REFEREED ARTICLE

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Farmer livelihood assets contributing to the sustainable livelihoods of smallholder livestock farmers in the Northeast Region of Thailand

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ABSTRACT

This study assesses the livelihood sustainability of smallholder livestock farmers in the Northeast Region of Thailand. Three livestock farming systems, ruminant (RM), non-ruminant (NRM), and mixed livestock farming (MF) were analysed. A total of 205 households were sampled in a district that focuses on livestock farming. Linear discriminant analysis was used to identify significant contributing factors to sustainability. For RM and MF, the income-expenditure ratio was identified as a significant factor, and for NRM the significant factor is adequate experience with livestock rearing. The results suggest that livestock farming is a good livelihood option for smallholders. Human assets are vital and need to be improved through training supported by appropriate information systems for livelihood improvement. The concerned agencies, particularly government and local organizations, could be more proactively involved in terms of policy planning, project formulation, and implementation.

KEYWORDS: Livestock farming system; livelihood assets; smallholder livestock farmers; sustainable livelihood; rural development; Thailand

1. Introduction

Agriculture remains an important sector of the economy in Thailand and supports 25% of the population. The major aspects of agricultural production are linked with a variety of crop cultivation systems, horticulture, livestock and fisheries. Over the last two decades, the GDP contribution of agriculture has been between 8 to 10%, according to the Ministry of Agriculture and Cooperatives (MOAC, 2011). Among households dependent on this sector, about 2 million are below the poverty line, with an annual average income less than THB[3] 18,000 per person (MOAC, 2011). The challenge lies in bringing agricultural households out of poverty and making them sustainable.

Thailand has been emphasizing the sustainability concept to improve farmers' livelihoods since the 1990s (Chanpen, 1995; Jitsanguan, 2000; Jitsanguan, 2001). Towards this end, various methods of livestock production have been integrated into agricultural systems (Ito and Matsumoto, 2002; FAO, 2002), and many studies have confirmed that livestock can bring high economic returns (Dovie *et al.*, 2004), and improve socio-economic status, and reduce poverty among smallholder farmers (LCDI[4], 2004; De Haan, 2005; Dixon *et al.*, 2001; ILRI[5], 2003; ILRI, 2011; Holmann *et al.*, 2005).

The gap between farmers and those engaged in other occupations is wide, and farmers are considered the poorest group (FAO, 2001). A review of agricultural GDP and agricultural development policies in Thailand during the last two decades reveals that agricultural development projects often focus on assessing achievements only in terms of increased farm and livestock production and income, rather than addressing the achievement of sustainable livelihoods using available assets.

Since the early 1990s, sustainable livelihoods has been addressed by many as an important component of sustainable development. Most of the discussion on sustainable livelihoods has focused on rural areas, where people make a living from some kind of primary self-managed production system (Krantz, 2001). Many rural people diversify household income sources, which is an effective strategy for coping with adversity and improving overall security (Worku, 2007). According to Chambers and

[3] THB: Thai Baht; 1 USD equals approximately 35 THB as at 30 October 2016.

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Conway (1991, p.6), "A livelihood is sustainable if it can cope with and recover from stress and shocks, maintain or enhance capabilities and assets, and provide sustainable livelihood opportunities for the next generation in the short- and long-term", to which Scoones (1998, p.5) adds, "…while not undermining the natural resource base."

Livelihoods are comprised of people, their capabilities, and their means of making a living, and include both tangible resources and intangible assets. Livelihood activities, assets (natural, physical, human, financial and social) and access to assets are what determine the standard of living attained by individuals and households (Ellis, 1999). The sustainable livelihood approach (SLA) puts people at the centre of a development process or intervention, and is based on the belief that people need a range of assets to achieve positive livelihood outcomes and sustain positive changes (Carney, 1999; DFID, 1999; DFID, 1998; Brocklesby and Fisher, 2003).

The Department for International Development (DFID) has adopted SLA as a standard tool to improve understanding of livelihoods by identifying the main factors that affect them, and the relationships that can be used in planning new and evaluating existing development activities (Adato and Meinzen-Dick, 2002; DFID, 1999). SLA helps us to understand farmers' livelihood assets, strategies, and outcomes, which can be used to analyse livelihood sustainability.

The objective of this paper is to assess the livelihood assets of smallholder livestock farmers by looking at their human, natural, physical, social, and financial assets, and to use asset variables to explain sustainability. SLA is used as a framework to select livelihood asset variables in three systems, i) ruminant livestock farming or RM (e.g. cattle and buffalo); ii) non-ruminant livestock farming or NRM (e.g. swine and poultry), and iii) mixed livestock farming or MF (a mix of ruminant and non-ruminant animals). Farmers were classified as smallholder farmers if their land holding size was less than 22 rai (3.52 ha), and linear discriminant function analysis was used to identify significant factors.

2. Material And Methods

Study area

Non Sung District was selected as the study area because it is an important district for livestock farming in Thailand. Non Sung is located in the central part of Nakhon Ratchasima Province in the Northeast Region (Figure 1). Nakhon Ratchasima Meteorological Station reported that from 2000 to 2014, the average number of rainy days was 102 per year, with average annual rainfall of 1,050 mm, which is 65% of the national average. Seasonal hazards are drought and high saline soil (January-April), occasional flooding (June-October), plant pests (dry season), and animal diseases (rainy season). These characteristics of Non Sung District present common features of the Northeast Region, which is characterized by a poor natural resource base. The district consists of 16 sub-districts and 208 villages. Eighty-six percent of the population is engaged in agriculture. Due to animal disease outbreaks, the number of households rearing livestock declined from 11,635 households in 2005 to 6,692 households in 2009. Since then, the number of livestock farmers has been gradually increasing. According to Thailand's Department of Livestock Development (DLD), in 2014, some 7,358 farm households were engaged in livestock farming (DLD, 2014).

Data and methods

This is an exploratory and analytical research using both quantitative and qualitative data, collected from secondary and primary sources. The primary data was collected in a reconnaissance survey and key informant interviews to profile area characteristics, common problems, and smallholder livestock farming systems. Group discussions were conducted to identify and select variables followed by a household survey with a structured questionnaire to collect data from sample households. A sample size of 205 households was drawn. A stratified, simple random sampling method was used to draw samples proportionately from all sub-districts in Non Sung. The number of farmers in RM, NRM, and MF systems was 88, 52, and 65, respectively. Socio-economic characteristics and the livelihood asset structure of farmers in the three systems are compared using pentagon graphs. Linear discriminant analysis was applied to identify linear functions to classify farmers into 'non-improved' or 'improved' livelihood groups as an indicator of sustainable livelihoods linked with livestock farming.

Farmers were asked to evaluate the impact of livestock farming in terms of 'better' status (improved living) or 'poorer' status (non-improved living), before and after engaging in livestock farming. If farmers feel they have improved their living standards, it is reasonable to assume they will be able to sustain their livestock farming operations. A 'successful' livelihood can be predicted by placing one or more of the independent variables into the discriminant functions. A case can be predicted to fall in the 'improved living' group when the value of function (D) is higher than zero, and into the 'non-improved living' group when the value of (D) is lower than zero. The self-reported status of a farmer's livelihood was taken as the dependent variable. Equation (1) is the discriminant model applied in this study.

$$D = D_2 - D_1$$

$$= (a_2 + b_{21}X_1 + b_{22}X_2 + \ldots + b_{2n}X_n) - (a_1 + b_{11}X_1 + b_{12}X_2 + \ldots + b_{1n}X_n)$$

$$= (a_2 - a_1) + (b_{21} - b_{11})X_1 + (b_{22} - b_{12})X_2 + \ldots + (b_{2n} - b_{1n})X_n \quad (1)$$

Where,

D = Discriminant function

D_1 = Classification function of group 1: non-improved living group

D_2 = Classification function of group 2: improved living group

a_j = Constant score

b = Non-standardized coefficients

X = Independent variable or discriminant variable

n = the number of discriminant variables where $n \geqslant 1$

A livelihood asset index was developed using a Likert scale by computing a weighted average index (WAI) for

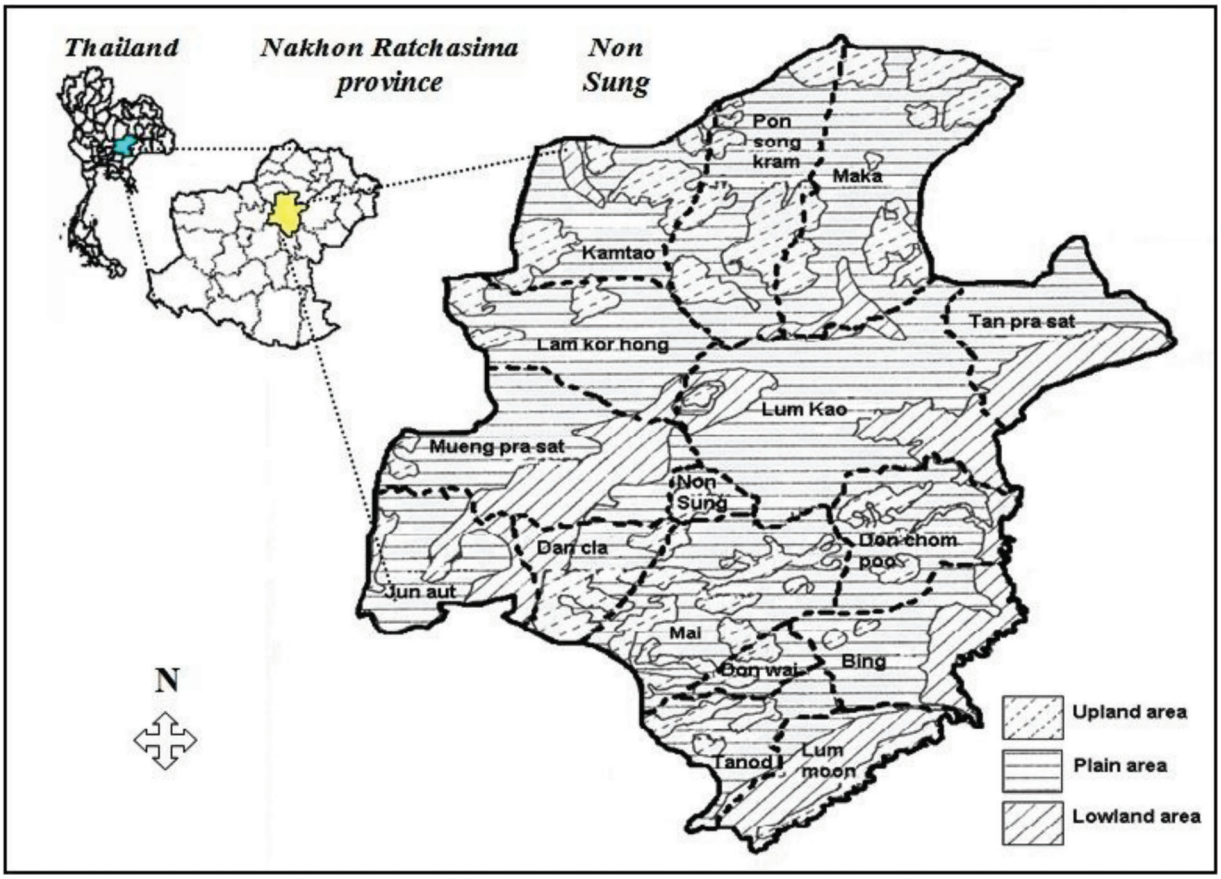

Figure 1: Map of Non Sung District, Nakhon Ratchasima Province

Table 1: Ratings of weighted average indices

WAI Score	0.00-0.20	0.21-0.40	0.41-0.60	0.61-0.80	0.81-1.00
Adequacy	High Inadequacy	Inadequacy	Moderate	Adequacy	High Adequacy
Accessibility	Never	Rarely	Sometime	Often	Always
Quality, Security	Very Poor	Poor	Moderate	Good	Very Good
Ability Level	Very Low	Low	Moderate	High	Very High
Livelihood Asset Index	**Very Low**	**Low**	**Moderate**	**High**	**Very High**

each category of asset for the three systems. A five-point Likert scale was used (from 0 to 1) with variable weights for five classes (0.2, 0.4, 0.6, 0.8, and 1.0). Weight 0.2 is the lowest, or 'least situation' and 1 is the highest or 'best situation'.

The WAI is defined in Equation (2):

$$WAI = (W_1F_1 + W_1F_2 + W_3F_3 + W_4F_4 + W_5F_5)/N \quad (2)$$

Where, $W_1 = 0.2$, $W_2 = 0.4$, $W_3 = 0.6$, $W_4 = 0.8$, and $W_5 = 1.0$; and F_1 to F_n (where n = 5) are the respective frequencies of response under those classes, and N is total responses.

The WAI values are presented in Table 1.

3. Results And Discussion

Livelihood asset analysis

The socio-economic profile and livelihood structure of smallholder livestock farmers is presented in Table 2. Five livelihood assets under three systems were analysed and compared using a set of indicators for each asset. The indicators under Human Asset are: adequacy of labourers, experience and skill, educational attainment of the labourers, accessibility to training, accessibility to information, and health status of the farmer.

Natural Assets include: adequacy of land, quality of soil, adequacy of water, and quality of water.

Physical Capital indicators are: accessibility to infrastructure services, adequacy of services, quality of services, adequacy of animal shelters, sanitation of animal shelters, security of animal shelters against theft, and adequacy of machines and instruments.

Social Assets has three indicators: social participation, community security, and market accessibility.

Financial Assets similarly has three indicators: adequacy of savings, accessibility to credit sources, and loan repayment ability of the farmer.

Human assets refer to the status of individuals and farm household members in terms of labourers, skill, knowledge, and health status.

In Thailand, farm labour availability is declining due to an occupational shift to non-agricultural activities. Farmers using RM and MF systems have relatively more inadequate labour than farmers using NRM systems.

Table 2: Socio-economic profile and livelihood structure of smallholder livestock farmers

Socio-economic profile and livelihood structure		livestock farming system		
		RM	NRM	MF
Number of households	Households	88	52	65
Average household size	Persons/HH	4.38	3.98	4.45
Average labourers for livestock farming	Persons/HH	1.95	1.92	2.00
Age of labourer				
Minimum-maximum age of labourer	Years	13-80	22-81	14-84
Average age of labourers	Years	51	53	50
Labourers older than 50 years	%	50.00	55.00	48.46
Educational level of labourers Primary level	%	83.98	84.00	84.38
Higher level	%	14.53	13.00	13.08
Farmers in very good health	%	88.64	90.38	84.62
Adequate labourers for livestock farming	%	22.72	36.54	21.54
Adequate experience and skill for livestock farming	%	31.82	25.00	21.54
Farmers with access to training about livestock	%	21.59	17.31	9.24
Farmers with access to information about livestock	%	36.37	36.54	30.77
Land holding size	(1ha=6.25rai)			
Average land holding size	Rai/HH	21.32	15.94	16.60
Average owned land size with title deed	Rai/HH	10.83	8.22	10.79
Insufficient land for livestock farming	%	32.95	25.00	49.23
Insufficient water for livestock farming	%	26.55	11.54	43.07
Average farm size				
Cattle and buffalo	Heads/HH	11	-	10
Swine	Heads/HH	-	21	10
Chickens	Heads/HH	-	36	27
Ducks	Heads/HH	-	29	29
Infrastructure system				
High accessibility	%	94.31	90.39	86.15
Adequate infrastructure facilities	%	88.63	84.61	76.93
Livestock housing				
High safety and security	%	48.86	40.38	41.54
Moderate sanitation	%	57.95	63.46	56.92
Highly adequate livestock housing	%	45.46	44.23	35.38
High adequacy machinery and instruments	%	60.23	48.07	49.23
Participate in social group s& activities	%	47.73	51.92	53.95
High security in social	%	89.77	61.54	69.23
High accessibility to markets	%	36.36	44.23	40.00
Return from livestock farming				
Average income from livestock	'000 Baht/HH	86.59	158.28	125.87
Average profit	'000 Baht/HH	19.43	37.63	19.81
Farmers who have savings	%	97.73	82.69	92.31
Farmers indebted	%	77.27	78.85	75.38
Average short-term debt (< 1 year)	'000 Baht/Debtor	32	35	28
Average medium-term debt (2-5 years)	'000 Baht/Debtor	47	138	35
Average long-term debt (>5 years)	'000 Baht/Debtor	214	113	89
High accessibility to credit	%	44.32	51.92	36.92
High repayment ability	%	46.59	48.08	43.08

People involved in livestock rearing activities are mainly 50-60 years of age however, the research found an interesting fact that this occupation can employ a wide range of rural labours such as teenagers and over 80 years old, as long as they are in good health. More than 80% of farmers in all systems report being in good health.

Most farmers have only primary level education. The low education level is a constraint on farmers' improvement. Farmers in RM systems have more experience with livestock farming than those in NRM and MF systems. However, most farmers in all systems follow traditional practices for ruminant rearing and would benefit from improving their knowledge. For example, farmers in RM systems lack knowledge of marketing, farmers in NRM lack knowledge about vaccinations, DLD livestock farm standards, and commercial farming systems. Farmers in MF systems lack knowledge about breeding and crossbreed selection. Only 20% of farmers have trained or received information on livestock farming. Most are dissatisfied with the knowledge they gained through training. Government agencies, the private sector, and suppliers are important sources of information. Middlemen mostly provide market and price information. Informal meetings among farmers are a common way of sharing information.

Natural assets are basic resources such as land, soil, water, and animals needed to generate food and income. Half the farmers in MF and 30% in other systems have insufficient land for effective livestock rearing. The average land holding size of farmers in RM, NRM, and MF system is 21.32, 15.94, and 16.60 rai, respectively (1ha = 6.25 rai). Insufficient land and poor soil fertility are among farmers' major concerns. The average land owned by farmers is about half their total land holdings (10.83, 8.22, and 10.79 rai, for RM, NRM and MF respectively). Households with larger land holdings tend to invest, and wealthier households are more likely to invest larger amounts (Hohfeld and Waibel, 2013).

Land ownership reduces risk and provides incentives for long-term investment. A land title deed also strengthens farmers' rights and livelihood security, for example, a title deed can be used as collateral for loans.

Most farmers have soil problems that require help from government agencies for soil quality improvement. Few MF farmers employ good management practices such as allocating high land for dwellings and ruminant sheds, sloping areas for non-ruminant sheds, and low lying land for cultivation and water storage. They also need land for grazing and fodder production.

The common water sources in Non Sung are small open water channels, groundwater, village water supplies, and locally created small irrigation systems. Quality of water is 'moderate' as assessed by farmers. During the dry season, there are water shortages, high salinity, and water contamination problems. Nearly half the farmers in MF systems have inadequate water for livestock farming and most need to increase the water storage capacity of ponds and seek other sources for livestock production.

Livestock is a natural asset by itself, and animal draught power is considered a physical asset (DFID, 1999). Livestock can also be considered a social asset if they are kept as a mark of social status (Stroebel *et al.*, 2011). Native beef cattle are favoured because of their high disease resistance and suitability to the less than optimal natural conditions of the Northeast. Dairy cattle are not popular due to generally saline water and the lack of milk collection centres. The role of ruminant animals, especially buffalo, for draught power has likewise declined with increased farm mechanization. The average number of cattle and buffalo in RM and MF system has declined to 10 head per household.

Swine raised and fattened in the backyard normally generate income every quarter of the year. Commercial swine production requires more labour and financial investment in breeders, sheds, equipment, and good farm management practices. The average number of swine is significantly different between NRM and MF systems, with 21 and 10 head respectively.

Poultry is the most important source of protein. Poultry is mostly raised in the backyard or mixed with livestock. The number of poultry was declined after the avian flu outbreak in 2004. The average number of chickens in NRM and MF systems is only 36 and 27 per household. The average number of ducks in NRM and MF system is only 29.

Physical assets are assets created to fulfil basic human needs. Infrastructure, livestock shelters, machinery, instruments, and technologies are necessary for livestock production. More than 80% of farmers have adequate infrastructure facilities, except farmers in MF systems. Tambon Administration Organizations or Village Committees manage village water supply systems. The challenge is to reduce salinity and contamination levels. Electricity is expensive. Telecommunications, road networks, and transportation services are necessary for trade, access to social services, and exchanging information with outsiders. The quality of road links from sub-districts to villages is generally poor, and accessibility is more difficult during the rainy season.

Farm dwellings are constructed with local materials and mostly older than 20 years. Animal shelters have moderately good sanitation. The design and size of livestock shelters depends on the type and number of livestock, individual preferences, budget, and available materials. Poultry shelters and pigpens are built with sloping roofs made of local materials and the floors are often covered with rice straw and rice husks. Housing provides security to farmers and also livestock. Machinery is mostly old and rust is a problem due to the high salinity of the water in the area. Farmers will often borrow or rent machines and equipment from neighbours or relatives when needed. Whether or not a technology is adopted depends on its compatibility, a farmer's preference, and his/her production system (Johan, 2011).

Fodder cultivation is promoted to increase feedstuffs. Demand for commercial feed for non-ruminant production has increased because of convenience, nutritional value, and quality. The feed cost of swine rearing is 80% of the total cost of production. Some farmers minimize costs by mixing commercial feed with local ingredients, for example, kitchen waste and residue from cultivation, rice mills and noodle factories. Based on the field survey, the following practices have been observed. Local feedstuffs for poultry are rice bran, broken rice, and other cereal grains, worms, and insects. Minerals and vitamins are mixed with feedstuffs to improve animal health and growth rate. Effective microorganisms, or EM, have been introduced to resolve the problem of bad odours from livestock excretions, to increase effective digestion, and to treat wastewater and dung. Breeding via artificial insemination (AI) has been promoted to improve production and the genetics of local breeds. AI can help improve the livelihoods of livestock farmers by increasing animal products and conserving genetic diversity (Johan, 2011).

Social assets influence other livelihood assets by promoting cohesiveness, security, and sharing systems. Social assets have a direct impact on the efficiency of economic relations, and the management of common resources (natural and physical assets), and facilitate innovation and knowledge sharing (DFID, 1999). Non-monetary exchange among farmers through their social networks creates opportunities to exchange livelihood assets such as labour, production inputs, information and knowledge about livestock production, and market accessibility (Prateep, 2006). Sharing assets and resources is part of traditional Thai culture and helps farmers solve farming problems, overcome capital shortages, increase livelihood security, and reduce the risk of outside dependency. Unfortunately, this sharing tradition is declining and is evident in all three farming systems.

Group discussions revealed that training and information shared by social groups helps increase farmers' abilities and expand their markets. Visiting markets at regular intervals for buying and selling merchandise and transacting marketing functions also increases social interaction that enhances social assets. Accessibility to markets depends on transport networks and types of livestock. Only 40% of interviewed farmers in RM, NRM, and MF systems visit markets regularly. Farmers mostly sell their livestock and livestock products to middlemen, mobile markets that come to or near their village, cattle-buffalo market fairs, slaughterhouses, and district markets.

Financial assets are important for undertaking any livelihood activity. In terms of income generation, livestock farming provides income from direct sale of products and manure. The average income from livestock in NRM is approximately THB 158,280, which is higher than farmers in RM and MF systems, who earn

THB 86,590 and 125,870 per year respectively. It was found that some farmers earn a higher income from training and selling fighting cocks. The price of a good fighting cock is approximately THB 5,000-10,000. Animal dung generates bio-fertilizer, from 4 to 7 kg per head of cattle per day, and 2 kg per head of swine per day, and is sold at two Thai Baht per kilogram. Some farmers produce worms and grubs from non-ruminant animal dung to feed their poultry and fish, or they can sell it for 14-23 Baht per kilogram. Fodder cultivation helps farmers reduce feeding costs and generates supplementary income. However, 75-80% of the income is spent on livestock production.

More than 80% of farmers in RM, NRM, and MF systems have savings in the form of movable property, such as livestock, bank savings, cash, rice and grain or vegetable seeds, and vehicles. Farmers use their savings for investment in agricultural production, meeting emergency needs, and at times coping with economic vulnerabilities.

Regular inflow of money comes from credit, remittance income, and transfers from the state as subsidies or special grants. More than 75% of all farmers in the three systems are indebted. The Bank of Agriculture and Agricultural Cooperatives, Village Funds, Savings and Credit Cooperative Societies, and informal credit providers are the main sources of credit. For short-term debt (< 1 year) and medium-term debt (2-5 years), farmers in NRM systems have the highest debt (THB 35,000/debtor in short-term debt and THB 138,000/debtor in medium-term debt). RM system farmers have the highest average long-term debt (>5 years) with approximately THB 214,000/debtor. In MF systems, farmers have the lowest average short-, medium- and long-term debt (THB 28,000, 35,000, and 89,000/debtor). Farmers in NRM systems have greater accessibility to credit than farmers in other systems. More than 40% of all farmers in all three systems have high repayment ability.

A Livelihood asset analysis was done using a five-point Likert scale. Indices were computed for all five asset types and compared across the three systems. The index values of all five types of assets for each livestock farming system are depicted in pentagon graphs (Figure 2). In Figure 2, the three systems show a similar picture in terms of asset characteristics. The physical asset index (RM =0.74, NRM=0.74, and MF=0.70) appears to be high in all three systems with little variation between them. Financial assets appear to be the next most important after physical assets, with an index value that varies from 0.72 (RM) to 0.69 (NRM) to 0.69 (MF). Social assets are mid-range (RM=0.69, NRM=0.66, and MF=0.66), followed by natural assets (RM=0.66, NRM=0.68, MF=0.59). Human assets have the lowest index value for all three systems (RM=0.54, NRM=0.54, and MF=0.51).

The livelihood asset indices show that good physical and financial assets provide ample opportunity for expansion and intensification of smallholder livestock farming, whereas human assets and natural assets indicate some constraints. These findings have strong implications for strengthening natural assets vis-à-vis human assets. In terms of gross income and profit earned by smallholder farmers, the NRM system is the most profitable, followed by MF and RM systems. The limitations of human and natural assets are reflected in the gross income and net profit as well. This suggests that public and private sector agencies could be more proactive in supporting and facilitating smallholder farmers through training programs, provision of improved livestock farming information, and improving accessibility to public services to increase opportunities for additional and alternative livelihoods.

Variables for measuring sustainability

A complex of inter-related factors in livestock farming influences growth, development and production (FAO, 1988). Variables for measuring sustainability are the independent variables, which were identified from farmers' livelihood assets during group discussion and the data collected from the household survey. Two types of variables were selected. The first type is common to the three farming systems and the second type is specific to different farming systems. Table 3 provides a list of the variables selected along with a brief description, value, and value label used for measurement.

Common variables were selected from human, social, natural, physical, and financial assets. Smallholders typically have higher profit per unit of output than large-scale producers, with and without costing of family labour (Nipon, 2013) hence, household labour is an important human asset for small farm activities. The number of household labourers, age, experience, health status, and accessibility to training and information were chosen to measure sustainability of farmers' livelihoods. Social security is a component of sustainable development and a main pillar of economic support and can be a determining factor for ensuring sustainable development (Răzvan-Dorin, 2012). Social participation and social security were selected as indicators as they provide opportunities. Accessibility to markets was selected as an indicator as it is related to social assets. El Mamuon (2013) found, for example, that market accessibility effects positive changes in social network building.

Land and water resources are essential natural assets (FAO, 2011), hence, land size, livestock rearing area, and soil and water quality were selected as indicators. Farmers who own land are more secure than those renting land. Legal title deeds issued to farmers give them full rights for using the land in their possession, and improved land access leads to improved household welfare (Winters *et al.*, 2009). Farmers who own land can escape poverty more easily than those who do not (Lawal, 2011).

Soil fertility and water quality are important for livestock feeding, health, and productivity (FAO, 2011). Poor quality or inadequate feedstuff and water can all lead to low productivity, high toxicity problems, and high morbidity and mortality of animals. Physical assets include the quality of infrastructure services such as electricity, village water supply, telecommunications, and transportation, safety and sanitation of animal housing, and machinery and equipment (FAO, 1988; Lawal, 2011; Raj Khanal *et al*, 2014), all of which can indicate livestock production capacity. Livestock housing is mainly concerned with the physical environment, where healthy, high yielding animals can be provided with optimal feeding and can reproduce without stress or suffering physical harm (FAO, 2011).

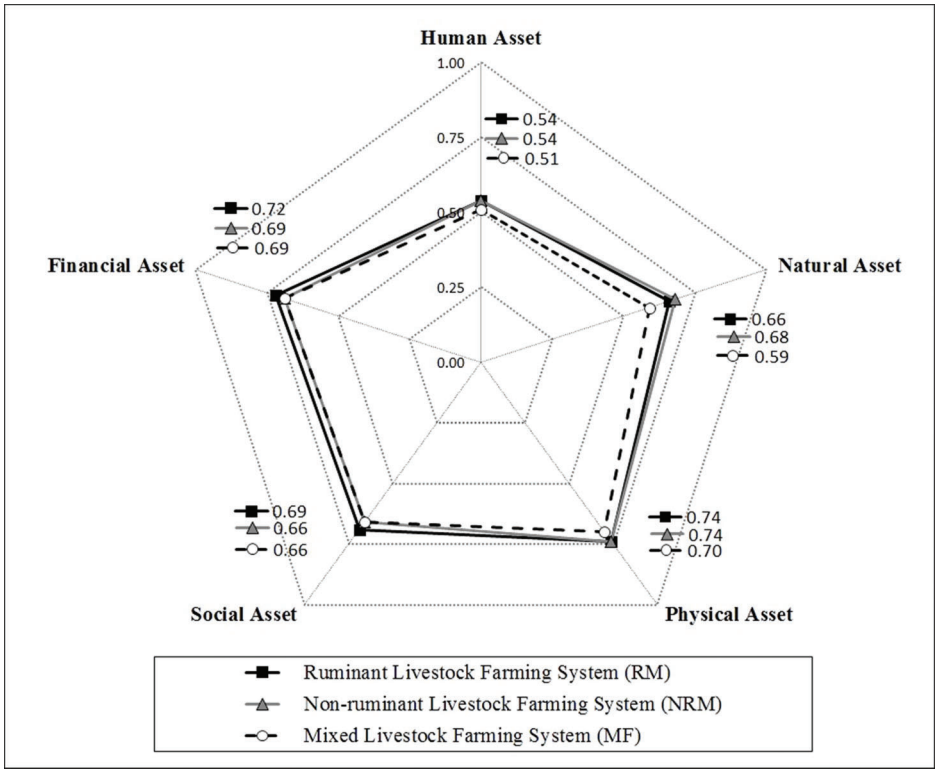

Figure 2: Livelihood asset pentagon of three livestock farming systems

Financial assets are used to achieve farmers' livelihood objectives, in the form of savings and credit, and regular inflows of money such as pensions, transfers from the state, and remittances (DFID, 1999). This asset category was assessed through: saving adequacy, loan accessibility, ability to repay loans, and income-expenditure ratio. Adequate savings provide opportunities for investment, and successful livestock farming increases savings. Loan accessibility and repayment ability indicate a farmer's liquidity, and income-expenditure ratio reflects the efficiency of the farm operation. If income is higher than expenditure, a livestock production operation is considered sustainable.

The number of livestock in each farming system is a specific variable. Ruminant systems consist of cattle and buffalo, non-ruminant systems swine, chickens, and ducks, and mixed livestock farming systems a combination of both ruminant and non-ruminant animals. The number of livestock should match the physical assets needed to generate maximum benefit to farmers.

Results of linear discriminant analysis

Linear discriminant functions for smallholder farmers in each livestock farming system were calculated using SPSS. The magnitude of coefficients indicates how strongly the discrimination variables affect the score. However, a non-standardized coefficient does not clearly indicate the relative contribution of the variable to the overall discrimination when a variable is measured in different units. The variables selected for analysis are presented in Table 3. The standardized coefficients presented in Table 4 explain the relative importance of each independent variable for the three farming systems. Table 5 illustrates the contribution of independent variables in order of ranking, following the standardized coefficient values that explain sustainable livelihood.

Linear discriminant functions for ruminant livestock farming (D_{RM})

Equation (3) highlights the relative importance and contribution of variables reflected in coefficient values.

$$\begin{aligned} D_{RM} = & -30.953 + 0.044\ \text{Labourer} + 0.030\ \text{Age} \\ & + 0.951\ \text{Experience} + 0.201\ \text{Health} + 1.073\ \text{Training} \\ & + 0.034\ \text{Information} + 0.787\ \text{Participation} + 0.194 \\ & \text{Security} - 0.044\ \text{Ownland} + 0.041\ \text{Livestockarea} \\ & + 0.173\ \text{Soil} + 1.694\ \text{Water} + 0.032\ \text{Cattle} - 0.065 \\ & \text{Buffalo} + 0.497\ \text{Infrastructure} + 0.019\ \text{Safety} + 0.426 \\ & \text{Sanitation} + 0.063\ \text{Machine} + 0.876\ \text{Market} + 1.067 \\ & \text{Saving} + 0.090\ \text{Loan} + 0.259\ \text{Payment} \\ & + 2.713\ \text{I/ERatio} \end{aligned} \quad (3)$$

Note: Coefficients of variables are not standardized. R^2 is 0.696.

Classification results of 88 households using RM systems show that 96.60% of the original grouped cases are correctly classified. The standardized coefficient in Table 4 and 5 shows that income and I/E ratio has the greatest coefficient value and makes the highest contribution to improved or non-improved living status in RM systems.

Farmers need high net income for future investment and living expenses. The price of good breeds of cattle

Table 3: Description of variables in discriminant analysis

Variable	Description	Value and value label
Dependent variable		
D	Meaning of farmer livelihood	Non-improved living Improved living
Independent common variables		
1. Human Asset		
Labourer	Number of household labourers	(Persons)
Age	Average age of household labourers	(Years)
Experience	Adequate experience for farming	Highly inadequate, Inadequate,Moderate, Adequate, Highly adequate
Health	Health status of farmers	Very poor, Poor, Moderate, Good, Very good
Training	Accessibility to training on livestock farming	Never, Rarely, Sometime, Often, Always
Information	Accessibility to information about livestock farming	Never, Rarely, Sometime, Often, Always
2. Social Asset		
Participation	Participation in social activities	Never, Rarely, Sometime, Often, Always
Security	Social security level	Very poor, Poor, Moderate, Good, Very good
Market	Accessibility level to market	Very low, Less, Moderate, High, Very high
3. Natural Asset		
Own land	Own land area	Rai (1 ha=6.25 rai)
Livestock area	Livestock rearing area (Stable/shelter and grazing area)	Rai (1 ha=6.25 rai)
Soil	Soil quality	Very poor, Poor, Moderate, Good, Very good
Water	Water quality	Very poor, Poor, Moderate, Good, Very good
4. Physical Asset		
Infrastructure	Quality level of Infrastructure	Very poor, Poor, Moderate, Good, Very good
Safety	Safety of animal stable/shelter	Very poor, Poor, Moderate, Good, Very good
Sanitation	Sanitation level of animal stable	Very poor, Poor, Moderate, Good, Very good
Machine	Adequacy of machinery and Equipment	Highly inadequate, Inadequate, Moderate, Adequate, Highly adequate
5. Financial Asset		
Saving	Adequacy of savings	Highly inadequate, Inadequate, Moderate, Adequate, Highly adequate
Loan	Accessibility to loans	Very less, Less, Moderate, High, Very high
Payment	Ability for loan payment	Very less, Less, Moderate, High, Very high
I/E Ratio	Income/expenditure from livestock production	Income-Expenditure Ratio
Independent Specific Variables		
Cattle	Number of cattle	head
Buffalo	Number of buffalo	head
Swine	Number of swine	head
Chicken	Number of chickens	head
Duck	Number of ducks	head

and buffalo are mostly higher than THB 40,000 per head. Income turnover for cattle is 1 to 2 years and for buffalo 2 to 3 years. Water quality level (Water) aids ruminant livestock digestion, increases health, pregnancy, growth, and productivity rates, especially during drought and low humidity periods. Social participation level (Participate) leads farmers to share resources in production, as well as offering farmers access to training and information, which contributes to their knowledge and capacity for strengthening their livelihood systems.

Linear discriminant functions for non-ruminant livestock farming (D_{NRM})

Equation (4) highlights the relative importance and contribution of variables reflected through coefficient values.

$$\begin{aligned} D_{NRM} = & -56.90 + 1.066\ \text{Labourer} + 0.045\ \text{Age} \\ & + 2.566\ \text{Experience} + 1.099\ \text{Health} + 0.439\ \text{Training} \\ & + 0.790\ \text{Information} + 0.663\ \text{Participate} + 0.855 \\ & \text{Security} + 0.038\ \text{Ownland} + 0.304\ \text{Livestockarea} \\ & + 0.893\ \text{Soil} + 2.277\ \text{Water} - 0.051\ \text{Swine} - 0.084 \\ & \text{Chicken} - 0.038\ \text{Duck} + 1.121\ \text{Infrastructure} + 0.139 \\ & \text{Safety} + 0.921\ \text{Sanitation} + 0.561\ \text{Machine} + 0.410 \\ & \text{Market} + 0.128\ \text{Saving} + 1.131\ \text{Loan} + 0.483 \\ & \text{Payment} + 6.589\ \text{I/ERatio} \end{aligned} \quad (4)$$

Table 4: Standardized canonical discriminant function coefficients

Independent Variables	RM[1]	NRM[2]	MF[3]	Independent Variables	RM[1]	NRM[2]	MF[3]
Common variables							
Labourer	0.012	0.187	0.258	Soil	0.039	0.150	0.161
Age	0.104	0.142	0.224	Water	0.396	0.411	0.195
Experience	0.295	0.492	0.092	Infrastructe	0.103	0.193	0.279
Health	0.031	0.102	0.196	Safety	0.007	0.036	0.074
Training	0.270	0.086	0.114	Sanitation	0.135	0.226	0.042
Information	0.010	0.165	0.202	Machine	0.040	0.218	0.139
Participate	0.331	0.223	0.300	Market	0.215	0.090	0.162
Security	0.054	0.251	0.380	Saving	0.266	0.040	-0.001
Own land	-0.108	0.066	-0.324	Loan	0.034	0.262	0.100
Livestock area	0.099	0.117	0.038	Payment	0.167	0.216	-0.094
				I/E Ratio	0.521	0.431	0.775
Specific Variables							
Cattle	0.077	None	-0.079	Swine	none	-0.179	-0.026
Buffalo	-0.132	none	0.020	Chicken	none	-0.571	-0.322
				Duck	none	-0.157	0.240

[1] RM: Ruminant livestock farming system
[2] NRM: Non-ruminant livestock farming system
[3] MF: Mixed livestock farming system

Note: Coefficients of functions are not standardized. R^2 is 0.808.

Classification results of 52 households in NRM show that all the original grouped cases are correctly classified. The standardized coefficient values in Table 4 and 5 show that adequacy of experience for livestock farming (Experience) has the highest value and makes the greatest contribution to improved or non-improved living status of farmers. Animals in NRM are more sensitive to rearing practices compared to those in RM systems, which means farmers' experience is extremely important in NRM systems. Income-expenditure ratio (I/E ratio) and water quality (Water) variables have absolute standardized coefficient values higher than 0.40, hence they have a high impact on production and livelihood. Income turnover of non-ruminants is shorter than for ruminants, and production costs are higher. Feed cost is about 60-70% of the total production cost. The net return is low due to low product price and high input costs, and is common in NRM systems. Most NRM systems use village water supplies. During the dry season, water often becomes more saline and is unsuitable for non-ruminant animals. This has implications for animal health. The number of chickens has an absolute value of standardized coefficient higher than 0.40, while other factors are lower than 0.20. Increasing or decreasing the number of chickens influences improved or non-improved status of a farmer's livelihood.

Linear discriminant functions of mixed livestock farming (D_{MF})

Equation (5) highlights the relative importance and contribution of variables reflected through coefficient values.

$$\begin{aligned} D_{MF} = & -44.492 + 1.391\ \text{Labourer} + 0.083\ \text{Age} - 0.401 \\ & \text{Experience} + 1.076\ \text{Health} + 0.860\ \text{Training} + 0.968 \\ & \text{Information} + 0.768\ \text{Participate} + 0.979\ \text{Security} - 0.149 \\ & \text{Ownland} + 0.026\ \text{Livestockarea} + 0.894\ \text{Soil} + 1.004 \\ & \text{Water} - 0.018\ \text{Cattle} + 0.018\ \text{Buffalo} - 0.015\ \text{Swine} \\ & - 0.039\ \text{Chicken} + 0.060\ \text{Duck} + 1.388\ \text{Infrastructure} \\ & + 0.326\ \text{Safety} + 0.192\ \text{Sanitation} + 0.272\ \text{Machine} \\ & + 0.785\ \text{Market} - 0.003\ \text{Saving} + 0.304\ \text{Loan} - 0.168 \\ & \text{Payment} + 7.903\ \text{I/ERatio} \end{aligned} \quad (5)$$

Note: Coefficients of functions are non-standardized. R^2 is 0.750.

Classification of 65 households in MF systems shows that 95.40% of the original grouped cases are correctly classified. The standardized coefficients in Tables 4 and 5 show that income-expenditure ratio (I/E Ratio) has the greatest value and makes a strong contribution to improved or non-improved living status. Other variables such as social security, own land, and number of chickens have absolute standardized coefficient values higher than 0.30. For maintaining farmers' living expenses and future investment, farmers need high net income. Smallholder farmers in MF systems who have improved their living status mostly feel safe and secure within their community. Their animals are protected against theft while they are away from home, and when labour is in short supply. Farmers in MF systems need land to expand their livestock production and grazing area. Other livelihood assets, such as financial and social assets can support and sustain farmers' livelihood improvement in MF systems.

Based on the discriminant analysis, 47 farmers out of 88 (53%) in RM systems, 25 out of 52 (48%) in NRM, and 37 out of 65 (57%) in MF, have improved their living conditions. Overall, 109 out of 205 (53%) farmers achieved improved living status with livestock farming. Thus, livestock farming is a good alternative livelihood and the results suggest that livestock farming could be intensified in other parts of Thailand with similar conditions.

The potential contribution of livestock sector development to livelihoods of the poor is significant (FAO, 2016). The most important common factor for RM and MF systems contributing to sustainability is the

Table 5: Important factors for smallholder livestock farm sustainability

Standardized	RM[1]		NRM[2]		MF[3]	
Coefficients (Absolute Value)	Common variables	Specific variables	Common variables	Specific variables	Common variables	Specific variables
>0.40	I/E Ratio		Experience I/E Ratio Water	Chickens	I/E Ratio	
0.31-0.40	Water Participate				Security Own land	Chickens
0.21-0.30	Experience Training Savings Market		Loan Security Sanitation Participate Machinery Payment		Participate Infrastructure Labourer Age Information	Ducks
⩽0.20	Payment Sanitation Own land Age Infrastructure Livestock area Security Machine Soil Loan Health Labourer Information Safety	Buffalo Cattle	Infrastructure Labourer Information Soil Age Livestock area Health Market Training Own land Saving Security	Swine Ducks	Health Water Market Soil Machinery Training Loan Payment Experience Security Sanitation Livestock area Savings	Cattle Swine Buffalo

[1] RM: Ruminant livestock farming system
[2] NRM: Non-ruminant livestock farming system
[3] MF: Mixed livestock farming system

income-expenditure ratio and for NRM systems, the most important factor is farmer experience with livestock rearing. Generally, non-ruminant systems are more sensitive to the physical environment than are ruminant systems. Experience and knowledge are therefore critical.

4. Conclusions

The livelihood pentagon analysis reveals that some variation exists among the livestock farming systems in terms of asset structure. Overall, physical and financial assets are indicative of strength and potential, whereas natural and human assets are indicative of weaknesses and limitations. Social assets fall between these two sets of assets and offer ample scope for integrating with and contributing to other assets. Considering all assets, the key factors influencing livestock farming and its sustainability are linked with income-expenditure ratio (net income) for RM and MF systems, and experience of farmers engaged in NRM systems. The linear discriminant function analysis revealed that more than half the farm operations are sustainable. This analysis can also predict the livelihood status of new smallholder farmers in RM, NRM and MF systems in terms of either improved or non-improved standard of living and the sustainability of their livelihoods.

Income-expenditure ratio (net income) and experience of smallholder livestock farmers in this region can be increased through training programmes and provision of improved livestock production information. Training and information should be available to all interested smallholder farmers and should focus on farm management, pricing and marketing, and technology for breeding and for disease protection. The concerned agencies, particularly government and non-government organizations, the private sector, and local organizations could be more proactively involved in terms of policy planning, project formulation and implementation in line with the identified factors.

Finally, the outcomes of this study have policy implications for decision makers, planners, practitioners, extension agencies, and farmers by offering appropriate options for integrating livestock farming with livelihood systems. Alternatively, it could help farmers select a livestock production system given their livelihood assets.

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