider range of opportunities for earning income. Poultry development programmes generally focus on health interventions, housing, feed supplementation and crossbreeding. Households, however, are not adopting intensifying technologies widely. Innovations in village poultry can only be successful if they fit the limited physical and economic resources of the farming households (Aklilu, 2007).

In poultry, an alternative to village poultry is to apply industrial poultry keeping methods. In almost every country there are small- and medium-scale poultry units involving commercial hybrids, compound feeds and industrial poultry housing methods. Industrial poultry keeping systems have to be completely market-oriented. They are very vulnerable to macro-economic disturbances.

Integrated Agriculture-Aquaculture

SE Asia has a long tradition of integrated farming. The Mekong River Delta in Vietnam is an example of a region where many farmers have integrated rice with fruits, vegetables, pigs, poultry and fish in Integrated Agriculture Aquaculture (IAA) systems. Bosma (2007) and Phong (2010) studied production performances, ecological sustainability, and decision making on diversification in rice-based high input fish, rice-based medium input fish and orchard-based low input fish farms. Nutrient balances and Life Cycle Assessment (LCA) were used to quantify the environmental impact of farms and their components (Phong et al., 2010).

Economic liberalisation in 1986, the introduction of modern rice varieties, big floods, and increasing market demands were driving forces for agricultural diversification and intensification (Phong et al., 2007). Whether or not an individual household practised a specific component and integrated different components depended on, in decreasing order, available family labour, wealth status, land area, family situation and market prices (Bosma, 2007). Intensification of the different IAA components was based mainly on the use of external inputs. In particular, farmers with sufficient capital tended to intensify their farming practices. The use of inorganic fertilizers was the main intensification strategy for the crop components. The use of concentrates and hybrid pigs were major tools in intensification of pig production. The intensification level of the fish component differed between areas. The use of concentrates and culture of catfish were the intensification strategies for fish in areas with access to urban and international markets.

Small Ruminants

Small ruminant keepers often are among the poorer groups in society. Budisatria (2006) studied the dynamics of small ruminant production systems in Central Java, an area in Indonesia renowned for the quality of its small ruminants. Farmers referred to their small ruminants as a saving that provides security and helps to accumulate capital. Manure was the second reason for keeping small ruminants. Drivers of change in small ruminant systems acted at national, regional, agro-ecosystem and household levels (Budisatria et al., 2007a). Over a period of 80 years of small ruminant development, the number of small ruminants increased seven-fold. Intensification of small ruminants implied changes in breeds kept and in management systems. The intensification of land use resulted in declining grazing areas and less family members available for herding small ruminant flocks. The majority of small ruminants are now kept in confinement, or in a combination of grazing and confinement. Household resources, i.e. family labour, time and capital availability, were the major factors determining whether farmers kept small ruminants or not (Budisatria et al., 2007a).

Dairying

Crossbreeding for dairying is a major tool in intensification of cattle production. Samdup (1997) and Patil (2006) evaluated the impact of crossbreeding in mixed farming systems in Bhutan and Gujarat (India), respectively, by collecting data on household resources, inputs, outputs and internal resource flows of households with and without crossbred cattle. In India, governmental and non-governmental institutions promote dairy development to contribute to poverty alleviation. This started with the introduction of Jersey and Friesian crossbreds through artificial insemination, as well as training in feeding and management. In Gujarat, crossbreeding for dairying was introduced in 1985. In Bhutan, crossbreeding was stimulated by the 1985 breeding policy which promoted crossbreeding with Brown Swiss in high altitude areas and with Jersey in areas with relatively good market access, and using local breeds in remote areas that have harsh environmental conditions (Samdup et al., 2010).

Kenya is prominent for integrating dairying into smallholder farming systems, particularly in the highlands, where farmers mainly use European dairy breeds: Friesians, Ayrshires, Jerseys, and Guernseys. Bebe (2003) studied the consequences of intensification of smallholder dairying in the Kenya highlands. Here, about 60% of the rural households have integrated dairy in their mixed farming systems. Major drivers were colonial history, favourable agro-ecology, supportive agricultural policies, and the traditional value of milk in people's diet (Bebe et al., 2002). Farmers intensify their farming practices by shifting from free-grazing to semi-zero- or zero-grazing (stall feeding). The semi-zero- and zero-grazing farms already comprise over three-quarters of all smallholder dairy farms.

SUSTAINABILITY

Concept

In 1987, the World Commission on Environment and Development published Our Common Future, in which sustainable development is defined as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. Thereafter, many different definitions and interpretations of the concept of sustainability have been published. The interpretation of sustainable development also depends on the hierarchical level and the stakeholders involved. There is a strong pressure from society to adopt the concept. It has become a core element in government policies, development plans, corporate strategies and even research programs.

The definition of sustainable agriculture, agriculture that is economically viable, ecologically sound and socially just at different hierarchical levels, implies that there are three major dimensions of sustainable development: economic, ecological and societal. Sustainable agricultural development evokes concern that current farming practices endanger the continuity of agricultural production systems, the rural areas, and the planet as a whole. At the global level, it addresses global public goods such as greenhouse gas mitigation, biodiversity conservation, and poverty reduction. At regional and agro-ecosystem level, farmers provide products and services to meet the food, ecological and society demands. At farm level, however, farmers' main interest is securing their own livelihoods. Conflicting interests among public and private interests are a typical problem in developing sustainable development strategies.

Assessment of Sustainability

Sustainability is not a measurable entity in itself, most studies use sustainability indicators to characterize sustainable development. Cornelissen (2003) developed a stepwise approach to implement sustainability, including: delineation of the system or innovation concerned; identification of Ecological, Economic, and Societal (EES) issues; translating EES issues into measurable sustainability indicators; assessing the contribution of sustainability indicators to sustainable development; communication of results. This approach assumes stakeholder engagement in identifying the issues to be addressed. The use of relevant indicators and their data sources is a key aspect in assessing sustainable development. A sustainability indicator measures the current status of an EES issue for a production system or innovation. The contribution of a sustainability indicator to sustainable development is often subjective. Sometimes the estimate of an indicator is compared with a target value and results are presented graphically. There is no one sustainability indicator set that fits all agricultural production systems; what is and what is not sustainable depends on the agro-ecosystem and the social, cultural and political context. The sections below discuss economic, ecological, and societal issues and indicators of livestock intensification as experienced in the different case-study areas.

ECONOMIC ISSUES

Estimates of contributions of livestock to livelihoods in the case-study areas were based on the indicator ‘value added’ (revenues minus variable costs) plus estimates of ‘additional’ benefits (Bosman et al., 1997; Moll et al., 2007). Revenues included the value of marketed products and the opportunity values of home consumption, manure, and draught power. Additional benefits represent the money saved by a household in a herd or a flock as guarantee that future requirements can be met, equivalent to an insurance premium not required, and the expenses avoided by selling animals for urgent cash needs, i.e. saving of financing expenses incurred by engaging formal or informal agents.

The case-studies are not directly comparable with regard to the economic benefits of different livestock types, but they confirmed that there was a livestock ladder with the smallest economic benefits from village poultry, followed by small ruminants, pigs, fish, local cattle, and the largest benefits from dairy cattle. For Tigray, the benefits from sales and home consumption of poultry were estimated at around 70 US\$ y^{-1} per household (for 2003-04). Modelling of the impact of innovations showed that New Castle Disease (NCD) vaccination could double these benefits (Aklilu, 2007). The modelling showed that housing and supplementary feeding each could have a positive effect on technical parameters, but a highly negative impact on economic benefits. Crossbreeding had a negative effect on technical as well as economic results. Value added estimates for the IAA farms were on average, 900 and 1240 US y^{-1} for 2002 and 2004, respectively. The share of farm income was highest for rice (42 and 48%), followed by fruits (19 and 29%), fish (25 and 9%), pigs (8 and 17%), cash crops (4 and 10%) and poultry (2 and -8%) (Phong et al., 2007). In 2004, the returns for poultry were negative, due to the Avian Influenza (AI) outbreaks in 2003 and 2004. AI caused a considerable decrease in demand and in the prices for poultry products, whereas the demand and prices for fish and pork increased. The farmers showed their resilience by intensifying the aquaculture component and pig production. The AI outbreaks very much affected farmers that had specialised in poultry production. In Indonesia, the economic benefits from sheep and goats were small: 120-165 US\$ y^{-1}. Exploration of innovation scenarios indicated that if farmers can specialise in sheep fattening on the basis of rice bran supplementation or in goat breeding the technical and economic performance can be improved 1.3-2.2 times relative to current production systems (Budisatria et al., 2008). In both Gujarat and Bhutan, farms with crossbred cows used more external inputs for cattle and had higher outputs than farms without crossbred cows (Patil and Udo, 1997; Samdup, 1997). Consequently, in Gujarat estimates of value added by cattle were 1.6 times higher in households with crossbreds compared to households with local cattle (400 vs 243 US\$ y^{-1}), whereas, in Bhutan, crossbreeding had an even bigger influence on milk production and estimates of value added by cattle were 10 times higher in farms with crossbreds compared to farms with local cattle (1030 vs 107 US\$ y^{-1}). Bebe et al. (2002) estimated that the total benefits of dairying were, on average, 1073 US\$ y^{-1} per farm in the Kenya highlands, of which 56% was from non-market (home consumption, manure, and insurance and financing) benefits.

Labour productivity, the economic returns per unit of family labour, is another economic indicator. It reflects how efficient family labour is used for livestock. The case-study results showed that labour productivity of dairying, using European or crossbred stock, was higher than for crops or wage labour (Moll et al., 2007). Smallholder dairying is also competitive with large-scale dairy farms, as it uses family labour and has no high requirements for investments. The returns per unit of family labour from small animals were below the minimum labour wage. Some innovations in small animals showed potential to increase economic benefits, however, the returns to labour remained below the minimum labour wage. Farmers with sufficient household labour, however, do not consider the use of family labour as a production cost, because alternative employment opportunities are limited.

Another important economic issue for intensification of livestock production is to increase local production and to reduce imports of livestock commodities. In Kenya, the success of smallholder dairying is shown by the fact that dairy production has become the main farm income source for over 600,000 mixed crop-livestock farming households. The smallholders produce about 70 percent of the total milk production, and imports are decreasing (Noah and Waithaka, 2005). In Bhutan, however, the implementation of crossbreeding policies with smallholder farmers has not been able to reduce the gap between supply and demand for dairy products. Imports come from India, the country with 70 million smallholder dairy producers. In India, as in many other developing countries, the informal milk market has about 80% of the market share (Patil, 2006). This is the most economical way of milk marketing.

The conclusion that smallholder dairying has brought economic gains for the households involved does not mean that there are no constraints. The major technical sustainability issue is lack of good quality feed. Farmers usually mention this to be their major constraint. Population increases are causing intensification of land use, disappearing grazing areas and shrinking farm sizes, as a result ruminants have to rely more on crop residues and forage from road sides or other marginal lands. In Bhutan, India and Kenya, milk production levels were around 5-6 kg per lactation day (Samdup et al., 2010; Patil and Udo, 1997; Bebe, 2003). It seems that the feed resources available on smallholder mixed farms (some grazing in communal areas, crop residues from the farm and small amounts of local concentrates) can only support such production levels. In the Kenya highlands, the size of farms has decreased by more than half over the past two decades, mainly because of subdivision through family inheritance. This shrinking of land holdings is a major concern with regard to the continuation of current farming practices. The free-grazing farms are disappearing, but these farms produced replacement stock needed for the semi-zero- and zero-grazing, as these farms were unable to produce sufficient heifers for replacement, because of low calving rates and high calf mortalities. The availability of replacement stock is a general problem in smallholder dairying.

ECOLOGICAL ISSUES

Livestock can be a major stress factor on the environment: land degradation, soil mining and overgrazing in semi-arid areas, deforestation and loss of biodiversity in rainforest frontiers, involution of mixed farming systems in densely populated areas, and pollution of water, air and soils in industrial livestock systems. Soil nutrient balances are widely used as sustainability indicators. Industrial livestock systems usually show large nutrient surpluses, whereas , e.g. studies in Sub-Saharan Africa show alarming nutrient depletion rates (Stoorvogel, 2007). Livestock usually have a positive effect on nutrient balances and resulting crop production. They collect, through feed purchases and collection of roadside forages, convert and deposit nutrients, but manure alone is not sufficient to restore nutrient deficits. In Asia, fertilizer use seems to be higher than in Africa. The IAA farms in the Mekong River Delta showed substantial N (84 kg ha^{-1}) and P (73 kg ha^{-1}) surpluses, indicating that intensification of rice, fruit trees and vegetables resulted in accumulation of nutrients in soil pools (Phong, 2010). The crop-livestock farms in Bhutan also showed relatively large N and P surpluses (Samdup, personal communication).

In the discussion about greenhouse gas emissions by livestock it is suggested that intensification of the livestock sector will help to mitigate greenhouse gas emissions, as less greenhouse gas is produced per kg of intensively-produced animal product than per kg of product from an extensive production system (Steinfeld et al., 2006). The LCA of the IAA farms showed that the relation between livestock and the environment is complex. In the Mekong River Delta, the major tools for intensification are the use of fertilizers and concentrates. The fish component of IAA farms in the research areas differed in intensification level. The LCA results indicated that the environmental indicators land use, energy use, global warming potential, eutrophication potential, and acidification potential per kg fish were higher in the low input fish system than in the medium and high input fish systems, due to the small fish yields in the former. The differences in intensification level between the high and medium input fish systems, however, did not result in differences in environmental impacts per kg of fish produced. The medium input fish ponds were better integrated with the other farm components than the intensively managed fish ponds (Phong, 2010). The average global warming potential per kg protein was higher for pigs and poultry than from fish. Overall, rice (0.8 ha paddy per farm) and pigs (11 pigs per farm) were the biggest contributors to the environmental impact of food production in the Mekong River Delta. This was mainly due to excessive use of fertilizers and methane emission from the paddy fields and the off-farm impact of the production of concentrates or pigs (Phong et al., 2010). The contributions of pigs and poultry to land use, global warming potential, acidification potential and eutrophication potential per kg product were within or slightly larger than the ranges found in the literature for industrial pig and poultry keeping (Phong et al., 2010). The energy use per kg pig or poultry was relatively low compared to industrial systems. It was concluded that to reduce impacts per kg pig and poultry, pig and poultry production should become more productive. However, if this is achieved by feeding more concentrates, the off-farm impacts of growing and producing the feed ingredients will increase the environmental impacts again.

Intensification generally increases pollution per unit area. An example of pollution per unit area is the finding that in Central Java, the housing of small ruminants close to the family quarters resulted in very high levels of drinking-water contamination with faecal bacteria (Budisatria et al., 2007b).

Reduction of biodiversity and domestic animal diversity are also issues of environmental impact of livestock production. There is a wide range of biodiversity, c.q. agro-diversity, indicators at the levels of genes, species and ecosystems. This will not be discussed here. Domestic animal diversity is a sub-set of agro-diversity. Intensification often starts with replacing local breeds by crossbreds or European breeds. Crossbreeding can also have a positive effect on biodiversity. In Bhutan, one of the policy objectives of promoting keeping fewer but more productive crossbred cattle was to reduce grazing in forest areas. This has been successful to some extent, as crossbred cows are milked every day and graze less in the forest than local cattle (Samdup et al., 2010).

SOCIETAL ISSUES

In developed countries major societal issues are welfare and health of animals, zoonoses, and food safety. These issues determine very much the public debate and acceptance of current animal production systems in society. These issues will not transfer easily to animal production in developing countries. In these countries, a major social issue is that only a part of the smallholder mixed farmers, in particular the better-off farmers, is able to take advantage of the increased demands for livestock products. The social, cultural and capital asset functions of livestock will remain important for the poor households. So, many of the poorer households are likely to be excluded from the increased market opportunities. This will result in a reduction of the number of smallholder livestock farmers. Whether or not smallholder mixed farmers will opt out from livestock production will also depend on the opportunities for employment in other sectors.

In the Mekong River Delta, farmers were asked about their most pressing sustainability issues. Farmers scored societal issues more often than economic and ecological issues. Education of their children was the main social issue. Farmers did not want their children to become farmers. From investment in education they expected a good job opportunities for their children (Phong, 2010).

Intensification, through crossbreeding, can also have an effect on cultural practices. In Indonesia, Madura cattle are used in the *Karapan*, a famous traditional bull race in Madura Island, and *Sonok*, a contest of harmonious walking of two cows or heifers with accompanying traditional music, events. Since 2001, crossbreeding is allowed in Madura. Farmers in districts where the cultural events are still of importance are not motivated to start crossbreeding. In other districts crossbreeding with Limousin is introduced and a new cultural practice, judging the physical appearance of crossbred bulls, is replacing the traditional cultural events (Schultinga, 2010). Another example of the resilience of small holders.

DISCUSSION

Sustainability assessments are used to compare different products or production systems, or to estimate the impact of specific technologies, so providing information about success or failure of innovation or intensification strategies. The main issue of intensification of smallholder livestock production is its contribution to household incomes. Smallholder dairying with European or crossbred stock increased household incomes. The introduction of dairying also creates job opportunities along the dairy chain.

In an FAO (2010) study on greenhouse gas emissions from the global dairy sector it is concluded that in industrialised countries the emissions per kg milk are much lower than in developing regions, due to lower production levels and less efficient milk production in developing countries. This study allocates all emissions to milk production and neglects other functions of cattle in smallholder systems. In the Kenya highlands the other functions comprised more than half of the cattle benefits. The total emissions per animal are much lower in smallholder crop-livestock farms than in industrial livestock farms. Nevertheless, the smallholder sector contributes significantly to global greenhouse gas emissions due to their large number of animals. But, this contribution is much less than in developed countries. Herrero et al. (2008) calculated that all of Africa's ruminants contribute about ten per cent of global livestock methane emissions.

Increase in milk production should preferable be the result of better feeding and management practices and not an increase in the number of animals. In Gujarat, modelling studies and field trials indicated that feeding more locally available supplements could increase milk yields at the most by about 20% (Patil, 2006). Increases in production have to come from concentrates and using European dairy breeds or crossbreds. The off-farm impacts of growing and producing the feed ingredients will increase greenhouse gas emissions on a global scale.

Growing and producing feed ingredients and cattle keeping also have a big impact on biodiversity in rainforest frontiers (Steinfeld et al., 2006). Kaimowitz and Angelsen (2010) argue that livestock intensification is not the answer to save tropical forests. Ranchers will only be willing to adopt land-saving practices when land has become scarce and most of the forest has gone.

The use of European dairy breeds or crossbreds is a major trade-off between poverty alleviation through dairying and preservation of domestic animal diversity. Farmers are the main actors in maintaining breeds, but we cannot hold them responsible for maintaining domestic animal diversity. In developed countries, public institutions and hobby farmers are major actors in breed conservation. Farmers need incentives to maintain local breeds. This can be economic incentives to produce niche products, or the recognition that local breeds are well adapted to local diseases or other harsh environmental conditions.

Another trade-off is the conclusion that dairying is not an option for the really resource-poor farming households. In the Kenya highlands, households with dairy cattle had about twice as much land as households without dairy cattle. Resource-poor farmers are more likely to own poultry, pigs, or small ruminants than large stock. Small animals better fit the farming conditions of the very poor, but their contributions to household incomes were small, and the productivity of the family labour invested in small animal was low. The potential of innovations in small animal systems to substantially increase incomes of rural households was low. Micro-credit and passing-on-the-gift programmes are needed to help poor households to invest in livestock and intensifying technologies. Small animals are more suitable for micro-credit and livestock loans-in-kind programmes than large ruminants. It usually takes a too long time before large ruminants can be repaid.

The impact of village poultry and small ruminants on the environment was small, except for groundwater pollution of housing small ruminants close to the family. In Vietnam, the main intensification strategy for pigs was the use of hybrid pigs and consequently the use of concentrates. This resulted in a relatively high environmental impact of pigs (e.g. pigs contributed 35% of global warming potential of the farms), due mainly to the impact of off-farm processes (Phong et al., 2010).

The market for milk is the major pull factor for smallholder dairying, and in countries such as India, Bhutan, and Kenya, it produces the majority of the milk of the country. In other sectors, large-scale industrial production accounts for the major part of the increases in livestock production. Nevertheless, the increasing demands influence the non-dairy farmers too, e.g. in Ethiopia, prices of village poultry and eggs had more than doubled over the last ten years due to the increase in number of consumers and the introduction of chicken on menus in local restaurants. The increasing demands can also have a negative impact on local production. In West Africa, the increasing demand for poultry products has a negative effect on local industrial poultry production, as the poultry meat demands are increasingly met by imports of whole chickens or inferior cuts (Dieye et al., 2007). Local poultry meat from small- or large-scale industrial units costs more than imported chicken products as a consequence of the higher production costs of feed and chicks.

Livestock production will continue to intensify. Often, livestock intensification policies focus on the economic dimension of sustainability. They tend to neglect the environmental and societal dimensions. Livestock development strategies need to include a sustainability analysis to assess the impact of intensifying technologies at different levels. Without development policies that deliberately consider the opportunities and threats faced by crop-livestock farming households, many of these households are likely to be excluded from the increased market opportunities.

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