UNIVERSITY OF HOHENHEIM
Institute of Animal Husbandry in the Tropics and Subtropics (480 a)
Prof. Dr. Anne Valle Zárate

Master Thesis

Assessing Input in Pig Production with Special Focus on Feed Resources and Feeding Management in Demand and Resource Driven Production Systems in Son La Province, Vietnam

By
HOANG THI HUONG TRA

This study was sponsored by DFG – Germany

September, 2003
Stuttgart, Germany

Acknowledgements

I would like to express my special gratitude to my supervisor, Prof. Dr. Anne Valle Zárate, for her special support throughout the two year study in the master course. I am greatly indebted for her constant support during study as well as during the fieldwork, including through field visits in Son La province.

I am extremely grateful to Ms. Ute Lemke for her careful advice throughout the field work in Vietnam and throughout the process of preparing this thesis, which contributed to enhancing the quality of the final work. I am so indebted for her help as well as her advice during the field work and writing thesis.

I would like to convey my special thanks to Dr. Le Thi Thuy for her help, her advice throughout the field work in Vietnam and my work in Son La making more comfortable.

I would like to express my sincere thanks to Prof. Dr. Le Viet Ly for his support and strong encouragement during the two years of study.

I would like to express many thanks to Dr. Brigitte Kaufmann for her help during the first time of preparing my proposal.

My thesis would not have been completed without the hospitality and warm welcomes offered by the farmers in Ban Bo, Ban Buon, Na Huong and Ban Keo, Son La province, who were so kind and generous in giving their time to help me during my field visits. I can not help thinking of Mr. Suong and his wife and children, who help me during the filed visit as well as care for me during the time I got sick in their home and in hospital. I would like to thank Mrs. Thanh, Mr. No and Mr. Hien for their warm help. I also would like to have thank Mr. Thong and his family in Ban Keo, Mr. No and his family in Na Huong, whom I stayed during the field visits.

The warm help and support of all staff members of Son La Veterinary Department, particularly Mr. Tang, Mrs. Chau, and Mrs. Thuc, were greatly useful in the research process. Without their assistance, I would have faced with a lot of difficulties during my field work. My thanks go to Mr. Van and Mrs. Ly, who made my communication with farmers possible and easy.

I would like to express my thanks to Prof. Dr. Nguyen Van Dong and Dr. Phung Thi Van for their various support to me during my field work.

I also wish to give many thanks to all of the members, especially Dr. Nils Teufel of the Institute of Animal Husbandry in the Tropic and Subtropics (480a)-Hohenheim for their friendship and for their help.

Last but not least, I am indebted to my parents, my brothers and sister for their support and encouragement during my study. I am so indebted to my mother-in-law for her help to care for my daughter and support me during my study, without her support I would not finish my study in abroad. I can not help thinking of my close friends Vuong Thanh Hao, Thanh Binh, Dieu Thuy, Duy Linh and Thanh Hoa for their encouragement and help during my study and writing thesis. Without their sincere friendship, my study in Hohenheim would be very difficult. I cannot express the depth of my appreciation to my dear husband Pham Huu Hung and my daughter Pham Hoang Y Nhi, who have been the closest, inspiring me throughout my study in Germany.

Abbreviations

AI	Artificial insemination
B	Ban pig breed
CP	Crude protein
CW	Cornwall
DM	Dry matter
DWG	Daily weight gain
FM	Fresh matter
hh	Household
kg	kilogram
L	Landrace
LW	Large White
MC	Mong Cai pig breed
M. duck	Muscovy-duck
ME	Metabolizable energy (Kcal, Mcal)
Mi.	Million
N	Sample size
No.	Number
S.P. vines	Sweet potato vines
SD	Standard deviation
VND	Vietnam dong (Vietnamese monetary unit)
Y	Yorkshire

Table of Contents

1 Introduction 9
2 Literature review 11
2.1 Agricultural production systems in Vietnam 11
2.1.1 Crop production 11
2.1.2 Livestock production 12
2.1.3 Integration of livestock and crop production 16
2.2 Pig production in Vietnam 17
2.2.1 Overview over pig production 17
2.2.2 Pig production systems and their characteristics 18
2.2.3 Pig breeds 19
2.3 Smallholder pig production in Vietnam 20
2.3.1 Characteristics of smallholder households 20
2.3.2 Characteristic of smallholder pig production in Vietnam 20
2.3.3 Input in smallholder pig production 21
2.3.4 Management in smallholder pig production systems 21
2.3.5 Performance of pigs under smallholder production conditions 22
2.3.6 Output from smallholder pig production 23
2.4 Feeding management in smallholder pig production systems 24
2.4.1 Availability and use of feed resources 24
2.4.2 Quantitative and nutrition of feeding rations for pigs under smallholder production conditions 26
2.4.3 Nutritional requirement of pigs 27
2.4.4 Feeding techniques and feeding management under smallholder production conditions. 27
2.4.5 Monetary input in pig feeding under smallholder production conditions 28
3 Material and methods 30
3.1 Material 30
3.1.1 Study area 30
3.1.2 Selection of households 32
3.2 Methods 32
3.2.1 Collection of secondary information 32
3.2.2 Pre-test of questionnaire 32
3.2.3 Discussion by using communication tools (calendar tool) 32
3.2.4 Key person interview 33
3.2.5 Household interview by using structured questionnaire 33
3.2.6 Measuring of pig weight 34
3.2.7 Quantification of feeding components and feeding ratios 34
3.2.8 Data analysis 34
4 Results 37
4.1 Smallholder production systems in Son La 37
4.1.1 Household members, family structure, work force 37
4.1.2 Land ownership 37
4.1.3 Cropping activities 38
4.1.4 Livestock husbandry 40
4.1.5 Revenue from agricultural activities 41
4.2 Pig production 43
4.2.1 Pig breeds 43
4.2.2 Input in pig production 45
4.2.3 Performances of pigs 46
4.2.4 Output from pig production 49
4.3 Pig feeding 52
4.3.1 Feed resources 52
4.3.2 Quantitative composition of feeding rations 60
4.2.3 Nutritive values of feeding rations 71
4.3.4 Pig feeding management and feeding techniques 76

4.3.5 Monetary input in pig feeding 80
5 Discussion 84
5.1 Discussion of results 84
5.1.2 Smallholder production systems in Son La 84
5.1.2 Pig production 87
5.1.3 Pig feeding 93
5.1.4 Quantitative composition and nutritive values of feeding rations in different seasons 96
5.1.5 Pig feeding management and feeding techniques 100
5.1.6 Monetary input in pig feeding 101
5.2 Discussion of methods 103
5.2.1 Calculation methods 103
5.2.2 Quantitative composition and nutritive values of feeding rations assessed by different methods 104
6 Conclusion 105
7 Summary 107
8 Reference 109
9 Annex 117

List of Tables

Table 1: Pig production systems in Vietnam. 18
Table 2: Number and proportion of different sow genotypes in Vietnam in 1998 20
Table 3: Reproductive performance of sows under smallholder conditions in literature, by genotype 22
Table 4: Growth rate of different pig genotypes under smallholder farm conditions. 23
Table 5: Pig feeding for smallholder farms. 25
Table 6: Nutrient intake by LW-MC crossbreds from 15-50 kg under smallholders in Central Vietnam . 27
Table 7: Nutritional requirements in different reproductive phases of local sows (I and Mong Cai)..... 27
Table 8: Nutritional requirements for fattening pigs of crossbreds amongst local and exotic breeds (Landrace x local pigs and Large White x local pigs) 27
Table 9: Farmers' feeding strategies for different feed components in time of relative feed abundance and shortage, study location Son La province 28
Table 10: Annual feed costs, annual total costs, annual output, benefit for one year, and input and output relation from pig production, calculated for the last 12 month, by village 29
Table 11: Main animal species kept in Son La, population and meat yield 30
Table 12: Overview over villages investigated, and pig production characteristics 31
Table 13: Position and place where key person interviews were done 33
Table 14: Family structure in investigated households, by village (mean ± SD) 37
Table 15: Total land, upland, flat land and forest land per household in the investigated households, by village (% of households, mean ± SD) 38
Table 16: Planting crops and plot size per crop in investigated households, by village (% of households, mean ± SD) 38
Table 17: Cultivation of main crops and total yield of those crops in investigated households, harvested in last 12 months, by village (% of households, mean ± SD) 39
Table 18: Percent of households keeping animals and number of animals kept per household, by village (% of households, mean ± SD)..... 41
Table 19: Percent of households getting a cash revenue from agricultural and off-farm activities, by village in the last 12 months..... 42
Table 20: Percentage of households keeping a certain pig type, and number of pigs per household, by village (% of households, mean ± SD) 43
Table 21: Genotypes of sows and gilts in investigated households, by village 44
Table 22: Percentage of households having certain expenses in pig production, by village (% of households) 45
Table 24: Reproductive performance of sows in investigated households, by breed..... 47
Table 24: Daily weight gain for pigs, by genotype..... 49
Table 25: Percent of households extracting pigs, numbers of extracted pigs per household and average weight of pigs extracted in the last 12 months, by village 51
Table 26: Overview over feedstuffs used in investigated households, by village 52
Table 27: Amount of feedstuffs used for pig production in one year per household in investigated households (% of households, mean ± SD), by village..... 53
Table 28: Overview over harvesting times of main feedstuffs, times of using produced vs. purchased feed, by village..... 56
Table 29: Time of shortage of the main feed resources used for pig feeding in investigated households, by village..... 57
Table 30: Different feeding strategies in different seasons in investigated households, by village..... 58
Table 31: Percentage of investigated households using maize for different purposes in the last 12 month , by village (% of households)..... 59
Table 32: Quantitative composition of feeding rations for empty and pregnant sows on test day in the time of feed shortage, by village (kg feedstuff/sow/day) (% of sows getting the respective feedstuff, mean ± SD of kg feedstuff/sow/day) 61
Table 33: Quantitative composition of feeding rations for lactating sows on test day in the time of feed shortage, by village (kg/sow/day) (% of sows getting the respective feedstuff, mean ± SD of kg feedstuff/sow/day) 63

Table 34: Quantitative composition of feeding rations for fattening pigs of all ages on test day in the time of feed shortage, by village (kg feedstuff/pig/day) (% of pigs getting the respective feedstuff, mean ± SD kg feedstuff/pig/day) 64
Table 35: Quantitative composition of feeding rations for empty and pregnant sows in the time of feed abundance, by village (kg FM/sow/day) (% of sows getting the respective feedstuff, mean ± SD kg feedstuff/sow/day) 65
Table 36: Quantitative composition of feeding rations for lactating sows in investigated households in the time of feed abundance, by village (kg/sow/day) (% of sows getting the respective feedstuff, mean ± SD of kg feedstuff/sow/day) 67
Table 37: Quantitative composition of feeding rations for fattening pigs in the time of feed abundance, by village (% of pigs getting the respective feedstuff, mean ± SD of kg feedstuff/pig/day) 68
Table 38: Quantitative compositions of feeding rations for empty sows and sows in investigated households on test day in the time of feed shortage, assessed by measuring (kg/sow/day), by village (% of sows getting the respective feed stuff, mean ± SD of kg feed/sow/day) 69
Table 39: Quantitative compositions of feeding rations for lactating sows in investigated households on test day in the time of feed shortage, assessed by measuring (kg/sow/day), by village (% of sows getting the respective feed stuff, mean ± SD of kg feed/sow/day) 70
Table 40: Quantitative composition of feeding rations for fattening pigs in investigated households on test day in the time of feed shortage, assessed by measuring, by village (kg/pig/day) (% of pigs getting the respective feed stuff, mean ± SD of kg feed/pig/day) 71
Table 41: Daily intake of crude protein in the ration supplied for empty and pregnant sows at different seasons and assessed by different methods in investigated households, by village (mean ± SD g CP/sow/day) 72
Table 42: Daily intake of metabolizable energy in the ration supplied for empty and pregnant sows at different seasons and assessed by different methods in investigated households, by village (mean ± SD kcal ME/sow/day) 73
Table 43: Daily intake of crude protein in the rations supplied for lactating sows in different seasons and assessed by different methods in investigated households, by village (mean ± SD g CP/sow/day).. 73
Table 44: Daily intake of metabolizable energy supplied for lactating sows in different seasons and assessed by different methods in investigated households, by village. (mean ± SD kcal ME/sow/day) 74
Table 45: Daily intake of crude protein supplied for fattening pigs at different seasons and assessed by different methods in investigated households, by village. (mean ± SD g CP/pig/day)..... 75
Table 46: Daily intake of metabolizable energy supplied for fattening pigs at different seasons and assessed by different methods in investigated households, by village. (mean ± SD kcal ME/pig/day) 75
Table 47: Daily feed intake, crude protein and metabolizable energy supplied for fattening pigs at different seasons and assessed by different methods in investigated households, by genotypes. (mean ± SD kcal ME/pig/day) 76
Table 48: Overview over feeding practices for different types, age groups and reproductive stages of pigs, by village..... 78
Table 49: Water using for pigs in the investigated farms, by village..... 80
Table 50: Purchasing price of different feed components at time of interview (mean, minimum and maximum) 81
Table 51: Seasons of price maxima and price minima..... 81
Table 52: Amount of crude protein (CP) and metabolizable energy (ME) (excluding vegetables) to produce 1 kg of pig extracted in investigated households, by village (mean ± SD)..... 82
Table 53: Annual feed costs, annual total costs, annual revenue, benefit for one year, and input and output relation from pig production, calculated for the last 12 month, by village 83

List of Figures

Figure 1: Development of the cattle and buffalo population in Vietnam 1990-2002 (million heads) 14
Figure 2: Development of the poultry population between 1995 and 1999 (million birds) 15
Figure 3: Development of the pig population between 1995 and 1999 (1 million heads)..... 17
Figure 4: The location of Son La province in Vietnam (red). 30
Figure 5: Location of selected villages in Son La province and schematic view of villages' distance to town 31
Figure 6: Average cash revenue per household from agricultural activities including cropping, livestock (excl. pig) and pig production, and off-farm activities in the last 12 months (mean ± SD), by village. 42
Figure 7: Genotypes of boars used for mating of sows (last litter born, respectively) in investigated households, by village..... 45
Figure 8: Costs in pig production (purchasing feed, buying pigs and costs of services) in one year in investigated households (mean ± SD), by village..... 46
Figure 9: Age-weight plots for pigs of different genotypes and from different villages. Plots include measurements from the first weighing and for a sub-sample of pigs the measurements from the second weighing in addition..... 48
Figure 10: Weight extraction from pig production (selling, slaughtering and giving pigs as a gift) in investigated household in the last 12 months (mean ± SD), by village 51
Figure 11: Amount of maize used for different purposes in the last 12 months in investigated households, by villages (mean ± SD)..... 60
Figure 12: Ban sow with her piglets (Thai farm in Song Ma) (Tra, 2003)..... 117
Figure 13: Mong Cai sow (Kinh farm in Son La) (Lemke, 2002) 117
Figure 14: Keeping pigs in Ban Keo – Song Ma. (Tra, 2003)..... 117
Figure 15: Poor hygienic conditions in Ban Keo – Song Ma. (Tra, 2003). 117

1 Introduction

Vietnam is an agriculture-based economy. Two thirds of the Vietnamese land are hilly and mountainous. Rural upland areas in Vietnam can be characterized by: poorly developed infrastructure, poor resources and unsteadily short and long-term availability of resources (Devendra *et al.*, 1997a). When comparing to the better-off lowland and delta areas of Vietnam, the situation of farmers in Vietnam's mountainous areas is hampered (Kaufmann and Valle Zárate, 2002). The mountainous area can be again separated in the mountain valleys and areas near towns, which are high population density, corresponding a high land pressure, but have a better-developed infrastructure; and in the hillsides, hilltops the population density is low, lower land pressure, but the infrastructure is poorer. This situation of the highlands calls for options of development animal husbandry, especially developing pig production is becoming the best way, to improve farmers' living level.

Pig keeping is widely spread throughout the country and pigs are considered to be one of the most important livestock species (Lehane, 2000). However, pig production is mainly conducted by smallholders in Vietnam (Singh *et al.*, 1996). In smallholder farms, availability of local feed resources used for pigs is unstable and unbalanced throughout the year (Hai and Pryor, 1996). Feed resources and amount used depend on the harvesting seasons because feeds for pigs come mainly from farm-produced feed resources such as maize, cassava, by-products like rice bran, and especially a lot of vegetables. Local pig breeds are predominantly kept by smallholders and are well adapted to farm conditions where feed is low in nutrients and sometimes scarce (Rodriguez *et al.*, 1997). Proportion of local pigs in the total pig population in Vietnam is gradually decreasing due to replacement by exotic and crossbred pigs.

Ban breed is originating from upland areas in Northwest Vietnam, where it was the predominant breed. But introduced higher-yielding pig breeds have stepwise replaced it such as Mong Cai and crossbreds. Even though, they are now still kept on hillsides, and in villages far from town. The respective production systems can be characterised as resource driven: production is adjusted to the utilization of the available resources. Farmers feed their pigs mainly by available farm-produced feed resources but the feed resources are not stable throughout the year. The monetary input in pig feeding is low, but the growth performances of pigs and cash revenue from pig production are also low.

Mong Cai breed is used as the main maternal breed and is kept mainly in Northern Vietnam because of its greater reproductive ability. The improved Mong Cai breed is now also kept in the mountain valleys and areas near town because it has been introduced. The respective production systems can be characterized as demand driven, meaning that resources are reserved for the desired production level. Farmers feed their pigs not only on available farm-produced feeds but also purchased more feeds to supplement pigs with higher quantity feed and better quality of feed. The monetary input is higher but growth performances and cash revenue from pig production are also higher.

Therefore, to find out the most suitable genotypes for the actual farming systems and avoid resource mining, the comparison of input between two smallholder production systems: resource driven production keeping Ban sows and demand driven pig production system keeping MC sows was conducted. Feed is considered as the main cost factor affecting pig production benefit.

There are some studies on pig production in smallholder farms and there are also some studies on feed resources and feeding management of local pigs in Vietnam. The differences in production efficiency of demand and resource driven production systems are indicated but have not been assessed so far and the detailed information on the input in pig production especially feeding input and feed prices have not been considered yet. Otherwise, there is also a lack of studies on feeding management and nutritive values of pig feed diets in different seasons under household conditions. Therefore, there is a need to describe the

current feeding management and feed resources used in different pig keeping systems in order to measure, and analyse constraints and potentials of feeding in pig production systems: relatively far from town – resource driven production systems, and closed to town – demand driven production systems.

For that reasons, a survey on the feed resources and feeding management throughout the year for different pig genotypes in villages far from town and near to town in Son La province was carried out to fulfil the following research objectives:

- to describe utilised feed resources and feeding management,
- to record type (qualitative assessment) and amount (quantitative assessment) of feed components for pigs,
- to assess monetary input in pig feeding

in comparison for pig production in resource and demand driven production systems with the considering seasonal changes in feed resources and feeding practised**.**

2 Literature review

2.1 Agricultural production systems in Vietnam

Agriculture has been and is an important economic sector in Vietnam. About 80% of the total population live in rural areas (Vuu, 1996; Tuyen *et al.*, 1998; Hai, 2002), and 70 % of the population depend on agricultural production for their livelihood (Xuan *et al.*, 1995; Ly, 2001). In 2001, agriculture accounted for 23.6% of the country's Gross Domestic Products (GDP) (National Statistic Yearbook, 2001).

Paris (2002) has found that mixed farming has been the major agricultural system practised by smallholders in Asia. This farming system is also predominantly practised in Vietnam (Ly, 2001).

Dixon *et al.* (2000) have classified the following farming systems for South East Asia: lowland rice farming system, tree-crop mixed farming system, upland intensive mixed farming system and highland extensive mixed farming system. All of these farming systems have been identified in Vietnam.

2.1.1 Crop production

Crop production is the most important part in the agricultural sector in Vietnam. The contribution of crop production to the agricultural Gross Domestic Product was 77.8% in 2001 (National Statistical Yearbook, 2001). The food crop output grew continuously with an average annual growth rate of 5.6% between 1989 and 1999, compared to an average population growth of 2% per year in the same period (Hai, 2002). The cereal output per capita increased steadily (Hai, 2002).

In Southeast Asia, crop production is predominantly conducted in small-scale farms (Devendra and Thomas, 2002a). The characteristics of cropping in Southeast Asia are: wet rice in lowland areas; annual and perennial crops, including stable roots and tubes planted in uplands; fruits, vegetables and root crops planted in gardens. The crop diversification is affected by availability of irrigation (Edwards and Little, 1996).

According to Devendra *et al.* (1997a) and Devendra and Thomas (2002a), cropping systems existing in Vietnam include:

- shifting cultivation: produce upland rice, subsistence agriculture,
- lowland rice-upland annual crop systems: upland annual crop grown after or before the main rice crop,
- multiple upland annual crop systems: dominant production system for uplands and hilly lands. The main crops in this system are maize and vegetables, legumes, cassava,
- annual and perennial crop-inter-cropping systems: in hill lands and on steeper slopes, with maize, upland rice, cassava, taro and sweet potato,
- perennial tree crop systems: based on coconut, rubber and fruit trees providing significant opportunities for the integration of cropping with animal production.

Devendra *et al.* (1997b) found that rice-based systems are predominant in Vietnam and rice is the most important product of the agricultural sector. Since 1989 and after the institution of economic reforms since 1986, Vietnam has become a rice exporter (Hai, 2002). In 1999, the rice export volume peaked at 4510 thousand tonnes, and reached 20% of total exported rice in the market (Hai, 2002).

In the total arable land of 32.9 million ha, the total cropping area was about 12.5 million ha (= 38%), including 10.5 million ha annual crops (National Statistical Yearbook, 2001). Rice cultivation areas have been increasing considerably and reached 7.6 million ha or 61% of the total cropping area in 2000 (Hai,

2002). In 2001, the gross output from paddy was 32 million tonnes/year (National Statistical Yearbook, 2001).

Maize is another main agricultural product, used for animal feeding, especially pig and poultry feeding. Lich (1996) mentioned that about 50% of the total maize yield (equal to 0.6 million tones) has been used for animal husbandry. The Vietnamese maize production has increased following the rapid increase of animal feed demand since last decade, from 660 thousand tons in 1990 to 1930 thousand tons maize in 2000 with an annual average growth rate of 11.2% (Huan *et al.*, 2002). In North Vietnam, the maize production has developed in all agro-ecological zones but especially in the Northern mountainous provinces (Huan *et al.*, 2002).

In addition to maize and rice, crops like sweet potato, cassava, groundnut, soybean and other beans, sugarcane, fruit trees, and perennial commercial trees such as coffee, rubber, tea and coconut are cultivated in Vietnam (Devendra *et al.*, 1997b).

Sweet potato is another important crop used for human consumption and as animal feed. Sweet potato is mainly grown in Northern Vietnam, with more than 46% of the total planted area and about 48% of the total sweet potato yields in the whole country (National Statistical Year Book, 2001).

Soybean is cultivated not only for human consumption but also used for animal production as a protein source (Lich, 1996; Tuyen *et al.*, 1998). However, only about 7.6% of total produced amount of soybean were used for livestock production in 1995 (equal to 9,600 tons) (Tuyen *et al.*, 1998).

The cassava yield in the Northern region was 0.8 million tons and reached 28% of total cassava yield in the whole country (National Statistic Yearbook, 2001). Of which, cassava yield in North-east Vietnam was 0.3 million tonnes equal with 10% of whole cassava yield. Cassava is considered to be a rather important feedstuff for pig production in Central and North Vietnam, especially in the mountainous areas (Ngoan *et al.*, 1996).

2.1.2 Livestock production

Animal production is a major component of the agricultural economy in Asia (Devendra and Thomas, 2002b). In 2001, the livestock sector made a contribution of 19.5% to the agricultural Gross Domestic Product (National Statistic Yearbook, 2001). Livestock husbandry is providing food, enhancing the crop production, providing additional economic goods, services and generating income for farmers (Steinfeld and Mack, 1997). The livestock sector in Vietnam creates employment for about half of the rural population (Tuyen *et al.*, 1998). It also plays an important role in the reduction of poverty and enhancing the family food security, the quality of life and rural development (Tuyen *et al.*, 1998). In rural areas in Vietnam, especially in the mountainous areas, it makes a more important contribution to farm incomes as compared to lowland, where it may make up to 30-40% of the total household income (Vuu, 1996; Tjallden, 1999). For many households, particularly in hilly or mountainous regions, animals are also important for family celebrations and special occasions throughout the year and connected to the local customs and feasts (Xuan *et al.*, 1995; Valle Zárate *et al.*, 2003).

95% of the livestock are owned by small-scale and resource poor farmers in Southeast Asia (Devendra and Thomas, 2002a). Animal husbandry in Vietnam is also mainly carried out by smallholder households (Thong, 1996a), and within mixed farming systems (Ly, 2001). The characteristics of animal production systems in Vietnam are (Ly, 1996; Tjallden, 1999):

- use of indigenous breeds with small body size and low productivity but suitable for local conditions and adapted to poor feeding conditions,

- deficit of protein in animal feeding rations in large parts of the country,
- lack of green fodder of high quality for ruminants,
- poor disease control and veterinary infrastructure,
- limited capital especially for animal feeding and facilities for processing of feeds,
- Weakness in research capacity and in extension services, resulting in slow transfer of technological innovations to smallholders.

According to Xuan *et al.* (1995) and Tung (1999), three animal production systems exist in Vietnam:

- the state-run semi-industrial or industrial farms, which comprise about 5% of the total animal production. These farms usually rear 300 to 1000 dairy cows or 20 to 40 thousand heads of poultry or 500 to1000 sows. These farms are located in all agro-ecological zones,
- the medium size commercial farms, which are private farms and keep an average of 100 to 400 sows, 1000 to 10000 broilers or layers, or 10 to 100 dairy cattle.
- the backyard system, which is the most widely practised throughout the country. These farms usually keep 1 to 2 cattle or buffaloes, 1 to 2 sows and about a dozen of chicken.

The development of animal production in Vietnam has recently been influenced both by a series of incentive policies e.g. establishment of breeding programs, encouragement of animal health and veterinary services; but also by the application of certain technical improvements e.g. artificial insemination (Thong, 1996b). Parallel to the increase of the average annual income per capita, the meat consumption per capita has increased as well (Robinson, 1996). Consequently, the number of livestock in general has increased continuously (Xuan *et al.*, 1995; Thong, 1996a; Ly, 2000). Moreover, Vietnam has become an exporter of non-ruminant meat products in the world (Vercoe *et al.*, 1997), however, until now only small amounts are exported.

The development of animal production in the rural areas has been encouraged based on local conditions such as appropriate animal genotypes kept and sustainable feed resources used, and this promotion has created more employment, improved health status, social and gender benefits, functional literacy, environmental conservation and in addition increased food security and income (Vuu, 1996; Lukefahr and Preston, 1999). Recently, priority programs have been developed in Vietnam to improve livestock production including programs on better utilization of local feedstuffs and improvement measures for breeding stock. Beside the development and utilisation of lean meat pigs, dairy cattle and commercial chicken is considered as one priority in animal production by the Vietnamese government, but also the development and conservation of local animal breeds are new focus of activities.

Ruminant production

In Vietnam, ruminant production is conducted by state farms, medium-sized private commercial farms and by small farms in rural and urban areas (Devendra *et al.*, 1997b). However, small and family operated farms conduct predominantly ruminant production in Vietnam (Tuyen *et al.*, 1998) and with usually low number of ruminants per household (one to two heads). Cattle and buffaloes can make use of agricultural by-products and crop residues (Tuyen *et al.*, 1998). Between 1990 and 2000, the number of cattle has increased with 3.2% annual growth may be due to the high local demand of dairy products and the new policy on dairy cattle and beef cattle development from the Government of Vietnam. The number of buffaloes has been lightly reduced (figure 1), which may be the reason of increasing mechanisation in agricultural sector and the decreasing use of draught animals

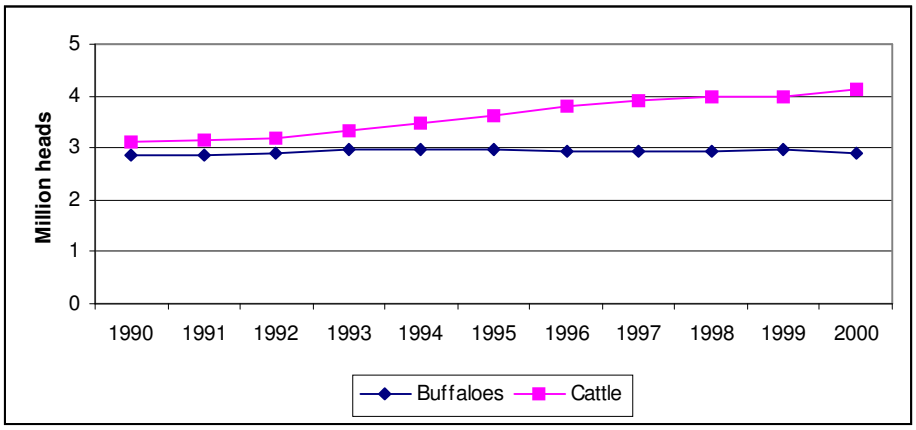


Figure 1: Development of the cattle and buffalo population in Vietnam 1990-2002 (million heads)
Source: National Statistical Yearbook, 2001

Farmers raise cattle mainly for long-term saving and as draught animals (Rodriguez *et al.*, 1997). In 1999, about 3.7 million Yellow cattle were kept in Vietnam accounting for 75% of the total cattle population (Tjallden, 1999). This native breed is mainly used for draught power. Due to their small body size (adult body weight of 160 to 180 kg/head), and the low growth performance under the prevailing keeping conditions, the population of Yellow cattle could not meet the increasing demand for beef (Thuong, 1996a). Dairy cattle and Zebu crossbreeding programs have been established to meet the beef and milk demand. Exotic breeds such as Holstein-Frisian and Red Sindhi have been imported. In 1996, Zebu and crossbred zebu cattle represented about 14.5 % of the total cattle population. Crossbreds were mainly crossbreds between Red Sindhi and local Yellow cattle (Rodriguez *et al.*, 1997; Tuyen *et al.*, 1998). In 1996, about 0.5% of the total cattle population was dairy cattle, mainly crossbreds of Yellow cattle and Holstein-Friesian (Tuyen *et al.*, 1998). The demand for milk has been increasing especially in Ho Chi Minh City and Hanoi for many years and has caused an increase in the number of private dairy farms (Thuong and Vang, 1996).

Buffaloes in Vietnam are almost exclusively kept on smallholder farms and are mainly of the swamp type (Sanh *et al.*, 1996). The buffalo population is mainly kept in Northern Vietnam, and 50% of the buffaloes are found in the north-western uplands (Tjallden, 1999). Keeping buffaloes provides draught power, manure, and a source of saving to the farmers (Hoang and Perkin, 1996). In the past, buffalo meat was second important after beef but its role has increased due to about 50% of meat sold on the market purporting to be beef is actually buffalo meat (Ly, 1996). Production of buffaloes for lowlands to produce meat has become an important activity in the mountainous area in Vietnam (Pehu, 1999).

In general, goats are raised in marginal areas. However, the goat populations in each region in Vietnam are closely related to the consumers' tradition and eating habits (Thong *et al.*, 1991). In recent years, urban consumers have shown an increasing consumption of goat meat and milk products but still do not use them for daily consumption. In 1995, the total goat population was 0.4 million, of which 72% were kept in North Vietnam and 28% in South Vietnam (Binh *et al.*, 1996). The biggest part of the goat population was concentrated in mountainous areas (Binh *et al.*, 1996). Goats are usually kept under extensive conditions in small herds of 5 to 7 heads (Thong *et al.*, 1991). The main Vietnamese goat breeds are Bach Thao goats (dairy goat) and Co goat (meat type) and make up about 80 % of the total goat population (Binh *et al.*, 1996). Exotic goat breeds have been imported with the objective to improve the goat production as well as the dairy goat performance of local goat breeds (Binh *et al.*, 1996).

The combination of tethered grazing and cut-and-carry are the most common methods of feeding cattle and buffaloes (Danh *et al.*, 1996). Ruminants are kept in the cropping area, are fed almost exclusively on fibrous crop residues and are allowed only strictly controlled access to grazing on road sides, fallow land and raised boundaries between rice fields and other cropping areas (Ogle and Phuc, 1997). However, free grazing is the most common way of keeping ruminants in smallholders, especially in mountainous area (Quan, 2000). The areas for free ranging are declining due to expansion of crop production, and the soil quality in grazing areas is often low; therefore quality and quantity of available forage are limited (Quan, 2000). Shortage of pasture will be the main constraint for ruminant keeping. By-products and crop residues (like rice straw, sugar cane top, green maize leaves) are also used for ruminants (Duong *et al.*, 1996), but the amount, the quality, and the degree of processing are low (Quan, 2000). In the time of feed shortage, rice straw is often used for feeding at night, in cold, and rainy weather when grazing is not possible (Ly, 1996).

Poultry production

Poultry is present in almost all agricultural households, which comprise nearly 80% of the population of Vietnam. Flock size varies from a dozen to hundreds of birds (Vang and Ly, 2000). Farmers raise mainly local poultry breeds such as Ri chicken or Bau and Co ducks (Liem, 1996). Poultry feeding in smallholder households is based on agricultural crops and agricultural by-products (Liem, 1996). Over the last years, the poultry population has been increasing continuously with 9.2 % annual growth rate (see figure 2). In the areas which cultivated paddy and have many rivers, ducks are kept in higher populations such as in Mekong delta. In regions of high altitude such as Central Highland and the Southeast of Vietnam, higher chicken populations are kept (Liem, 1996).

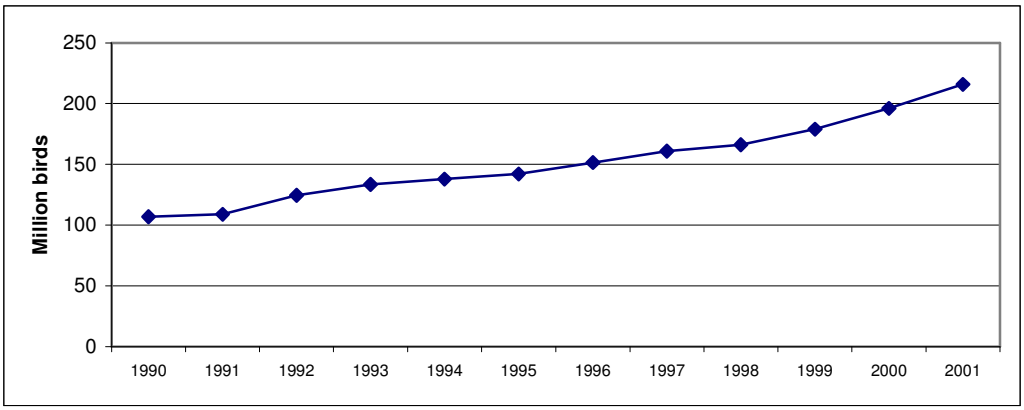


Figure 2: Development of the poultry population between 1995 and 1999 (million birds)
Source: National statistical Yearbook, 2001

The chicken production ranks second behind swine production, accounting for nearly 19% of agricultural Gross Domestic Products in the total livestock production (National Statistic Yearbook, 2001). Local chicken breeds make up about 96% of the total population (Ly, 1996). The Ri breed makes up the major proportion of chicken flocks in all regions in Vietnam since it is a dual-purpose bird, well adapted to prevailing keeping and climatic conditions, and with the ability to scavenge (Thong, 1996a). Besides local breeds, crossbreds of local and exotic breeds are becoming increasingly popular such as Rhode-Ri and Kabir-Ri, due to their higher production performance. These crossbred chickens still show a similar physical appearance and comparable taste of meat like the local chicken breeds. Today, the most common exotic breeds are Arbor Acres, Ross 208 and Lohmann Meat (meat type), and Goldline, Brown-Nick (egg type) (Thuong and Vang, 1996). Exotic chickens are mainly kept in breeding centres (Thong, 1996). In

addition, colour feature chickens like Jancun, Luong Phuong, Kabir, and Sasso have been imported to be kept as free ranging chicken in gardens (Thuong and Vang, 1996).

In the last years, there has been an increase in the number of private farms for commercial chicken in some areas, where the conditions for commercial chicken raising have been developed e.g. demand of consumers, available markets and feed resources (Thuong and Vang, 1996). With regard to chicken keeping, three production systems are distinguished (Vang and Son, 2000):

- the scavenging system with low initial investment and input. Chicken are scavenging, hatching is natural. The system is characterised by a high disease occurrence and a high poultry mortality,
- the semi-commercial or semi-intensive system combining the extensive and the semi-intensive systems with better nutrition, better disease control and bigger flock size (Liem, 1996),
- the commercial or intensive system, mainly exotic breeds are kept. Mainly set up in cities or peri-urban areas, where availability of services is better (Liem, 1996), and demand for meat and eggs is high (Vang and Son, 2000).

In Vietnam, the number of ducks kept depends on the available water sources (Binh, 1996). 70% of the duck flock is kept in South Vietnam (Nind and Tu, 1998). Duck keeping is strongly developed in the Mekong River Delta, where both water resources and feed resources (due to a developed rice production) are available (Liem, 1996). Keeping ducks can be seen as a low-input enterprise since ducks can pick up about 70% of the rice left in the paddy plots after harvesting (Liem, 1996). There are several local duck breeds, e.g. Co duck and Bau duck. The Co breed, which makes up about 78 % of the total duck population in Vietnam, represents the egg type with a performance of about 180 to 200 eggs/year (Dong and Hieu, 1996). The Bau duck breed represents the meat type with a live weight of 1.5 to 2.0 kg at maturity (Ly, 1996). In addition, some exotic duck breeds have been imported in recent years including Cherry Valley, Perkin, and Cherry Valley Super Meat and Khaki Campbell (Ly, 1996).

2.1.3 Integration of livestock and crop production

Crop-livestock-integrated systems have often developed over hundreds of years, and are reasonably productive and inherently sustainable (Ogle and Phuc, 1997; Lukefahr and Preston, 1999). Farmers often integrate crops and animals to maximise the income from their small land area and income per capita (Paris, 2002). Other objectives are to minimise production risks, diversify sources of income, guarantee feed security and increase land productivity and improve production sustainability (Paris, 2002). It is said that in the next two decades, the demand for animal products in Asia will be more than double. Development of crop-animal production systems in Asia will be a consequence of this trend (Devendra and Thomas, 2002b). A sustainable development strategy for small-scale farms in Southeast Asia may be through integration of crop, fish and animals (Edwards and Little, 1996). Rice by-products such as rice bran and broken rice are important feed resources for livestock production. Rice straw is the main feed source for ruminant in wintertime. The most commonly practiced farming systems in the delta regions of Vietnam involve the integration of several components, namely livestock, aquaculture, horticulture and rice cultivation (called the VAC systems mean garden (crops) – pond (fish) and the stable (animals)) (Ogle and Phuc, 1997).

According to Devendra *et al.* (1997b), four integrated systems, which include animals, can be observed in Vietnam:

- pigs – ducks – chicken – vegetables – fruits – aquaculture
- pigs – ducks – goats – rice – vegetables – fruits – aquaculture

- pigs – ducks – cattle – vegetables – fruits – aquaculture
- goats – pigs – fruits – aquaculture

However, the integration is different not only between regions but also within regions. In the lowlands, dominant integrated systems comprise rice – secondary crops – non-ruminants – ruminants. In highland, integrated systems comprise cash crops – upland rice – ruminants – non-ruminants (Tung, 1999).

Pig production is closely integrated with crop production system in most of production systems and plays an important role in the overall agriculture production system, especially, in small-scale livestock production (Tuyen *et al.*, 1998). In addition, the appropriate use of local feed resources and indigenous pig breeds in smallholders requires close integration between crops and pigs within the system (Rodriguez *et al.*, 1997).

2.2 Pig production in Vietnam

2.2.1 Overview over pig production

The pig can be considered to be the most important domestic animal in Vietnam. Due to the high population density in Vietnam and the resulting limitations in the availability of land for cropping, pig rearing is considered to be an important activity of farm households (Thuan *et al.*, 2000). The pig population of Vietnam was about 19 million pigs in 1999 including about 14% sows and 86% fatteners (Kinh *et al.*, 2002), and was in absolute terms the biggest pig population in South-East Asia (with the exception of China). The number of pigs in Vietnam has been steadily increasing over the last years with 7.4% annual growth rate (figure 3). The percentage of pig genotypes with high lean meat and a low fat percentage in the total population is also increasing gradually (Ly, 2000). However, the overall production performance of pigs under smallholder farm conditions is considered to be low.

Pork is the main source of animal protein for human consumption and makes up about 70% of the total meat consumed in Vietnam (Singh *et al.*, 1996; Hai and Nguyen, 1997). Pigs further constitute a meat source, a source of manure (used as fertilizer), a source of income, but also play an importance role in people' s customs (Hai and Pryor, 1996; Peters, 1998; Jones, 2002; Valle Zárate *et al.*, 2003).

Hai and Pryor (1996) have shown that the main constraints for the development of pig production are unfavourable policies, an insufficient breeding system, a poor veterinary management, insufficient utilisation of feedstuffs in each region, weakness of the marketing system and a poor environmental hygiene.

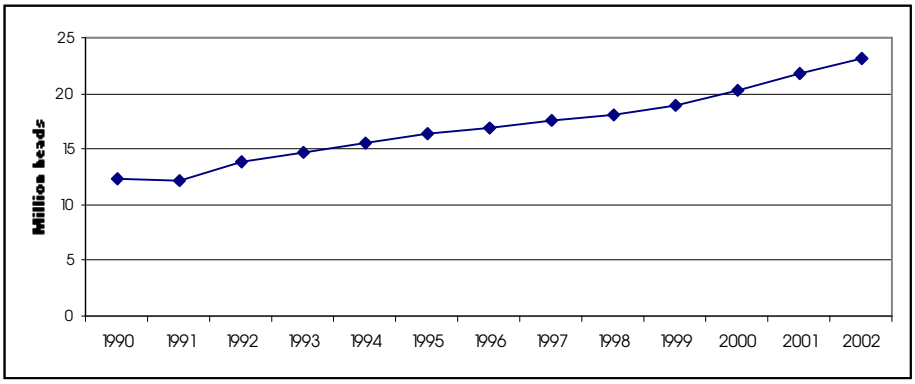


Figure 3: Development of the pig population between 1995 and 1999 (1 million heads)
Source: FAO, 2003.

Since the early 1990s, Vietnam customers in urban areas have increasingly preferred to buy pork with higher lean meat content (Thuong and Vang, 1996). Finished pigs with a higher lean meat percentage were sold easier and at higher prices than finished pigs with a low lean meat percentage (Thuong and Vang, 1996). Today, pig production in Vietnam has two objectives namely to fulfil the domestic demand for pork and to produce pork for the export. However, the pork amount exported is still small and makes up only between 5 to 8% of the total pork production in Vietnam (Nha *et al.*, 1996). However, keeping pigs under smallholder's production conditions is still predominant (Thong *et al.*, 1996; Singh *et al.*, 1996; Kinh *et al.*, 2002).

2.2.2 Pig production systems and their characteristics

Different authors have used different ways to classify pig production systems in Vietnam. For instance, Xuan *et al.* (1995) distinguish three different systems:

- backyard farms, using farm by-products to feed pigs and making use of the labour force of women and children in the family,
- medium size commercial farms with 100 to 400 sows,
- state run semi-industrial or industrial farms with 500 to 1000 sows/farm.

According to Kinh *et al.* (2002), there are four types of pig keeping systems in Vietnam including smallholder, small-medium, medium and large pig production systems. Smallholder pig production systems occupy 80% of pig population (table 1). In smallholder farms in Northern Vietnam, local pig breeds are mainly kept.

In addition, Lan (2000) and Thuy (2001) have defined five types of pig keeping systems in Vietnam:

- weaner production: keeping sows to produced weaners,
- grower production: keep sows to produce grower and keeping and/or purchasing weaners to produce growers,
- weaner-grower-fattening production,
- fattening production from weaners, and
- fattening production from growers.

Table 1: Pig production systems in Vietnam.

	Smallholder	**Small-medium**	**Medium**	**Large**
Herd size	1–10 pigs	5–20 sows or 30–100 fatteners	20–500 sows or 100–400 fatteners	> 500 sows or > 4000 fatteners
Trends	Modest increase	Significant growth	Rapid growth	Modest growth
% of total pig herd in Vietnam	80	10	5	5
No. of pigs (mil)	15.1	1.9	0.9	0.9
Breeds	North: mostly local. South: mostly cross with exotic	Cross and exotic	Exotic	Exotic

Source: Kinh *et al.* (2002)

2.2.3 Pig breeds

Thong *et al.* (1996) and Truc (2001) have classified three pig types occurring in Vietnam:

- the meat type: Yorkshire, Landrace and various crossbreds of imported western pigs e.g. Yorkshire x Landrace, Yorkshire x Landrace x Duroc,
- the bacon type: improved local pigs such as Ba Xuyen and Thuoc Nhieu, crossbreds with more than 50% exotic blood,
- the lard type: native breeds, improve local pig breeds and crossbreds with less than 50% exotic blood.

The last two types make up more than 70% of the total pig population in Vietnam (Thong *et al.*, 1996).

In North and Central Vietnam, local breeds like Mong Cai, Ban (Meo), Moi and Muong Khuong are predominantly kept at smallholder farms (Thong *et al.*, 1996). Local breeds can consume lower quality feed and require less time and care intensity compared to exotic pigs or crossbred pigs, and the input required for local breeds is lower, e.g. the price of buying animals, cheap feed resources, and a lower requirement of veterinary care (Rodriguez *et al.*, 1997). However, the productivity of local pigs is also low e.g. a low growth performance and a high feed conversion rate (Hai and Nguyen, 1997). However, under the poor keeping condition MC pig breed still grow well while exotic breeds do not (Lai, 1998). The carcass of local breeds contains a high proportion of fat and a low lean meat percentage (Singh, *et al.*, 1996; Ly, 1996). The Mong Cai breed has become the major sow line in Vietnam (table 2). This breed has a higher reproductive performance compared to other local pig breeds. It is kept in more market oriented production systems but also requires higher investments in order to achieve a higher performance (Ly, 1993). The Ban breed is kept predominantly in the mountainous, more remote villages in more subsistence-oriented production systems (Anh and Dzung, 1994; Ly *et al.*, 1999). The Meo pig is stepwise replaced by higher-yielding pig breeds such Mong Cai or crossbreds.

In South Vietnam, higher yielding genotypes such as Ba Xuyen and Thuoc Nhieu (crossbreds of uncertain genetic make-up) and other crossbred genotypes are predominantly kept (Thong, 1996a).

Regarding exotic breeds, mainly Landrace, Yorkshire, Hampshire and Duroc have been imported (Ly, 1996). Exotic breeds and crossbreds are often kept in the big farms and in peri-urban areas and show higher production performance under favourable keeping conditions (Hai *et al.*, 1996; Van *et al.*, 2001). Keeping those genotypes is connected with a higher production risk due to their susceptibility to diseases – one constraint for farmers to keep exotic/crossbred pigs. Another big constraint is the high investment required, especially regarding feed. However, keeping improved genotypes of fattening pigs in small-scale farms can return a benefit when high-quality feed can be provided by better-off farmers (Viet *et al.*, 1996).

Crossbreds between local and exotic breeds are widely distributed in Vietnam (Ly, 1996). Crossing programs usually include (Y x MC), (L x MC), (Y x Thuoc Nhieu), (Y x Ba Xuyen), (Y x (L x MC). In 1996, about 60% of the fattening pig population were commercial crossbreds (Ly, 1996). The crossing of local pigs with Y and L results in an increase in the growth performance (Hai and Pryor, 1996).

Table 2: Number and proportion of different sow genotypes in Vietnam in 1998

Criteria	**Number (head)**	**%**
Exotic sows and crossbreds (>50% exotic)	190,600	7.3
F_1 sow crossbreds (<50% exotic)	872,300	33.5
Mong Cai	1,351,200	51.9
Others local sow breeds	188,200	7.3
Sow population in Vietnam	**2,602,300**	**100.0**

Source: Thien (2002)

2.3 Smallholder pig production in Vietnam

In Southeast Asia as well as in Vietnam, majority of pig producers are smallholders and most of them live in rural areas (Jones, 2002). Smallholder farming systems comprise the predominant part of pig production in Vietnam (Thong *et al.*, 1996). Pigs kept in smallholder farms account for about 80% of the total pig population (Kinh *et al.*, 2002).

2.3.1 Characteristics of smallholder households

Waters-Bayer and Bayer (1992) have defined smallholders as families, which practise labour-intensive forms of farming with low levels of purchased inputs and with no more than a few acres of land for the more or less exclusive use within the household. In addition, their production system is not specialised but diversified regarding crop and livestock production. (Lukefahr and Preston, 1999) found small-scale farms are not only limited landholdings but also have limited access to capital, equipment and supplies. Devendra and Thomas (2002b) have defined small farm as farms with low capital input; limited access to resources; low level of economic efficiency; diversified agriculture and resources used; conservative farmers who are illiterate, living on the threshold between subsistence and poverty, and suffer from inability to use new technology.

Smallholder households in Vietnam are said to be characterised by low economic power and low levels of formal education (Ly and Chinh, 1996; Ly, 2000). Smallholders in Vietnam keep only small numbers of livestock, about one to two heads of big ruminants, about 1 to 2 sows or 3-5 fattening pigs and a dozen of poultry (Ly and Chinh, 1996; Thong, 1996). Livestock fulfils diverse functions in smallholder production systems: ensuring against production risks, and utilisation of low-cost feedstuffs based on farm-generated resources (Waters-Bayer and Bayer, 1992). Local livestock breeds are mainly kept under smallholder farm conditions (Lukefahr and Preston, 1999). In smallholder production systems, women play an important role in animal husbandry (Lukefahr and Preston, 1999).

2.3.2 Characteristic of smallholder pig production in Vietnam

Devendra *et al.* (1997a) found that smallholder pig production in Vietnam is often integrated with several animal species such as ducks, chicken, ruminants and fish, and is usually integrated with crop production.

Smallholder pig production systems are based on the keeping of indigenous breeds (Ogle and Phuc, 1997), due to their adaptability to the prevailing environment conditions and to the low-input systems (Ngoan *et al.*, 1996).

Pig production in smallholder farms is based on the use of farm-produced feedstuffs and agricultural by-products and a traditional feeding management. The utilised feed and feeding rations are characterised by a high fibre content and low amounts of protein and energy (Loc *et al.*, 1997). Monetary input in feeding in these systems is low.

Farmers keep sows or fattening pigs, or both sows and fatteners (Lan, 2000). Generally speaking, 1 to 2 sows and 3-5 fattening pigs are kept per smallholder (Singh *et al.*, 1996); or 1-5 pigs (Lan, 2000); or 1-2 sows and 2-10 fattening pigs are kept in smallholder farms depending on the families' situation (Ogle and Phuc, 1997). Socio-economic conditions of smallholder farms greatly affect on the pig keeping. Pig production is better developed in rich smallholder farms but is not well performed in poor smallholder farms with low number of pig per litter and low number of litters per sow per year (Thuan *et al.*, 2000). In addition, Valle Zárate *et al.* (2003) mentioned that rich households can keep a big herds of fattening pigs while a poor household can keep a sow or few fattening pigs with available household resources.

In smallholder farms in the study region, pigs are sold after weaning for fattening/breeding purpose, and as fatteners for slaughter. However, farmers may sell fattening pigs earlier than optimum due to cash or feed shortages (Lemke *et al.*, 2002). Almost all pig producers in Vietnam sell pigs as living animals (Kinh *et al.*, 2002). Most of the smallholder farmers sell pigs through middlemen. The price of pigs is based on the estimated carcass quality in case of fattening pigs (Kinh *et al.*, 2002).

In smallholder farms, pig keeping is mainly a task of women and children, which is especially true for pig feeding (Tung, 1999).

2.3.3 Input in smallholder pig production

Input in pig production includes pigs, capital, feed, and labour (Steinfeld and Mack, 1997). Pigs themselves are an input resource but difficult to quantify because of their mobility (Steinfeld and Mack, 1997). According to Astrom (2000), most smallholders keep between two and four piglets from a sow's offspring and sell the rest. On the contrary, Lan (2000) found that only low percentage of smallholder farms keep their own pigs (26%) whereas 74% of farmers bought pigs under intensive pig production. Feed input includes farm-produced feed and purchased feed. The capital input includes the aspects of buying breeding/animals for fattening, buy feedstuffs, payment of veterinary care as well as mating fee (Thuy, 2001).

When compared to the other inputs in the intensive keeping system, input in feeding is considered as the most important part equal to 88% (Lan, 2000), and 94% (Thuy, 2001) of total costs. On the other hand, buying feed costs in the fattening pig keeping farms are lower with only 70% (Thuy, 2001).

2.3.4 Management in smallholder pig production systems

Management in smallholder farms includes the aspects of breeding, feeding, and hygiene. This part will focus on the breeding management and hygienic management.

Breeding management varies in different production systems of different ethnic groups in Vietnam (Lemke *et al.*, 2000). Piglets are often weaned late, the common weaning age location lies between 45 and 90 days; some farmers do not wean their piglets at all (Duyet, 2000; Lemke *et al.*, 2000; Kaufmann and Valle Zárate, 2002). Lan (2000) found the average weaning age of piglets was 57 days. Better piglet management will improve reproductive performance of sows raised by smallholder farms (Taveros and More, 2002). Sows are culled when they no longer to able to yield a good performance (Lan, 2000).

Sows are commonly inseminated by AI in smallholder farms in Northern Vietnam in intensive production (Lan, 2000). Today, many farmers return to natural mating for their sows. Boars are available also in remote areas. Lemke *et al.* (2000) found that few Kinh farmers used female offspring for replacement of their own sows. Quac *et al.* (2000) stated that in smallholder farms in Vietnam's mountainous areas, poorly developed management skills in pig production negatively influence the performances of pigs.

The hygienic management in smallholder pig production is considered to be poor (Loc *et al.*, 1996), which has a negative impact on the animal losses in smallholder pig production. Hog cholera, Salmonellosis, respiratory diseases are the most frequent diseases in small-scale pig production in Central Vietnam (Loc *et al.*, 1996), classical swine fever (Lan, 2000) and food-and-mouth disease (Thuy, 2001) in smallholder farms in Northern Vietnam. In other hand, Tung (1999) found that Pasteurellosis and Colibacilosis are common diseases, causing high losses in smallholder farms in North Vietnam. Most of farmers call veterinary services or buy medicine on their own (Lemke *et al.*, 2000). Antibiotics can be obtained easily and many farmers treat their animals themselves (Devendra *et al.*, 1997c). In the highlands, the percentage of households vaccinating their animals is lower than in the lowlands (59% versus 69%) (Tung, 1999). Vaccination has a lower coverage in remote areas. Not all of farmers accept vaccination due to high costs or considered as not necessary (Lemke *et al.*, 2000).

2.3.5 Performance of pigs under smallholder production conditions

Reproductive performance

The performance of pigs depends on the environment including keeping conditions and on the genotype of pigs (Lemke *et al.*, 2000). The reproductive performance of sows under smallholder production conditions can among others be influenced by factors like improper use of selection, inadequate feeding of gilts and sows, poor management of boars, and problems with detecting heat or timing of insemination (Kinh *et al.*, 2002).

Ban pigs show a low reproductive performance under extensive production conditions. Mong Cai pigs show very high reproductive performance under different production systems as compared to other genotypes (table 3). However, MC versus Ban has not been tested under the same keeping conditions. L and LW show very high numbers of litters per sow per year under semi-intensive production conditions.

Table 3: Reproductive performance of sows under smallholder conditions in literature, by genotype

Genotype	**Production system**	**No. litters/ sow/year**	**No. pig born alive/litter**	**No. weaning piglets/litter**	**Source**
Ban	Extensive	1.0	5.4	4.3	Lemke *et al.*, 2000
Ban	Extensive	1.2	7.3	-	Lemke *et al.*, 2002
MC	Extensive	1.5	12.4	11.5	Lemke *et al.*, 2000
MC	Semi-intensive	-	10.3 – 11.2	9.1 – 9.8	Loc, 2000
MC	Semi-intensive	1.8	11.2	-	Lemke *et al.*, 2002
LW x MC	Semi-intensive	-	10.6	9.0	Duong and Do, 2000
LW x MC	Semi-intensive	-	9.2	7.3	Quac *et al.*, 2000
L x LW x MC	Semi-intensive	1.9	12.0	10.7	Hot *et al.*, 1999
LW and L	Semi-intensive	1.8 – 2.2	8.8	7.5	Duyet, 2000
LW and L	Intensive	-	10.6	9.3	Le and Tuyen, 1998

Growth performance

Production performances of pigs also depend on many factors such as management practices, environment and the pig breeds kept (Lemke *et al.*, 2000). Table 4 shows growth performance data determined by different authors for local breeds, crossbreds and exotic breeds in Vietnam. However, data were recorded in different production systems using different ways of calculation and are therefore hardly comparable. Under extensive production conditions, different genotypes have relatively low performances, especially, Ban pig. Under better keeping conditions, pigs have a higher growth rate such as LW x MC pigs (Loc, 1996).

Table 4: Growth rate of different pig genotypes under smallholder farm conditions.

Genotypes	**Production system**	**Location**	**DWG (g/pig/day)**	**Sources**
Ban	Extensive	Son La province	61	Valle Zárate *et al.*, 2003
Ban	Extensive	Son La province	70	Lemke *et al.*, 2000
Ban	Extensive	Son La province	185	Lemke *et al.*, 2000
LW x Ban	Extensive	Son La province	115	Valle Zárate *et al.*, 2003
MC	Extensive	Son La province	166	Valle Zárate *et al.*, 2003
MC	Extensive	Son La province	190	Kaufmann and Valle Zárate, 2002
MC	Semi-intensive	Northern Vietnam	411	Quac *et al.*, 2000
LW x MC	Extensive	Son La province	165	Valle Zárate *et al.*, 2003
LW x MC	Extensive	Central Vietnam	204*	Loc, 1996
LW x MC	Semi-intensive	Central Vietnam	375	Loc, 1996
LW x MC	Semi-intensive	Central Vietnam	398 – 405	Loc, 2000
LW x MC	Intensive	Northern Vietnam	418	Quac *et al.*, 2000
LW and L	Intensive	Ha Tay province	567 – 819	Viet *et al.*, 1996

*fed only farm-produced feeding resources

2.3.6 Output from smallholder pig production

In smallholder farms can be raised both for subsistence or commercial reasons, with an increasing emphasis on the second role (Perkin, 2002). In villages with lower market access and more subsistence oriented production, keeping pigs for home consumption still plays a considerable role, especially compared to villages near town with better market access and more market-oriented production (Thuy *et al.*, 2002; Lemke *et al.*, 2002).

Output from pig production includes number and weight of weaned piglets sold, number and weight of fattening pigs sold, slaughtered pigs and pigs are given as a gift. In the other hand, output from pig production can be considered as cash sources from pig production, and manure.

Different pig performances result in a different total output from the pig herd in one year (Lemke *et al.*, 2002). In villages with more market-oriented production, an extraction of about 540 kg pig live weight/hh/year was recorded; while on the other hand in villages with lower market orientation, low extraction levels of about 160 kg live weight/hh/year were determined (Lemke *et al.*, 2002). The total extraction of pig weight was lightly higher in a study of Thuy *et al.* (2002): 610 kg pig live

weight/hh/year in more market-oriented village and 230 kg pig live weight/hh/year in less marker-oriented village

Lan (2000) found that a MC sow could produce 22 piglets/year with an average weaning weight of 8.2kg/piglet, equal with 2.2 million VND under intensive production level. Output from one fattening pig was 70kg, equal with about 0.7 million VND/fattening period (4 months) (Lan, 2000). Thuy (2001) showed the output from farms, which produce weaning piglets, was 22.4 piglets (MC x exotic breeds) with 8.8 kg of weight/pig on average. Farmers can yield 2.3 million VND/year under intensive production conditions. In addition, she showed that the output in term of weight from fattening pigs was 80kg/fattening pigs, equal with 0.7 million VND/fattening period (4 months). However, in farms, where diseases occurred, output of pig production was much lower in term of weight and cash (Lan, 2000; Thuy, 2001).

In smallholder farms, pig manure is used as fertilizer for rice and other crops, and is considered one of the main reasons for keeping pigs (Astrom, 1997; Peters, 1998; Tjallden, 1999; Lehane, 2000). On the contrary, Tung (1999) found that pig manure in highland households was not as important as it was in lowland households due to its important role in crop production.

2.4 Feeding management in smallholder pig production systems

2.4.1 Availability and use of feed resources

In Vietnam, crops are diverse, and local feed resources are plentiful (Singh *et al.*, 1996). Cassava, rice bran and rice, fermented fish, concentrate feed and rice distiller's by products are used all year round. Whereas, maize, sweet potato vines and water spinach are used on a seasonal base (Loc *et al.* 2003).

Pigs are often fed available feed from the farm (Tjallden, 1999). In addition, farmers buy additional soybean, maize, rice, rice by-products or cassava root (Tjallden, 1999). Lemke *et al.* (2000) found that almost all Kinh households buy feed such as vegetables, maize or cassava for feeding but few farms use soybean or fish in Northern Vietnam. On the contrary, Thai and H`mong farmers often can not afford to buy feed or are not willing to spend money on pig feed and they may overcome feed shortage by collecting feed in forest. However, it is true for Thai farmers, which stay in remote areas only (Lemke *et al.*, 2000).

The main protein sources in pig diets in Central Vietnam are fish, soybean, groundnut cake and shrimp by-products, but they are rather expensive (Ly *et al.*, 2003). Besides the farm-produced feed resources, non-farm produced feeds such as distiller's grain or so ybean curds are used for pigs (Lan, 2000).

As seen in the table 5 below, smallholder farms rarely used concentrate feed for pigs. However, mixing complete feed and farm-produced feeds or mixing farm-produced feed with by-products is more common in smallholder farms. In this table authors did not clarify the term "popular" but it is assumed to explained the amount and frequency of feed used.

In smallholder farms, feed resource scarcity, poor nutritional quality of diets, and less availability and high price of conventional protein supplements are major constraints to pig production (Loc *et al.*, 1997 Rodriguez and Preston, 1997).

Table 5: Pig feeding for smallholder farms.

Production systems	**100% complete feed**	**Concentrate + farm-produced feeds**	**Complete feed + farm-produced feeds**	**Farm-produced feeds + by-products**
Smallholders	0/+	+	++	+++
Large & medium scale	+++	++	0	0

Key to symbols: 0 = no use; + less popular; ++ popular; +++ very popular
Source: Kinh *et al.* (2002)

Farm-grown feed resources

The main farm-produced feed resources for pigs in Vietnam include maize, rice bran, broken rice, cassava, soybean, and different vegetables (Ngoan *et al.*, 1996; Tuyen *et al.*, 1998), including plants with very low nutritive value like banana stem. Quantity and quality of local feed resources are not stable throughout the year (Hai and Pryor, 1996). After harvest, ration contains higher levels of energy, but energy-rich feed is very limited in the off-season (Hai and Pryor, 1996) and feed shortage often occurs before the next harvest (Lemke *et al.*, 2000). In smallholder pig production systems, mainly crop by-products occupy 84% to 97.5% of the total feed amount used (Lan, 2000; Kinh *et al.*, 2002). The use of those feed resources depends on the seasonality of production.

Maize has a relatively high nutritive value in term of protein content (Huan *et al.*, 2002). Maize is also considered as the high-energy feedstuff (Church, 1991). Crude protein content is 8.8% and ME content is 3081 kcal (Chinh *et al.*, 2001). Maize is a very digestible and palatable feed (Church, 1991). Maize accounts for 45-49% in the rate of feed for pig feed under smallholder farms (Huan *et al.*, 2002). Maize is often harvested from September to November and from December to January in the Northeast region of Vietnam in the main supply source of maize. Therefore maize is available in market during this time (Huan *et al.*, 2002). However, supply of maize is not stable during 12 months of the year. A shortage of maize often occurs from April to August in Northern Vietnam (Huan *et al.*, 2002). During the time of maize shortage, its price in the market increases. In addition, maize prices fluctuate between harvest and other times of the year due to the lack of adequate processing and storage facilities (Tuyen *et al.*, 1998). The most expensive maize price was 2500 VND/kg and the cheapest maize price n market was around 1800 VND in Northern Vietnam (Huan *et al.*, 2002).

Rice bran is an energy rich feed (Eusebio, 1980). Its crude protein is relatively high with 7.6% and its energy content is 1325 kcal (Chinh *et al.*, 2001). 98% smallholder farms used rice bran for pig production (Kinh *et al.*, 2002). It is interesting to see that a basal ratio of rice bran and banana stem would give the better fattening result as compared with ratio of maize and banana stem (Falvey, 1981). Rice bran is available in farms after harvesting of rice, especially when milling rice for home consumption and is only stored in small amount due to fast changing quality. However, rice bran has a high crude fibre (8.6-19.6%) and should not be used with over 40% for pig feed (Tran *et al.*, 1985).

According to Eusebio (1980) and Church (1991), cassava is an energy source for animals. However, cassava root is low in protein and contains cyanide (Loc, 1997; Perez, 1997). The feeding more than 50% cassava meal in the ration decreases the live weight gain and the feed conversion of pigs (Eusebio, 1980). However, the diets containing 60% of whole cassava plants such as flour, peels, leaves and tender stems had no adverse effect on the performance of growing pigs (Akinfala and Tewe, 2001). Using ensiled cassava and cassava by-products can replace up to 50% of the cereal by-products (rice bran) in pig diets under smallholder farm conditions (Ngoan *et al.*, 1996). However, processed cassava is not fed common in Vietnam. in Vietnam, though, the price of cassava roots and cassava by-products is cheaper than that of rice bran and maize (Ngoan *et al.*, 1996). The harvesting time of cassava is from March to April and from

October to December (Phuc *et al.*, 1997). In 1993 farm gate prices were between 150 and 250VND/kg for fresh cassava. While the traders sell the cassava for about 300-400VND/kg (Rake *et al.*, 1993). Loc (1996) found that the farmers often sold fresh cassava with low price (250VND/kg) but often buy dry cassava with 1600-1800VND/kg in Central Vietnam.

Soybeans can be used as protein source for animals, it is palatable, high digestible, and high energy value (Church, 1991). However, raw soybeans are harmful for pigs (Church, 1991). In some farms, a small amount of soybeans is used as protein-rich supplement. According to Kinh *et al.* (2002), only 5% of soybeans produced in whole country is used for pigs. In 1993, the soybean price was about 4000 VND (Rake *et al.*, 1993).

Vegetables used as pig feeds include mainly sweet potato vines but also other garden and water plants, old leaves of cabbage, watercress, wild taro and forest vegetables. Sweet potato leaves have high protein content and can be used as a protein supplement for pigs (Ly *et al.*, 2003). They can be planted and harvested all year round in case water resources are available (Duyet et al, 2003). Banana stem is also a main feed resource even though its poor nutritive values (0.6%CP and 94kcal/kg DM).

Commercial feed

Commercial feed includes concentrate and fishmeal. Both are purchased by smallholders in varying amounts and with varying frequency (Tung, 1999; Lan, 2000; Valle Zárate *et al.*, 2003). Good quality fish meals is excellent sources of proteins and fishmeal is highly digestible (Church, 1991). However, its high price limits the use in smallholder farms. Fish is the common protein source in smallholder farms in Central Vietnam (Astrom, 2000). Dry fish contain 64.2 % CP content and also a high ME content with 3560 kcal/kg fish (Chinh *et al.*, 2001).

There are two types of concentrate feed including concentrate, which cannot be fed solely to pigs due to high CP content (medium 40%) (feeding enterprises' nutrition information) and complete feed, which can be fed solely to pigs with a low protein content of around 14-18% depend on the types of pigs. Today, concentrate and complete feeds are commonly used in medium and large-scale pig farms in Vietnam. On the contrary, pigs produced on small-scale farms are rarely fed concentrate feed (Ngoan *et al.*, 1996). The proportion of concentrate feed or compound feed in the pig-feeding ration of smallholder farms is between 2.5 - 16% under smallholder farm condition in northern Vietnam (Lan, 2000; Kinh *et al.*, 2002).

Feed additives like vitamins, minerals and enzymes are sometimes used in smallholder pig production (Kinh *et al.*, 2002).

2.4.2 Quantitative and nutrition of feeding rations for pigs under smallholder production conditions

Nutrition is the primary factor influencing sow productivity such as the number of piglets reared per sow per year (Cole *et al.*, 1993). Protein in the diets plays an important role in sow nutrition and has considerable affect on gilt growth rate, live weight, piglet birth weight, mortality until weaning, and interval between two litters (Duyet *et al.*, 2001). However, dietary protein is the most frequently lacking component in pigs diets in Vietnam because feedstuffs available as source of energy are low in protein and protein supplements are expensive (Pond *et al.*, 1995). In literature, there are very few reports on feed intake, CP, or ME fed for breeding and lactating sows in smallholder farms. Duyet *et al.* (2003) used rations for pregnant Mong Cai pregnant sows of 144-180 g CP/sow/day under on-farm trial. Nga *et al.* (2000) shown that MC lactation sow was fed 640g CP under the on- farm trial – in the semi-intensive production conditions.

In addition, protein levels in the diet affect the growth performance of pigs (Ly *et al.*, 2003). In addition, Loc *et al.* (1997) found that the investigated nutritive value of pig rations for LW x MC fattening pigs under smallholder production conditions in Central Vietnam was very low as compared to feeding requirement (table 6). Quang (1997) discovered energy and protein content in diets used by households in Hung Yen province lower than pig requirements. Lai (1998) found in on-farm trials that MC fattening pigs from 11-21 kg were fed very low CP contents (about 48g/pig/day).

Table 6: Nutrient intake by LW-MC crossbreds from 15-50 kg under smallholders in Central Vietnam

	Feeding requirement	**Xuan Loc village**	**Binh Dien village**
DM (kg/pig/day)	1.4	1.29	1.35
ME (Kcal/pig/day)	4,325	4,110	4,206
CP (g/pig/day)	213	94	98

Source: Loc *et al.* (1997)

2.4.3 Nutritional requirement of pigs

Nutrient requirement of local sows (I and MC) and fattening pigs (local x exotic breeds) were shown in the tables following according to recommendation of authors.

Table 7: Nutritional requirements in different reproductive phases of local sows (I and Mong Cai)

	Feed intake (kg)	**CP (g/pig/day)**	**ME (kcal/pig/day)**
First two-thirds of gestation period	1.0 – 1.3* 1.2 – 1.4**	119 – 168* 144 – 168**	2,500 – 3,900* 3,540 – 4,130**
Last one-thirds of gestation period	1.3 – 1.6* 1.3 – 1.5**	151 – 179* 156 – 180**	3,500 – 4,100* 3,835 – 4,425**
Lactation phase	2.8 – 3.3* 2.0 – 3.5** 2.8 – 3.2***	384 – 453* 420 – 490** 420 – 512***	7,400 – 8,600* 9,000 – 10,500**

Souce: ***Nghi *et al.* (1985); *Thuong *et al.* (1992); **Viet and Len (2003)

Table 8: Nutritional requirements for fattening pigs of crossbreds amongst local and exotic breeds (Landrace x local pigs and Large White x local pigs)

Body weight	**Feed intake (kg)**	**CP (g/pig/day)**	**ME (kcal/pig/day)**
10 – 20 kg	0.7 – 1.2	118 - 176	2,125 – 3,176
20 – 50 kg	1.5 – 2.1	208 - 259	3,988 – 5,564
~ 60 kg	2.4	286	6,352

Source: Thuong *et al.* (1992)

2.4.4 Feeding techniques and feeding management under smallholder production conditions

Feeding management is very important aspect of pig production (Church, 1991). In Northern Vietnam, feeding rations for their pigs based on smallholder farmers' own experience (Quang, 1997). The feed input for sows in different reproductive stages is usually the same, shown in smallholder farms in Hung

Yen province in Northern Vietnam: in the first three months of gestation, energy and protein are supplied in abundance but in the final phase of pregnancy and in the lactation, protein is deficient (Quang, 1997). Whereas, Astrom (2003) found that small-scale farms in Central Vietnam were fed their sows depend on the different stage with higher rice bran, rice, cassava and sweet potato vines in lactation phase. Quang (1997) found that in poor smallholder farms, the shortage of nutrients for pig diets is more serious than in better-off farms due to very scare feed resources.

In some regions, the nutritive value of rations given to sows for pregnancy is not sufficient and consequently the weight of newborn and weaned piglets is very low (Quac, 2000). Valle Zárate *et al.* (2003) found that sows in smallholder farms in Son La province were rarely fed on concentrate feed. In addition, Tjallden (1999) discovered in Hanoi, all sows were fed rice by-products, vegetable, vine, sweet potatoes, maize and fish meal but not concentrate. Concentrate is mainly used for fattening pigs (Tjallden, 1999; Valle Zárate *et al.*, 2003). Nutritive values (crude protein and energy) for weaning and growing pigs have also been shown to be deficient in a study of Quang (1997), who found that in poor smallholder farms, the shortage of nutrient for pig diets is more serious than better-off farms due to very scare feed resources.

Lan (2000) found that 100% of investigated households cooked feed before feeding and 85% of them used raw vegetables to feed for pigs. In addition, she found that majority water sources fed to pigs come from wells.

The feeding strategies for pigs in time of feed abundance and feed shortage in smallholder farms show in table 9 below.

Table 9: Farmers' feeding strategies for different feed components in time of relative feed abundance and shortage, study location Son La province

Component	Season of feed	Villages closed to town	Villages far from town
Concentrate	Abundance	- Higher amount/day/pig - Regular purchase	- Higher amount/day/pig - Irregular purchase
	Shortage	- Purchase by more farmers - Use credit to purchase	- Purchase by more farmers, but still less than villages near town - Almost no credits used
Maize	Abundance	- Higher amount/day/pig - Produced maize mainly for feeding	- Lower amount/day/pig - Produced maize mainly for selling
	Shortage	- Buy additional maize - Use credit to buy	- Replace by vegetable, cassava and rice bran
Cassava	Abundance	- Lower amount/day/pig	- Higher amount/day/pig
	Shortage	- Same or smaller amount/day/pig - Purchased by few farmers	- Increase amount/day/pig - No purchase

Source: Lemke *et al.* (2002)

2.4.5 Monetary input in pig feeding under smallholder production conditions

The price of maize and other agricultural products in the markets shows strong variations throughout one year and depends among others on the harvesting season (Huan *et al.*, 2002). Seasonal shortage of feed and increasing of price happened when stored amount of previous harvest are used up (shortly before nest harvest) (Lemke *et al.*, 2000). During the time of feed shortage, feed prices are increased in the market (Huan *et al.*, 2002). Therefore the feed costs as well as total costs for pig production to produce one kg of weight increase, too.

Pig feed costs represent around 70 % of the production price in smallholder production systems (Singh *et al.*, 1996; Peters, 1998). In the Red River Delta, feed costs amount to 62 - 70% of the total production costs (Lan, 2000). The use of concentrate causes especially high costs for fattening pig and makes up to 62% in the total expense in pig production (Manh *et al.*, 2000). On the contrary, if farmers do not invest in commercial feed for fattening pigs, the feed costs account for only 29% (Manh *et al.*, 2000).

The costs of feed per kg weight gain was determined to be between VND 8000 to 1100 for fattening pigs in on-farm trials under semi-intensive production systems (Thanh *et al.*, 2002).

Feeding costs per sow, producing weaners for selling accounted for 88-94% in the total costs/year (table 10). on the other hand, feeding costs per fattening pigs amounted to 69-71%. In farms keeping sows, farmers need to invest 1000 VND to get back 1200-1260 VND. In families keeping fattening pig, farmers can earn 1070-1500 VND from 1000 VND investment.

Table 10: Annual feed costs, annual total costs, annual output, benefit for one year, and input and output relation from pig production, calculated for the last 12 month, by village

	Sow (one sow/year)	**Fattener (one fattener/period)**
Feeding costs (million VND)	1.53	0.44
	1.83*	0.48*
Total cost (million VND)	1.74	0.64
	1.94*	0.68*
Total output (million VND)	2.20	0.66
	2.32*	0.73*
Benefit (million VND)	0.47	0.23
	0.38*	0.05*
Production costs/kg weight extraction	9620	9010
(VND/kg)*	9850*	8590*
Input output ratio	1.26	1.5
	1.20*	1.07*

*production costs includes feeding costs, buying pigs, veterinary treatment and matting fee
Source: Lan (2000); * Thuy (2001)

Due to high pressure of land, pig production is becoming more important, especially in smallholder farms. Feeding is the main factor which influence pig production performances and smallholder economy. There are few researches related to smallholder pig production, especially in semi-intensive and extensive production systems. Therefore, the purposes of this study is to get a better understanding of the feeding management and feed resources used during a year, nutritive value of feed diets, monetary feeding input in one year, and feed prices during a year. Such information may be useful for the development of pig production in smallholder farms in the future by improve output and efficiency. In addition, this result can contribute to the optimizing the sustainable use of local available resources.

3 Material and methods

A field work was conducted from March to May 2003 in Son La province, Socialist Republic of Vietnam.

3.1 Material

3.1.1 Study area

Son La province is located in the mountainous zone of Northern Vietnam. Son La town is located about 300 km away from Hanoi capital. The average annual temperature is 21.4°C with annual rainfall of 1295 mm, and an average humidity between 74 and 86 % (Statistical Year Book, Son La province, 2001).

Figure 4: The location of Son La province in Vietnam (red).

Today, Son La province has a population of 924,000 people with population density of 66persons/km^2. Agricultural area is about 190,000ha, consisting of 41,000ha rice (upland rice and paddy rice), 55,000 ha maize, 16,000 ha cassava, 650 ha sweet potato, 10,000 ha soybean and 3,500 ha sugarcane (Son La Statistical Yearbook, 2001).

Table 11: Main animal species kept in Son La, population and meat yield

Livestock species kept and total meat production	**2001**
Buffaloes (‘000 head)	129
Cattle (‘000 head)	96
Pig (‘000 head)	420
Goat (‘000 head)	39
Poultry (‘000 head)	3,051
Total slaughtered meat (ton/year)	14,100

Source: Son La Statistical Yearbook, 2001

For the present study, 4 villages have been selected. The objective was to cover two production systems with the selected villages namely:

- Resource driven pig production system in regions far from town: Na Huong and Ban Keo
- Demand driven pig production system in regions close to town: Ban Bo and Ban Buon.

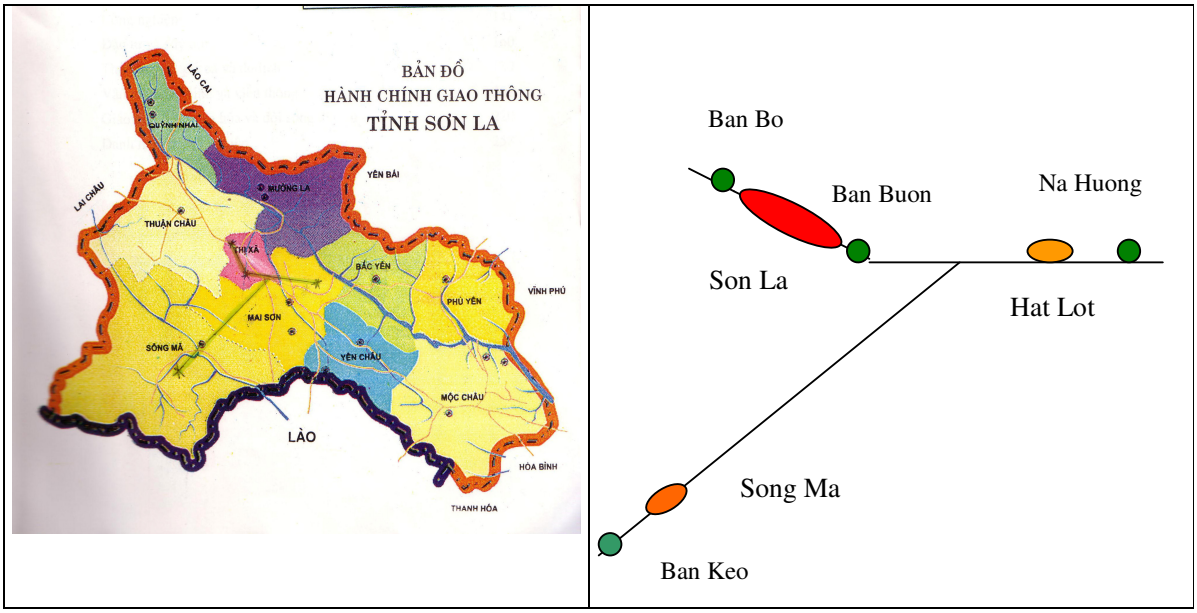


Figure 5: Location of selected villages in Son La province and schematic view of villages' distance to town

Table 12: Overview over villages investigated, and pig production characteristics

Province	**Son La**			
District/town	**Son La**		**Mai Son**	**Song Ma**
Commune	Chieng An	Chieng Coi	Hat Lot	Na Nghiu
Village	Ban Bo	Ban Buon	Na Huong	Ban Keo
Distance to town	Near town (1 and 2 km)		Relatively far from town (4 and 6 km)	
Population density	Higher		Lower	
Pig production intensity	Intensive		Semi - intensive	Extensive
Predominant sow breeds	Mong Cai		Ban	
Production system	Market oriented		More market-oriented (less than villages near town)	More subsistence oriented
Performance level	Higher-yielding		Lower-yielding	
Function of pigs	Mainly income functions		More income function	Less-income functions
Total output from pig production	Higher		Lower	
Monetary input	Higher		Low	
Feed resources used for pigs	Farm-produced plus purchased feeds		Farm-produced feeds	

3.1.2 Selection of households

In both production systems, smallholder farmers of the ethnic group of Black Thai were selected. The major criterion to select households was pure Mong Cai sow-keeping with the respective offspring in villages near town and pure Ban sow-keeping with the respective offspring (piglets, weaning and /or fattening pigs) in villages farer from town. To select the households, the author had a meeting with the leaders of villages and asked them about families, which keep Mong Cai sows in villages near to town and Ban sows in villages far from town. After getting the lists of households, the author visited all of household keeping sows together with the village leaders and then selected the households keeping MC sow breed and Ban sows breed with their offspring. The author gave priority for households belonging to the D2 – Subproject of The Uplands Program. At the time of selection, some of those farms had no any offspring. Therefore, some of other farms, which do not belong to project were selected in addition. Finally, 10 smallholders who keep Ban sows in each of two selected villages far from town, and 10 householders who keep Mong Cai sows in each of two selected villages near to town, were selected. A total of forty households was selected.

To conduct PRA tools, six of respective ten households were selected again in each village. The selection of households for the calendar tool was conducted by chance. Six households in each villages divided into two groups with their house located near each other. In total, twenty-four households were selected for the calendar tool.

3.2 Methods

3.2.1 Collection of secondary information

Secondary information concerning animal husbandry, pig production, utilization of feed resources, and feeding practices, nutritive value of feed components, nutritional requirement for pigs was gathered from the reports of subproject D2- The Uplands Program, library of University of Hohenheim - Germany as well as library of National Institute of Animal Husbandry – Hanoi.

3.2.2 Pre-test of questionnaire

A pre-test of the questionnaire was conducted before starting household interview and was used for development of the final version of the questionnaire. Nine farmers were interviewed for the pre-test of the questionnaire including 3 farmers in Na Huong, 4 farmers in Ban Bo and 2 farmers in Ban Buon. Eight farmers were part of sample size later on interviewed.

3.2.3 Discussion by using communication tools (calendar tool)

One of the communication tools used in the Participatory Rural Appraisal (PRA) approach is the seasonal calendar diagram. Group discussions were held with farmers (including three farmer per group per time).

The calendar tool was conducted by using big papers drawing 12 months from April – 2002 to March – 2003 and small coloured cards to collect information including harvesting time of feedstuffs used as pig feeds, the times of feed shortage/abundance in one year, feeding practices for different pig types in different seasons, available feed resources per season, composition of pigs' rations used in different seasons, the time when purchase of feedstuffs is required, kind of feedstuffs bought, prices of feed and frequency of purchase per season.

Each farmer, who attended the calendar tool, was asked questions, answers were written down to small cards or drawn directly on the big papers. During the calendar tool, the author wrote additional notes to the note papers. After all, on all cards the order has indicated, comments we immediately written to the big papers after that.

3.2.4 Key person interview

Key person interviews were conducted to collect information on feed supply and demand in different seasons in the research areas commercial feed, types of feeds preferred by farmers, common diseases of pigs related to feeding system as well as feeding in pig production in smallholder farms. Specialists with deep and detailed knowledge were selected for interview (see table 13).

Table 13: Position and place where key person interviews were done

Position	Place
8 feed trader	Son La town
2 feed traders	Co Noi - Mai Son district
3 feed traders	Hat lot – Mai son district
1 feed trader	Na San – Mai Son district
5 feed traders	Song Ma district
1 dealer of fattening pigs	Son La town
1 dealer of post-weaning pigs	Son La town
2 extension workers	Son La town
1 veterinarian	Son La town

3.2.5 Household interview by using structured questionnaire

Farmers were interviewed using a structured questionnaire. The first part of questionnaire was perform to yield information about socio-economic status of smallholders includes:

- total land for cropping, upland, flat land, and forest land;
- family members,
- off-farm activities, and income from off-farm
- crop areas and yield, total yield of crop sold in one year, price, and time of harvesting
- maize left for animal, maize left for pigs,
- livestock species kept, number and price of livestock sold in one year,
- feed resources used for ruminant, and poultry

The next section of the questionnaire focused on pig production including:

- information on pig population per household; characteristics of pigs kept (genotypes, age, sex of pigs, reproduction stage of sows, and growing stage of fattening pigs),
- reproductive performance of sows such as number piglets born alive, weaning number per litter, interval between two litters, and number of pig died,

- number and price of pig bought and sold in one year, number and weight of pig slaughtered and gift as a present,
- pig production management in general, and hygienic conditions, diseases and treatment as well as expense in treatment in one year.

The final part of questionnaire focused on:

- pig feeding management including information on type and amount of used feedstuffs and feed using for each types of pigs at interview time and in season after harvesting,
- purchased feedstuffs amount, frequency of purchase and prices, use of farm-own feedstuffs,
- feeding resources in different seasons, time of feed shortage, and strategies to overcome feed shortage,
- feeding practises and management in general

(see detail questionnaire in Annex 2).

Each interview was lasted about 1.5 to 2.0 hours. One Thai interpreter was engaged to help to conduct the interviews with farmers speaking mainly Thai.

3.2.6 Measuring of pig weight

To determine the growth performance of different pig genotypes in different areas, all offspring of Mong Cai sows and Ban sows, which was available at the visiting time, was weighed twice during the survey time. The pigs were weighed by using a 100 kg capacity portable scale with an accuracy of 0.5 kg. Piglets, weaning piglets and fattening pigs were considered. A biopsy forceps was used for marking all weighed pigs. Due to shortage of time, pigs in villages closed to town (Ban Bo and Ban Buon) were weighed with 65 days distance between two times weighing. The distance between two times weighing is 68 days in Na Huong and only 35 days in Ban Keo.

3.2.7 Quantification of feeding components and feeding ratios

To determine feed components' quantity, all kinds of feed used for pigs. Feed components and feed intake were recorded using a 10 kg capacity scale with an accuracy of 0.05 kg. All types of feedstuff, which farmers prepared for cooking, were weighed, and then the weighing of the ration of cooked feed that farmer would give their pigs, was weighed again after cooking, to find out the feed amount given for each pig. The weighing feed was conducted in afternoon when farmers cooked feed. The cooked feed in one time often used for pigs in one day.

3.2.8 Data analysis

Analysis of quantitative data

Descriptive statistics of collected data were calculated by using Excel 2000. Data were collated and summarized using means, standard deviation, and ranges. The following formulas were used in particular:

$$\text{DWG (g/day)} = \frac{(Second\ weight - first\ weight)\ (g)}{(Second\ age - first\ age)\ (day)}$$ (1^{st} and 2^{nd} refer to 1^{st} and 2^{nd} weighing)

Litters/sow/year = $\frac{Total\ litters\ per\ sow}{Age\ of\ sow\ (year)}$ (sow > 1 litters)

Mortality until weaning = $\frac{(Number\ pigs\ born\ alive - Number\ pigs\ weaned)\ (per\ litter)}{Number\ pigs\ born\ alive\ (per\ litter)} x\ 100$

Interval between two litters = dates of last farrowing – dates of the farrowing before last farrowing (distance between the 2 dates in days)

Weight extraction from pig production in one year = Total weight of all pigs sold + total weight of pigs slaughtered + total weight of pigs given as a present (in last 12 months)

Revenue from pig production in cash = weight of pigs sold x price + weight slaughtered pigs x price (equivalent price of fattening pigs sold) + weight pigs gifted x price (equivalent price of weaners sold) (in last 12 months)

Time of feed shortage was determined as time when almost farmers have not enough feed and need to reduce feed amount for pigs or purchase more to compensate the shortage. Time of heavy shortage occurs when feed amount is completely finished and farmers need to buy more or replace by other feed. In most households it often prolongs from March to July.

Time of feed abundance means that feed is available in all farms and farmers can feed enough for pigs, corresponding to the time after harvesting from September to November in most of households.

Total feedstuff used = total produced feed/farm + total purchased feed/farm (12 last months)

Total sweet potato vines used per year (kg/year) = yield per day (kg) x period harvesting (day)

Feed intake = total amount of feedstuffs except vegetables and banana stem

CP g/pig/day = total amount of crude protein contents in feedstuffs used for pig feed

ME kcal/pig/day = Total amount of ME content in feedstuffs used for pig feed

CP and ME values were indicated in “Composition and Nutritive Value of Animal Feed in Vietnam”.

Amount of crude protein (CP) (excluding vegetables) to produce 1 kg of pig extracted = Total CP amount calculated from total feed resources used in one year including farm produced feed and purchased feed (kg) divided for total weight extraction from pig production in one year (kcal) (kg CP/kg)

Metabolizable energy (ME) (excluding vegetables) to produce 1 kg of pig extracted = Total ME amount (Mcal) calculated from total feed resources used in one year including farm produced feed and purchased feed divided for total weight extraction from pig production in one year (Mcal/kg)

Total cash revenue from livestock and pigs was calculated from the number, weight and price of livestock/pigs sold.

Cash revenue from cropping was calculated by the amount sold and the prices of crops sold. Genotypes of boars used was calculated by percentage of sows mated with boar genotypes in the last litter born.

Buying pig costs was calculated by number of pig bought times weight and price. Feed costs were calculated by all costs expense for feeding in one year by market price (actual purchased price) for really purchased feed only.

Cash revenues from crop, livestock and pig were also calculated in period of 12 months with crops sold, livestock sold and pigs sold, to the respective items.

Total costs in pig production/hh/year= feed costs + mating costs + veterinary fees + costs for buying pigs

Benefit/hh/year (VND) = Total revenue/hh/year – Total costs in pig production/hh/year

$$\text{Input-output ratio} = \frac{Total\ revenue\ of\ \ pig\ \ production/hh/\ year\ (VND)}{Total\ costs/hh/\ year\ (VND)}$$

Analysis of qualitative data

Qualitative data were recorded during the fieldwork mainly used in the discussion and for interpretation of results.

4 Results

4.1 Smallholder production systems in Son La

4.1.1 Household members, family structure, work force

As the table 14 shows, the average family size in investigated households was between 5.0 and 6.7 persons including 3.0 to 4.4 mature members. The lower number of children caused the smaller family size in Ban Bo and Ban Buon (about 5 persons) compared to Na Huong and Ban Keo (almost 7 persons). The small proportion of old persons in all interviewed families might be explained by the replacement of the three-generation-family by two-generation-family.

Table 14: Family structure in investigated households, by village (mean ± SD)

Village	**Ban Bo**	**Ban Buon**	**Na Huong**	**Ban Keo**
N households	10	10	10	10
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Total family members/hh	5.0 ± 1.3	5.3 ± 1.8	6.7 ± 1.8	6.6 ± 2.3
Old (> 65 years old)	0.6 ± 0.8	0.5 ± 0.8	0.2 ± 0.6	0.5 ± 0.5
Mature (16 – 65 years old)	3.0 ± 1.1	3.4 ± 0.8	4.4 ± 2.1	3.3 ± 2.4
Children (< 16 years old)	1.4 ± 0.7	1.4 ± 0.5	2.1 ± 1.0	2.8 ± 0.6

Household interview

4.1.2 Land ownership

The total land of a family consists of agricultural land, forestland, and land for house and garden. Agricultural land again consists of upland areas and flat land.

Figures in table 15 show that the total land per household was about 1 ha in Ban Buon, Ban Bo and Ban Keo, but was much higher in Na Huong with about 3 ha per household. The highest upland area was around 2.5 ha in average in Na Huong, while was around 0.5 to 1.0 ha in other villages. Upland area occupied around 64-76% of the total agricultural land in investigated households. Flat land plots in each family were very small (0.1 - 0.4 ha).

Looking at forestland, the biggest area per household was found in Ban Bo (1.6 ha). In the other three villages, forest area per household was about 1 ha. According to interviews, 50% of investigated households in Ban Buon and 20% of investigated households in Na Huong have not been allocated forestland. 10% of investigated households in Na Huong used forestland for maize production.

Table 15: Total land, upland, flat land and forest land per household in the investigated households, by village (% of households, mean ± SD)

Village		Ban Bo		Ban Buon		Na Huong		Ban Keo	
N households		10		10		10		10	
		%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
Land area for cropping/hh (ha)*		100	0.9 ± 1.2	100	0.8 ± 0.3	100	3.0 ± 1.4	100	1.2 ± 0.4
Of which:	Upland/hh (ha)	100	0.8 ± 1.2	100	0.6 ± 0.2	100	2.6 ± 1.0	100	1.1 ± 0.4
	Flat land/hh (ha)	90	0.2 ± 0.1	100	0.2 ± 0.1	100	0.4 ± 0.5	100	0.1 ± 0.0
Forest area/hh (ha)		100	1.6 ± 0.7	50	0.8 ± 0.8	70	1.0 ± 0.5	100	0.9 ± 0.3
Total land area/hh (ha)**		100	2.7 ± 1.7	100	1.2 ± 0.8	100	4.2 ± 1.9	100	2.4 ± 0.5

*garden land not included. ** house and garden included
Means were calculated for the households that have the respective land area only. Household interview

4.1.3 Cropping activities

Main crops

Rice, cassava, sweet potato and maize are main crops in the studied villages. Upland rice was a typical crop in mountainous regions in past times. It was given up by most of farmers especially in villages near town, but was still planted in Ban Keo (90% of investigated households) and Na Huong (10% of investigated households). Paddy rice was planted by almost all investigated households but was cultivated only on very small areas (around 0.1ha) due to a lack of suitable land. 90% of investigated households in Na Huong and 60 % of households in Ban Buon cultivated sugar cane. Cassava was also planted by almost all farmers (with the exception of Na Huong, where 70% of investigated farmers plant cassava), but occupied also very small areas (around 0.1-0.2 ha). All investigated households planted maize. Areas were small in Ban Bo, Ban Buon and Ban Keo (0.3 to 0.6 ha), but big in Na Huong (2.5 ha). Sweet potatoes were planted by almost all investigated households in Ban Bo, Ban Buon and Ban Keo, but were rarely planted in Ban Keo. The area of sweet potato per household was very small (0.01- 0.03 ha) (table 16).

Table 16: Planting crops and plot size per crop in investigated households, by village (% of households, mean ± SD)

Village	Ban Bo		Ban Buon		Na Huong		Ban Keo	
N households	10		10		10		10	
	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
Maize area/hh (ha)	100	0.3 ± 0.1	100	0.3 ± 0.2	100	2.5 ± 1.0	100	0.6 ± 0.3
Sugar cane/hh (ha)	0	-	60	0.3 ± 0.1	90	0.4 ± 0.3	0	-
Upland rice/hh (ha)	-	-	-	-	10	1.0	90	0.4 ± 0.2
Paddy rice area/hh (ha)	90	0.1 ± 0.1	100	0.1 ± 0	40	0.1 ± 0.1	100	0.1 ± 0.1
Cassava area/hh (ha)	100	0.1 ± 0.1	90	0.1 ± 0.1	70	0.2 ± 0.1	100	0.1 ± 0.1
S.P. area/hh (ha)	100	0.03 ± 0.02	100	0.03 ± 0.01	80	0.02 ± 0.02	20	0.01 ± 0.01

Means were calculated for the households planting the respective crop only
Household interview

Due to the big cultivation area of maize, the average maize yield per household per year in Na Huong was about 16 tons, much higher than in the other villages with an annual yield of 1 to 3 tons (table 17). In Ban Bo, the second maize crop was planted and had produced higher maize/hh/year comparing to other village, which have the same land area/hh. Almost of maize was sold in Na Huong and Ban Keo and the rest was used for animal production. In Ban Bo and Ban Buon, small part of maize was sold and the remaining part was used for animals.

Paddy rice was produced in nearly all farms in Ban Bo, Ban Buon and Ban Keo, while only 40% of investigated households in Na Huong plant rice. The second paddy rice crop has induced higher yield/hh/year in Ban Bo, Ban Buon and Ban Keo. Total rice yield was almost the same in Ban Bo, and Ban Buon (about 1.1-1.4 tons per household per year), but was lower in Na Huong and Ban Keo (0.3 –0.7 tons per household per year). Total upland rice yield was 1 ton in Na Huong and 0.6 tons in Ban Keo.

The cassava yield was between 2 and 3 tons per household and year in Ban Bo, Ban Buon and Ban Keo. A smaller cassava amount was harvested in Na Huong (0.7 ton in average). Farmers harvest cassava many times per year and dry it depending on the weather and their time availability**.** Most harvested cassava is used for animals and for alcohol making. Only small amounts were used for family consumption.

Sugar cane as cash crop is planted only in Ban Buon and Na Huong. In Na Huong, households yielded more sugar cane per year (17.8 tons per household) than households in Ban Buon (12.6 tons/year), because of different plot size of households (0.3 versus 0.4 ha). The amount used for family was not considerable but mainly used for selling. Sweet potato vines were one of the major vegetable sources for pigs. It is mainly grown in Ban Bo, Ban Buon and Na Huong, with an annual yield between 1 and 2 tons per year and household. In Ban Keo, few of the investigated farms were growing sweet potatoes, and the annual yield was low.

Table 17: Cultivation of main crops and total yield of those crops in investigated households, harvested in last 12 months, by village (% of households, mean ± SD)

Village	**Ban Bo**		**Ban Buon**		**Na Huong**		**Ban Keo**	
N households	10		10		10		10	
	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
Maize yield/year (ton)	100	3.0 ± 1.4[1]	100	1.1 ± 0.7	100	15.9 ± 3.8	100	2.4 ± 1.4
Upland rice yield	0	-	0	-	10	1.0	90	0.6 ± 0.6
Paddy rice yield/year (ton)	90	1.4 ± 0.6[2]	100	1.1 ± 0.7[2]	40	0.3 ± 0.2	100	0.7 ± 0.4[2]
Cassava yield/year (ton)	100	2.4 ± 1.3	90	1.9 ± 1.1	70	0.7 ± 0.3	100	2.7 ± 1.5
Sugar cane/year (ton)	0	-	60	12.6 ± 4.9	90	17.8 ± 7.5	0	-
S.P. vines/year (ton)[3]	100	2.2 ± 1.7	100	2.0 ± 0.7	80	1.2 ± 0.8	20	0.5 ± 0.4

[1]Including main crop and second crop of maize. [2]Including main crop and second crop of paddy rice
[3]Calculated from daily harvested amount and cultivation period
Means were calculated for the households that have the respective crop yields only. Household interview

Processing of crops and availability of agricultural by-products

Maize, rice, and cassava in investigated farmers are usually sun dried. Farmers usually mill rice every month for family consumption. The remaining rice bran is mainly used for pigs. Farmers also mill small amounts of maize per each time for animals. In Ban Bo, Ban Buon and Na Huong, farmers often dry

cassava and store it to use for their animals in time of feed shortage. However, in Ban Keo farmers often use fresh cassava for their animals: according to the interviewed farmers, they have no time to prepare the cassava for drying. In addition, some interviewed families, during the harvesting season and especially after raining periods, say that their pig can not consume all sweet potato vines harvested, therefore it is also dried and used for pigs in season of vegetable shortage (winter) in Ban Bo.

Sugarcane top and young maize leaves were used in families keeping ruminants. Households without ruminants often gave those feedstuffs to farms keeping ruminants. Old maize leaves could not be fed to animals and were often left in the field and later on burned during land preparation. Carrying them back home for cooking was difficult due to long distances and transportation efforts, because maize was mainly planted on upland plots. Corncobs after removal of grains were usually used as fuel. Paddy rice straw was used for ruminants or is left in the field in case families do not keep ruminants. Upland rice straw was usually not used and left in the field.

4.1.4 Livestock husbandry

Among the investigated households, a majority of investigated households was keeping ruminants, poultry, fish, cat and dog, while few smallholder farms keep rabbits, ducks, muscovy ducks, geese or goats (table 18). An exception was Ban Keo, up to 60 percent of farms kept goats with an average of 2.0 to 3.0 heads (despite goat is a new animal in this village). Buffalo and cattle are mainly kept as draught animals for ploughing and transportation with an exception of 2 families in Ban Buon kept dairy cattle. However, draught animals were loosing their importance. This was most evident in Ban Buon (10% of investigated households keep buffalo and 20% keep cattle) and less evident in Ban Bo (40% of households keep buffalo) and Na Huong (50% of households keep buffalo and 50% keep cattle). However, in Ban Keo, still 90% of investigated households kept buffalo for fieldwork in the upland. The numbers of cattle/buffalo ranged from 1 to 2 heads per family.

All interviewed families kept pigs, mainly kept sows with their offspring and/or fattening pigs, which were bought from market. Almost all investigated farms rear chicken with average numbers of 15 to 30 birds per household. In few farms, the chicken flock had just died around the time of interview due to epidemic diseases. Cats and dogs are kept in over 50 % of all investigated households in all studied villages, between 1 to 3 heads per family. Fish seems to be another important source of animal protein for household consumption but also a marketable commodity. About half of the investigated families in Ban Bo, Ban Buon and Na Huong, but 100% of investigated farms in Ban Keo have a fishpond.

Table 18: Percent of households keeping animals and number of animals kept per household, by village (% of households, mean ± SD)

Village	Ban Bo		Ban Buon		Na Huong		Ban Keo	
N household	10		10		10		10	
	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
Buffalo	40	1.5 ± 0.6	10	2.0	50	1.4 ± 0.5	90	1.4 ± 0.5
Cattle	0	-	20	2.0 ± 0.0	50	1.6 ± 0.5	10	1.0
Goat	10	1.0	0	-	0	-	60	2.2 ± 0.4
Duck	20	10.0 ± 11.3	20	6.0 ± 4.2	0	-	60	5.0 ± 2.1
M. duck	30	13.7 ± 6.0	50	5.8 ± 2.2	20	15 ± 14.1	0	-
Chicken	100	18.9 ± 13.5	80	29.3 ± 21.1	90	21.9 ± 17.2	90	15.6 ± 9.6
Pig	100	10.7 ± 5.2	100	7.6 ± 3.7	100	7.9 ± 2.9	100	6.3 ± 3.1
Geese	0	-	0	-	0	-	20	5.0 ± 2.8
Rabbit	10	13.0	30	5.7 ± 2.9	0	-	0	-
Cat	90	1.2 ± 0.4	50	1.0 ± 0.0	80	1.3 ± 0.7	40	1.0 ± 0.0
Dog	50	1.4 ± 0.9	60	1.0 ± 0.0	60	1.0 ± 0.0	80	1.9 ± 1.0
Fish (kg)*	60	135.0 ± 183.5	50	164.0 ± 150.8	40	153.8 ± 232.7	100	96.5 ± 94.2

*as total off-take (selling and family consumption) for one year
Means were calculated for the households keeping the respective species only. Household interview

4.1.5 Revenue from agricultural activities

In general, the household revenue in the investigated households is generated from agricultural activities (crop production, livestock production) and from off-farm activities.

As table 19 shows, all investigated households (with the exception of only 80% of households in Ban Buon) got cash revenue from crop production. Further, almost all of the households got a revenue from livestock production (without pigs), with the exception of Na Huong (there, only 30% of households got a revenue from livestock). All farms in the villages closed to town got a revenue from pig production, while the percentage of families in Na Huong and Ban Keo was lower with 80% and 70%. The percentage of interviewed farms getting a revenue from off-farm activities was low compare to those in agricultural activities with 40%, 50% and 70% in Ban Bo, Ban Buon and Na Huong, and only 20% of households, the lowest proportion of households get cash revenue from off-farm activities, in Ban Keo.

The contribution of off-farm activities plays relatively minor role in the total cash revenue of the farms. The highest cash revenue from off-farm activities in Ban Buon accounted for 41% of total household revenue. Ban Bo and Ban Keo had rather similar proportion of cash revenue from off-farm activities with 25% and 28% of total household revenue, but it was only 4% in Na Huong.

The contribution of crop production to the total household revenue played a very big role in Na Huong (26.9 million VND making up 93% of the annual household revenue), mainly due to the fact that maize was sold in large amounts. Cash revenue from cropping also played an important role in Ban Keo (4.7 million VND, accounting for 84% of the annual household revenue) compared to the revenue from livestock production (excl. pigs) and pig production (see figure 6). Here, maize was also the main cash revenue (81% in Na Huong and 80% in Ban Keo). Farmers in Ban Bo and Ban Buon earned lower absolute annual cash revenue from crops. (25% in Ban Buon and 13% in Ban Bo in all of investigated households) as percentage of total household revenue.

As a result, the proportion of revenue from pig production in the total annual household revenue in Ban Bo and Ban Buon is much higher than in Ban Keo and Na Huong. Especially the cash revenue from pigs sold in Ban Bo and Ban Buon was accounting for 63.3 and 58.8% of the total annual household revenue. The absolute revenue from pigs in Ban Buon and Ban Bo was also higher than the other two villages (7.5 and 4.7 million VND as compared to 2.2 and 0.7 million in Ban Keo and Na Huong).

The proportion of cash revenue from livestock production (excluding pigs) in the total cash revenue was lightly higher in Ban Bo with 13% (1.8 million VND) and Ban Buon 19% (1.5 million VND as compared to those in Na Huong with 5% (1.3 million VND) and Ban Keo 7% (0.4 million VND). Comparing to the cash revenue from crop production in Na Huong and Ban Keo, and cash revenue from pig production in Ban Bo and Ban Buon, cash revenue from livestock production (excl. pigs) contributed not considerable part of the total household revenue.

Table 19: Percent of households getting a cash revenue from agricultural and off-farm activities, by village in the last 12 months

Village	**Ban Bo**	**Ban Buon**	**Na Huong**	**Ban Keo**
N households	10	10	10	10
% hh get revenue from crops	100	80	100	100
% hh get revenue from livestock (excl. pigs)	80	90	30	80
% hh get revenue from pigs	100	100	80	70
% hh get revenue from off-farm activities	40	50	70	20

Household interview

Figure 6 shows the annual cash revenue from agricultural activities and off-farm activities

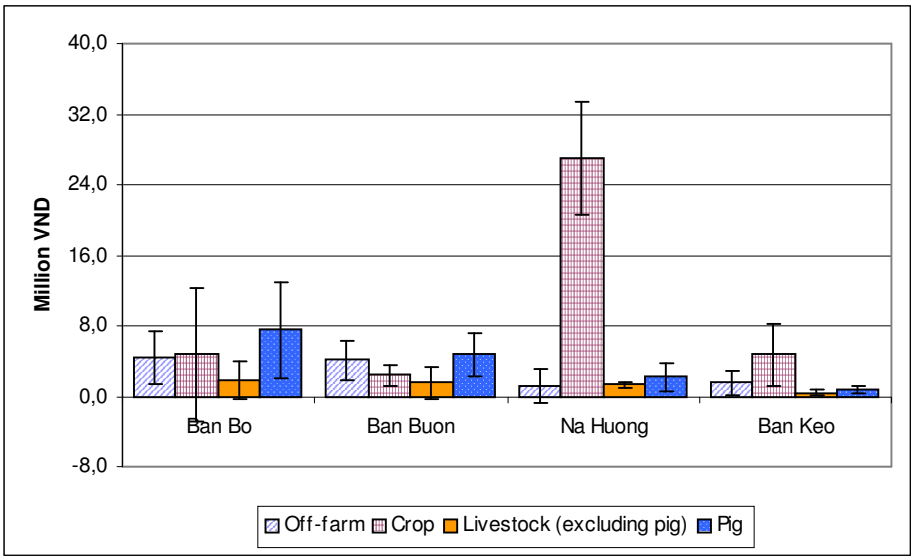


Figure 6: Average cash revenue per household from agricultural activities including cropping, livestock (excl. pig) and pig production, and off-farm activities in the last 12 months (mean ± SD), by village.

Production costs were not considered, when calculating cash revenues
Cash revenue from livestock and pigs was calculated from the number, weight and price of livestock/pigs sold
Cash revenue from cropping was calculated by the amount sold and the prices of crops sold
Exchange rate: 15400 Vietnamese Dong (VND) = 1 USD (2003). Household interview

4.2 Pig production

The major criteria for selection of household in selected villages was Mong Cai "sow-keeping" with the respective offspring in Ban Buon and Ban Bo and Ban "sow-keeping" with the respective offspring in Na Huong and Ban Keo, the offspring including sucking piglets, weaned piglets and/or fattening pigs. Therefore, 100% of the investigated households were keeping sows. Among them, 80 and 90% of households in Ban Buon and Ban Bo kept fattening pigs with an average of about 6 fattening pigs per household, and 100% of investigated households kept fattening pigs in Ban Keo and Na Huong with 4 to 5 heads per household (table 20). At the time of interview, the percentage of interviewed families in all 4 villages keeping piglets was very low, from 10 to 30%. The numbers of households keeping gilts was varying (50% of investigated households in Ban Bo and Ban Keo, even 70% in Na Huong, but only 20% in Ban Buon), with 1 to 2 gilts kept per household.

Table 20: Percentage of households keeping a certain pig type, and number of pigs per household, by village (% of households, mean ± SD)

Village	**Ban Bo**		**Ban Buon**		**Na Huong**		**Ban Keo**	
N households	10		10		10		10	
	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
No. sows/hh (head)	100	1.1 ± 0.3	100	1.3 ± 0.6	100	1.0 ± 0.0	100	1.1 ± 0.3
No. fatteners/hh (head)	90	6.2 ± 3.7	80	6.1 ± 2.9	100	5.1 ± 2.5	100	4.1 ± 2.2
No. piglets/hh (head)	30	11.0 ± 2.0	20	6.0 ± 1.4	10	11.0	10	6.0
No. gilts/hh (head)	50	1.4 ± 0.5	20	1.0 ± 0.0	70	1.0 ± 0.0	50	1.0 ± 0.0

Means were calculated for the households keeping the respective pig type only. Household interview

4.2.1 Pig breeds

The Ban breed (locally also called Meo breed) is the major indigenous pig breed in Son La province. The Ban breed is characterized by a black colour with six white spots at the feet and forehead, a white tip of the tail, and a white belly. However, some pigs are characterized by a completely black body (figure 13 in Annex 1).

The Mong Cai breed is an improved local pig breed in Vietnam, which originated from the Red River Delta. This breed is predominantly used as maternal line in Northern Vietnam. It has little, smooth bristles and is characterized by a coat with three colours: black, white and pink (figure 14 in Annex 1). The head is black with small and upright ears and the snout is pink. It has a concave back with black patches with a white band running from one side of the abdomen over the shoulder to other side of the abdomen, making a black saddle over the middle of its concave back. The pig has a big belly hanging down with white colour.

Sow and gilt breeds

As shown in table 21, all investigated households in Ban Buon and Ban Bo were keeping MC, and only one household in Ban Buon was also keeping Ban. In Na Huong, there is mainly Ban keeping but also some MC keeping, while in Ban Keo, the Ban breed is still the only kept pig breed.

In Ban Bo and Ban Buon as in other areas near town, Mong Cai sows have gradually replaced Ban sows because of their good reproductive characteristics and the good growth performance of their offspring. They are more easy to feed on local feed resources, especially fibrous vegetative feeds, especially farmers

do not need to invest in feeding and breeding as much as for crossbreds and exotic breeds. MC sows were widely kept in villages close to the town due to introducing of MC gilts and MC boars from D2-subproject on-farm trial. Moreover, 90 MC sows have been imported by Son La province extension services in 2000 to produce MC gilt for breeding.

Pig keeping in the study location has been influenced by The Uplands program (SFB 564, Hohenheim University), which introduced MC gilts in Ban Bo, Ban Buon and Na Huong.

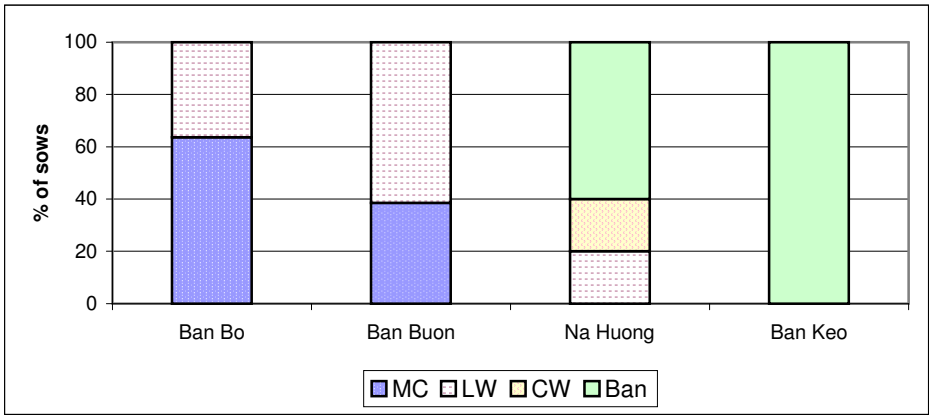
Table 21: Genotypes of sows and gilts in investigated households, by village

Village	**Ban Bo**	**Ban Buon**	**Na Huong**	**Ban Keo**
N households	10	10	10	10
N sows	11	13	10	11
Sow genotypes	MC	MC Ban	Ban	Ban
% hh keeping	100	100 10	100	100
N sows/hh	1.1 ± 0.3	1.3 ± 0.6	1.0 ± 0.0	1.1 ± 0.3
N gilts	7	2	7	5
Gilt genotypes	MC	MC	MC Ban	Ban
% hh keeping	50	20	20 50	50
N gilt/hh	1.4 ± 0.5	1.0 ± 0	1.0 ± 0.0	1.0 ± 0.0

Household interview

Boar breeds

The genotypes of mating boars used in the last litters born from respective sows in investigated households are presented in figure 7. Until 2001, Mong Cai boars were not kept in the four villages and were therefore not used for mating. MC boars were introduced to Ban Bo, Ban Buon and Na Huong through The Uplands program (SFB 564, Hohenheim University) and therefore became available for mating. The percentage of MC boars used was higher as compared to Large White boars (LW) (63.6% and 57.1% last litters from MC boars and 36.4 and 42.9% of litters from LW boars in Ban Bo and Ban Buon). Anyway, in Ban Bo and Ban Buon, the mating of sows was regulated by the project contract (at least one litter has to be matted by project boars), so that use of boar is not representative for other villages. In Ban Keo and Na Huong, Ban boars are still predominant with 100% (Ban Keo) and 60% of mated sows (Na Huong), respectively. In Na Huong, a wide variety of boars was used including Ban, Cornwall (20% of last litters) and Mong Cai (20% of last litters).



n of sows: n = 11 n = 13 n = 10 n = 11

Figure 7: Genotypes of boars used for mating of sows (last litter born, respectively) in investigated households, by village

Household interview

4.2.2 Input in pig production

The costs for pig production include the costs for buying fattening pigs, buying feed and paying for services such as mating, medical treatment, and vaccination. In Ban Bo and Ban Buon, all investigated households had expenses for feed purchase, and for services; but only 20% in Ban Bo and 40% in Ban Buon had expenses for buying pigs. In Na Huong, 80% and 90% investigated households were buying feed and paying for services and only one household bought pigs. In Ban Keo, one household bought feed due to having a farrowing sows, and 60% of households were paying for services; no investigated households did purchase pigs (table 22).

The total costs for pig production for one year varied between the households and in the different villages. Expenses for fattening pigs and feed in general cause the highest annual costs, compared to services (figure 8). In general, farmers in the study area often keep some piglets from the offspring, but in addition buy more piglets for fattening. In Ban Keo, interviewed farmers did not purchase additional piglets; they kept their own piglets for fattening or got piglets from relatives as a present. In Ban Bo, costs of buying pigs were rather high, accounting for 42% of the total costs (in 20% of households bought pigs).

However, in all of farms, which purchased feed, feed costs occupied over 80% of the total costs in pig production in one year in Ban Bo, Ban Buon and Na Huong, respectively.

Table 22: Percentage of households having certain expenses in pig production, by village (% of households)

Village	**Ban Bo**	**Ban Buon**	**Na Huong**	**Ban Keo**
N households	10	10	10	10
% hh purchasing feed	100	100	80	10
%hh buying pigs	20	40	10	-
% hh paying services*	100	100	90	60

*including mating costs, veterinary care, vaccination. Household interview

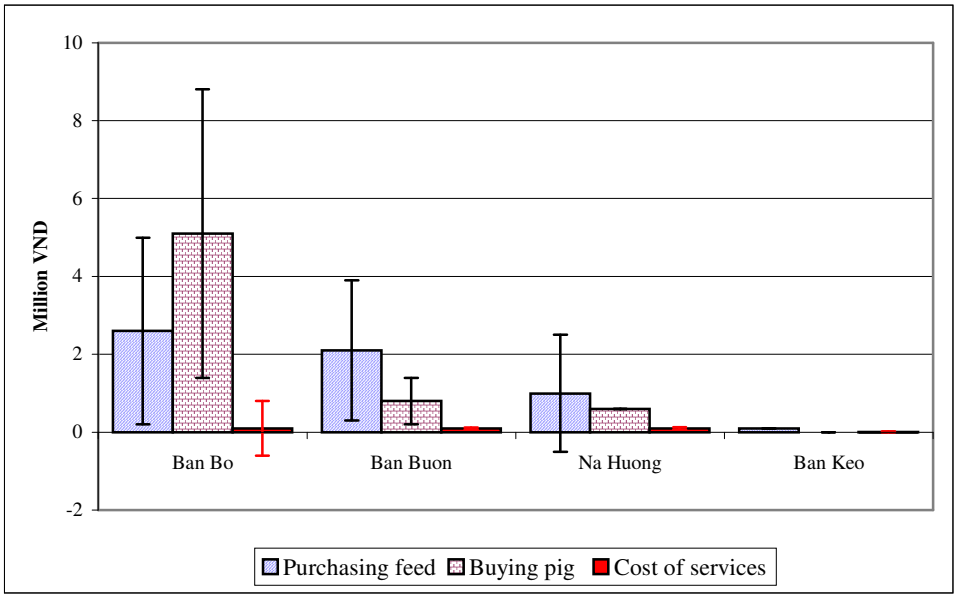


Figure 8: Costs in pig production (purchasing feed, buying pigs and costs of services) in one year in investigated households (mean ± SD), by village.

Costs of purchasing feed are calculated from market price for the really purchased feed only
Exchange rate: 15400 Vietnam Dong (VND) = 1USD (2003). Household interview

4.2.3 Performances of pigs

Reproductive performance

The average age of Mong Cai (MC) sows at the time of interview was 23.6 months; ranging from 11.0 to 60.0 months. The average age of Ban sows at the time of interview was nearly two times higher, namely 44.6 months, ranging from 24.0 to 96.0 months (table 24). The average number of piglets born alive per MC sow was about 10 piglets/litter while the Ban sows had a lower litter size with an average of 7.8 piglets born alive/litter. The biggest litter size recorded in MC sows was 14 piglets born alive/litter, the highest litter size recorded in Ban was 12 piglets/litter. MC showed a higher mortality of piglets until weaning of 2.3 piglets/litter (mortality = 29%), while Ban had a lower mortality until weaning of about 16% (1.4 piglets per litter on average). Due to the bigger litter size, litter size of MC at weaning was higher than that of Ban despite the higher mortality until weaning (7.4 and 6.2 piglets weaned/litter, respectively). Litter interval was very high in Ban breed with more than 300 days in average, however, with a high variation (litter interval ranging from 183 days to 515 days). In MC sows, litter interval was shorter, about 180 days with a lower variation (ranging from 156 to 220 days). Consequently, the average number of litters per MC sow per year was 1.3 with a range of 1.0 to 2.0, while the average number of litters/Ban sow/year was only 0.8 ranging from 0.5 to 1.3.

Table 23: Reproductive performance of sows in investigated households, by breed

Genotype	N of sows	Mean	SD	Minimum	Maximum
Age of sow at the time of interview (month)					
MC	23	23.6	11.4	11	60
Ban	21	44.6	16.2	24	96
Number of piglets born alive in the last born litter (head)					
MC	23	10.0	2.6	5	14
Ban	21	7.8	2.3	4	12
Lost piglets in the last born and weaned litter (head)					
MC	16	2.3	2.9	0	10
Ban	19	1.4	1.6	0	7
Number of piglets weaned in the last born and weaned litter (head)					
MC	16	7.4	3.2	3	12
Ban	19	6.2	1.9	4	10
Mortality rate in the last born and weaned litter (%)					
MC	16	28.5	34.1	0	100
Ban	19	16.0	17.1	0	58.3
Litter interval (day)*					
MC	17	182.0	15.4	156	220
Ban	19	304.9	103.2	183	515
Average numbers of litters/sow/year**					
MC	17	1.3	0.8	1.0	2.0
Ban	19	0.8	0.2	0.5	1.3

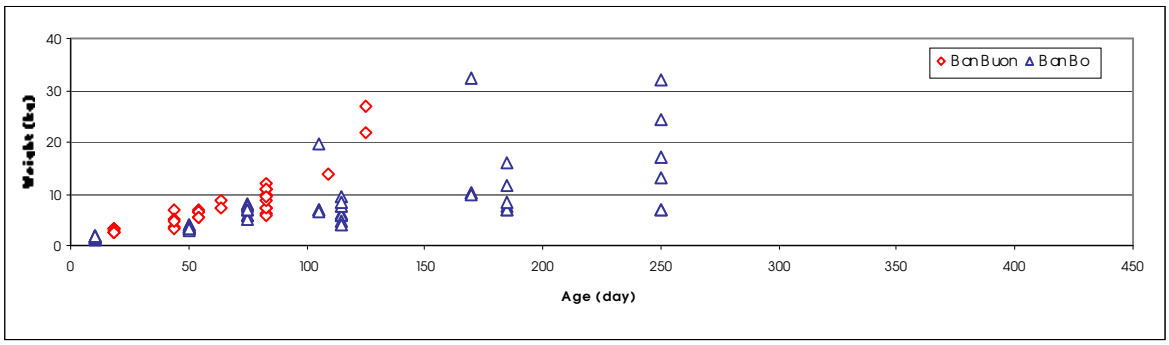
*calculated as difference between birth date of last litter and birth date of litter before last litter
**calculated as total litters per sow at time of interview/age of sow at time of interview (year), sows < 1 year were excluded. Household interview

Growth performances of pigs

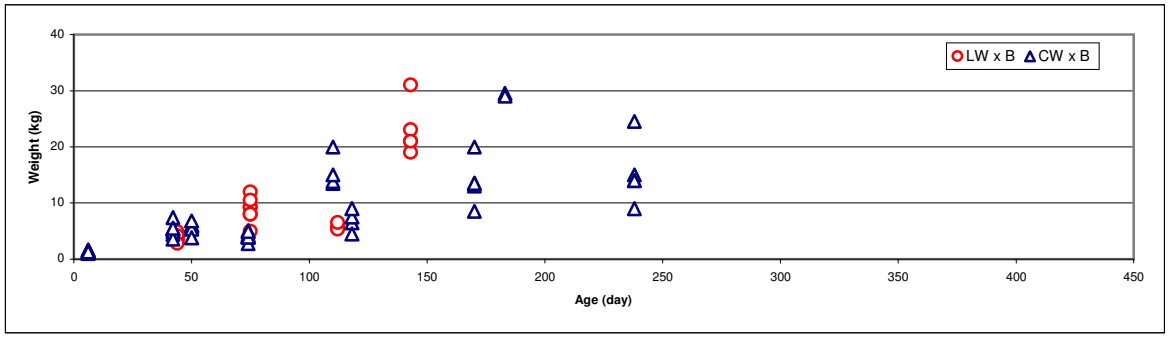
It was intended to weigh each pig twice with a certain time period between two weightings in order to get repeated measurements and calculate the individual growth rate from the data. The number of pigs weighed at the first and at the second time were different (223 and 134 heads). The smaller number of pigs at the second measurement date is due to the fact that pigs had been sold in the meantime or escaped from weighing.

Figure 9 shows the age-weight-plots for pigs of the four predominant genotypes in the investigated households. Repeated measurements for individual pigs (from first and second weighing) are presented in the same plot, respectively. The age to reach 20 kg of weight was used somehow as an indicator for growth performance.

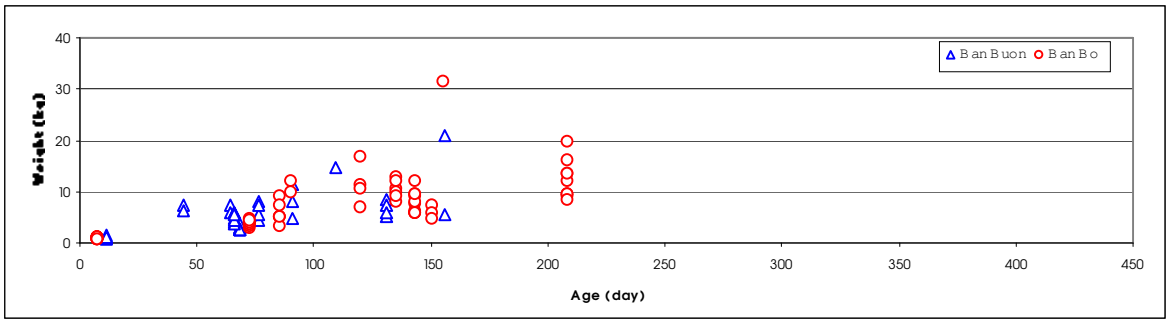
The LW x MC crossbreds showed the highest growth performance with many of pigs gaining 10 kg between 50 and 100 days of age and the first pigs reached 20 kg after 100 days. LW x Ban and CW x Ban also showed a high growth performance with the first pig reaching 20 kg after about 110 days. MC show a medium growth performance with the first pig gaining 20 kg after 150 days. Ban pigs show a low growth performance with the first pigs gaining 20 kg weight after 320 days (figure 9).



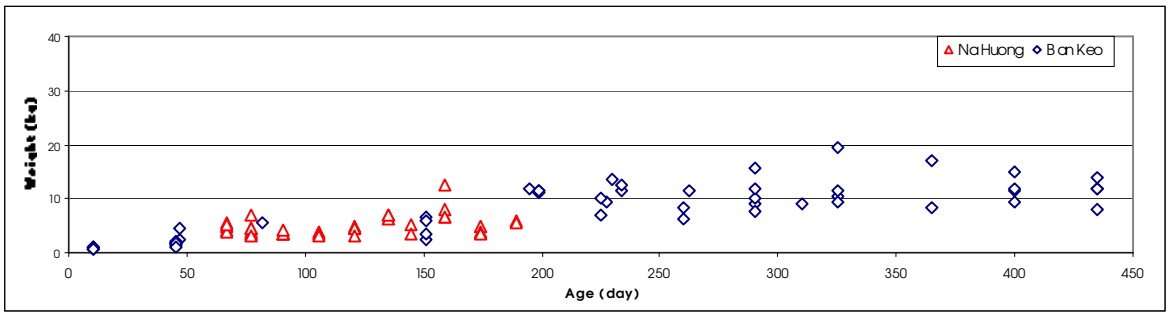
LW x MC (n = 86) including LW x MC in Ban Buon (n =32) and Ban Bo (n = 54)



LW x Ban (n = 24); CW x Ban (n = 56) in Na Huong



MC (n = 103) including MC in Ban Buon (n = 42) and Ban Bo (n = 61)



Ban (n = 88) including Ban in Na Huong (n = 36) and Ban Keo (n = 52)

Figure 9: Age-weight plots for pigs of different genotypes and from different villages. Plots include measurements from the first weighing and for a sub-sample of pigs the measurements from the second weighing in addition.

Table 24 below shows the daily weight gain for those pigs that could be measured twice. Because the age range of animals, for which data could be collected, was very broad, very young (<10 days) and very old pigs (>140 days) were excluded from calculations. Age intervals and resulting weight intervals are

presented in table 24. LW x Ban and CW x Ban pigs together showed the highest growth rate of 107 g/day in the considered age-interval. LW x MC pigs and MC pigs showed an intermediate growth rate with 81g and 67g/day in the considered age interval, respectively. The Ban breed had the lowest growth performance with 27g/day in the considered age interval. However, the obtained results have a low explanatory power; partly due to the very low sample size. Further, breed- and village-effects can not be separated, since MC and MC crossbreds are mainly kept in Ban Bo and Ban Buon, Ban crossbreds are kept in Na Huong, and Ban are kept in Na Huong and Ban Keo only.

Table 24: Daily weight gain for pigs, by genotype

Genotype	N	Age interval (days)	Weight interval (kg)	DWG (g/day)	
				Mean	SD
LW x MC	28	10 - 105	1.2 – 19.5	81.2	38.2
CW x Ban/LW x Ban	16	42 - 75	3.8 – 12.0	107.1	85.5
MC	15	11 - 91	1.1 – 12.0	67.3	79.2
Ban	21	10 - 121	0.8 – 5.4	27.2	26.2

Measuring pigs

4.2.4 Output from pig production

Output from pig production includes sold pigs, slaughtered pigs, pigs given away as gifts, and manure as products from pig production. However, in all investigated household pig manure plays a less important role. It returns no cash revenue and is not considered as a reason of keeping pigs. Pig manure was mainly used for home garden but rarely for field because of long distances, difficult transportation and very big amount needed as compared to chemical fertilizers. It was considered to be more important in villages near to town than in villages far from town because being used for home gardens.

Table 25 shows for selling pigs, slaughtering pigs and giving away pigs the respective percentage of households, the number of extracted pigs and the average weight of individual extracted pigs from selling, slaughtering and giving pigs as a present.

Performances of the pig genotypes, different input levels as well as ways of management have resulted in a considerable variation in the total numbers of pigs sold, the total weight sold per year and the annual cash revenue from pig production in the four villages.

In Ban Bo and Ban Buon, 80% households sold weaners with an average of 7.9 and 9.8 pigs per family per year, respectively. In Na Huong, only 50 % of households sold weaners, with the lower amount of 4.6 heads per household per year and 30% of households sold an average of 2.0 weaners in Ban Keo. The weight and age of weaners at the time of selling were different in different villages. In Ban Bo, farmers sold pigs at about 10.4 kg and at about 3 months of age (n=66), while farmers in Ban Bo sold younger pigs (2.5 month (n=80), at about 8 kg). Farmers in Na Huong sold older pigs (4 month of age (n=18), but only 8.4 kg average weight).

The percentage of investigated households selling fattening pigs was quite high in Ban Bo, Ban Buon and Na Huong (90%, 90%, and 80%), but was lower with only 50% in Ban Keo. Average numbers of fattening pigs sold per household were highest in Ban Bo with nearly 9.0 heads/household/year and with an average of weight of 60 kg (corresponding to 7 months of age (n=80)). In Ban Buon, investigated households sold about 5.0 fattening pigs/household/year with the average weight of 60 kg but an average

age of 8 months (n=46). Farmers in Na Huong sold 2.9 fattening pigs/household/year with about 60 kg weight but the considerably higher age of 10 months (n=23). In Ban Keo, the number of sold fattening pigs was lowest with 2.0 fattening pigs/household/year sold. The performance was also lower with an average weight of 42.8 kg and 12 months age (n=15).

In Na Huong, 90% of investigated households slaughtered pigs for home consumption or festivals while in other villages, only 30 to 40% of investigated households slaughtered pigs. Anyway, the average number of slaughtered pigs per family and year is not high in all villages, only 1 to 2 heads.

Only 10% of investigated households in Ban Keo and 30% of investigated households in Na Huong gave pigs as a gift to their relatives. In Ban Bo and Ban Buon, farmers usually do not use pigs as gifts for their relatives, but often sell them to relatives with a reduced price.

Figure 10 shows the total weight extraction in one year in the investigated households, consisting of pigs sold, pigs slaughtered and pigs given away as a present.

The highest weight extraction from selling pigs was recorded in Ban Bo (average 580kg/hh/year), followed by Ban Buon (340kg/hh/year) and Na Huong (220kg/hh/year). The smallest extraction was recorded in Ban Keo with 60 kg/hh/year. Results of this study show that output in pig production was important in all investigated farms in Ban Bo and Ban Buon with high number of weaners and fatteners sold as well as high weight extraction. Pig production was not considered as income generation by most investigated farmers in Ban Keo. In general, pigs have a socio-cultural function, which has, however, been almost lost in areas near town and is gradually lost in the areas more distant to towns.

In Ban Bo and Ban Buon, farmers slaughter pigs only for the New Year. In Na Huong and Ban Keo, farmers slaughter pigs not only for family consumption during the New Year celebrations but also for other cases such as worshiping, at harvesting time or the time of land preparation. The total slaughtered weight was 48kg/hh/year in Ban Bo, and about 20 kg in Ban Buon, Na Huong and Ban Keo.

Pigs are kept for income generation was practised in study villages, except in Ban Keo and played a more important role than for home consumption or giving a gift. In Na Huong, more pigs are sold than slaughtered or given away. Today, hired workers are paid in cash, and slaughter of pigs for feast was replaced by buying meat in the market, which is considered to be cheaper in Na Huong. In recent years, farmers mainly slaughtered small pigs for worshipping.

Table 25: Percent of households extracting pigs, numbers of extracted pigs per household and average weight of pigs extracted in the last 12 months, by village

Village	Ban Bo		Ban Buon		Na Huong		Ban Keo	
N households	10		10		10		10	
		Mean ± SD		Mean ± SD		Mean ± SD		Mean ± SD
No. of weaners sold (head/hh/year)	80%[1]	7.9 ± 4.6	80%[1]	9.8 ± 6.3	50%[1]	4.6 ± 1.8	30%[1]	2.0 ± 1.0
Weight of pigs (kg/pig)	66[2]	10.4 ± 1.8	80[2]	7.9 ± 1.8	18[2]	8.4 ± 2.4	6[2]	9.2 ± 4.6
No. of fatteners sold (head/hh/year)	90%[1]	8.9 ± 5.9	90%[1]	5.1 ± 2.3	80%[1]	2.9 ± 1.9	50%[1]	2.0 ± 0.7
Weight of pigs (kg/pig)	80[2]	59.4 ± 10.0	46[2]	60.0 ± 8.4	23[2]	61.3 ± 12.8	15[2]	42.8 ±10.1
No. of sold sows (head/hh/year)	20%[1]	1.0 ± 0.0	0%[1]	-	10%[1]	1.0	0%[1]	-
Weight of sow (kg/pig)	2[2]	100.0	0[2]	-	1[2]	68.0	0[2]	-
No. of slaughtered pigs (head/hh/year)	30%[1]	1.0 ± 0	30%[1]	1.3 ± 0.6	90%[1]	1.7 ± 0.9	40%[1]	2.0 ± 1.2
Weight of pigs slaughtered (kg/pig)	3[2]	48.3 ± 20.2	4[2]	22.5 ± 4.0	15[2]	19.1 ± 12.6	8[2]	19.5 ± 5.0
No. of pigs given as a gift (head/hh/year)	05[1]	-	0%[1]	-	305[1]	2.3 ± 1.2	10%[1]	2.0
Weight of pigs presented (kg/pig)	0[2]	-	0[2]	-	7[2]	6.4 ± 1.4	2[2]	8.0

[1]percentage of households sold/slaughtered/gift pigs. [2]Number of pigs sold/slaughtered/gift per villages
Means were calculated for households, which have respective types of extraction. Household interview

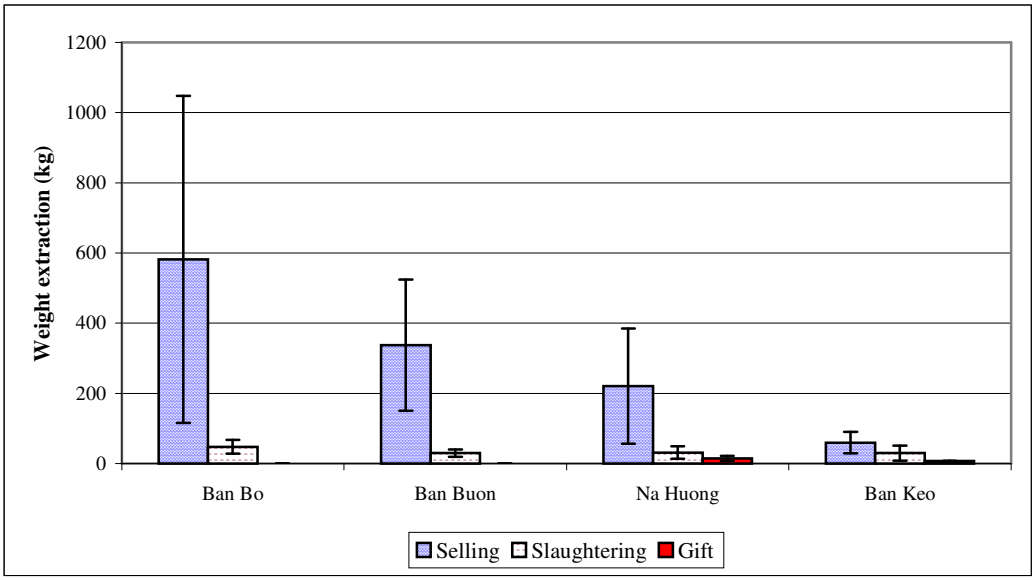


Figure 10: Weight extraction from pig production (selling, slaughtering and giving pigs as a gift) in investigated household in the last 12 months (mean ± SD), by village

Household interview

4.3 Pig feeding

4.3.1 Feed resources

In general, the feed resources used for pigs in Ban Bo, Ban Buon and Na Huong were quite similar, but in Ban Buon vegetable sources were more diversified in wintertime e.g. water dropwort, watercress and old leaves of cabbage (table 26). Feed resources used in Ban Keo were rather poor compared to other villages. Fresh cassava, rice bran, and vegetables such as Wild Taro, Rau Duong and banana stem were uses as main feeds for pigs.

Table 26: Overview over feedstuffs used in investigated households, by village

Village	**Ban Bo**	**Ban Buon**	**Na Huong**	**Ban Keo**
N households	10	10	10	10
Maize	++++	++	++	+
Rice bran	+++	+++	+	++
Rice	+	+	+	Not used
Dry cassava	+++	+++	+	+
Fresh cassava	+	Not used	+	+++
Dry fish	++	+++	+	Not used
Soybean	++	++	+	Not used
Concentrate	+++	++	++	Not used
Sweet potato vines	++++	+++	++	+
Cabbage	+	+	Not used	Not used
Water cress	Not used	+	Not used	Not used
Water dropwort	Not used	+	Not used	Not used
Wild taro	++	++	+++	+++
Rau Duong*	++	++	+++	+++
Banana stem	++	++	+++	+++
Papaya and pumpkin fruit	+	+	+	+
Distiller's cassava	++	++	+	+

Number of the symbol "+" in each field gives a subjective measure of the amount of feedstuffs used in the investigated households in one year
*Green herbaceous plant. No English translation known. Household interview and calendar tool

Table 27 gives an overview over the amount of different feedstuffs used in one year in investigated households in pig production, distinguished in the categories of purchased feed, farm produced feed, and total feed amount used.

The greater amount of crop products and by-products used in Ban Bo and Ban Buon compared to the amount of those feeds used in Na Huong and Ban Keo was due to higher numbers of pig kept. In addition, farmers in Ban Bo and Ban Buon feed higher amounts of purchased feed. On the other hand, in Na Huong and Ban Keo, there is less feed used, and the amount of purchased feed is lower or equal to zero. However, usage of feed resources in Na Huong are also different with those in Ban Keo due to bigger amount of feed and higher proportion of farms are used. It shows that farmers in Na Huong are tending to use more feed resources for pigs.

Table 27: Amount of feedstuffs used for pig production in one year per household in investigated households (% of households, mean ± SD), by village

Village	**Ban Bo**		**Ban Buon**		**Na Huong**		**Ban Keo**	
N households	10		10		10		10	
	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
Purchased maize (kg/year)	70	557 ± 516	70	269 ± 215	10	150 ± 483	0	-
Produced maize (kg/year)	100	1,840 ± 1622	100	715 ± 358	100	852 ± 483	80	278±186
Total maize (kg/year)	100	2,230 ± 1830	100	903 ± 330	100	867 ± 490	80	278 ± 190
Purchased rice bran (kg/year)	70	207 ± 199	70	313 ± 402	40	63 ± 58	10	60
Produced rice bran (kg/year)	90	358 ± 182	100	272 ± 152	60	271 ± 178	100	335 ± 170
Total rice bran (kg/year)	100	470 ± 260	100	490 ± 320	70	270 ± 180	100	340 ± 170
Purchased cassava (kg/year)	20	300 ± 283	30	433 ± 355	20	195 ± 148	0	-
Produced cassava (kg/year)	100	716 ± 318	90	672 ± 416	70	233 ± 107	100	833 ± 495
Total cassava (kg/year)	100	780 ± 290	100	740 ± 360	90	224 ± 107	100	830 ± 500
Purchased soybean (kg/year)	70	104 ± 175	90	50 ± 26	40	70 ± 35	0	-
Produced soybean (kg/year)	0	-	30	40 ± 17	40	70 ± 34	0	-
Total soybean (kg/year)	70	104 ± 175	90	64 ± 30	40	70 ± 35	10	1
Total dry fish (kg/year)	70	52 ± 57	100	84 ± 64	70	23 ± 11	0	-
Total concentrate (kg/year)	100	133 ± 140	90	68 ± 41	50	89 ± 69	0	-
Sweet potato vines (kg/year)	90	2,210 ± 1660	100	2,000 ± 710	80	1,170 ± 880	20	500 ± 400

Means were calculated for households that use respective feedstuffs for pig production. Household interview

In general the percentage of investigated households buying feedstuffs in Ban Bo and Ban Buon was much higher than in Na Huong and Ban Keo.

High numbers of households bought maize in Ban Bo and Ban Buon (70%) while only 10% of farms in Na Huong and no farm in Ban Keo bought. 70% of farms in Ban Bo and Ban Buon, 40% of farms in Na Huong and 10% of farms in Ban Keo purchased rice bran. Cassava was bought in Ban Buon, Ban Bo and Na Huong with small percentage (10 to 30%). Fish and concentrate were bought by a high frequency of investigated farms in Ban Buon, Ban Bo and Na Huong, but were (with an exception for fish) not bought in Ban Keo. Soybeans were bought by most farmers in Ban Buon and Ban Bo.

The time and frequency of feed purchases in the investigated households is however irregular. Around 10% and 20% of the investigated households in Ban Buon and Ban Bo purchase bigger amounts of maize after harvest at the time of the annual price minimum. Other farmers in Ban Buon and Ban Bo often buy maize in the time of feed shortage before harvest (often from March to July) with small amounts only and a high frequency of purchase. Rice bran and cassava are also needed in the time of feed shortage and are purchased with small amounts per time. Fish, soybean and concentrate feed are usually purchased throughout the year with only small amounts per time depending on the time farmers go to the market or depending on availability of capital. Each time, about 5 kg for concentrate, few kg of fish and soybean are purchased. Only when fattening pigs for selling, farmers often buy bigger amounts of concentrate and soybean to mix with farm-produced feed. The purchase of fish of one farm in Ban Keo was an exception, since the fish was bought for sick pigs (to increase their feed intake).

Farm-grown feeds, forest feeds and seasonality of production

The definition of "time of fed shortage" "time of heavy feed shortage" and "time of feed abundance" can be found in chapter 3.

The first maize crop is harvested between end of August/early September and October, the second crop from December and January. Maize is one of the main feed resources for pig production in Ban Bo, Ban Buon and Na Huong. Maize is used throughout the year in Ban Bo and Ban Buon (table 28). Maize is in the investigated households abundant from September to January. After that, the first households have finished the stored amount. Heavy maize shortage occurs in the investigated households from May to July. During the time of shortage, farmers in Ban Bo and Ban Buon often purchase additional maize. In Na Huong, the time of maize abundance is lightly shorter, from September to December and even shorter (September to November) in Ban Keo. The time of maize shortage lasts in Na Huong from April to July, but from December to August in Ban Keo.

Regarding upland rice, only one crop is harvested in the time between September and November. Paddy rice was planted in two crops per year in Ban Bo, Ban Buon and Ban Keo, only one crop is planted in Na Huong. The first paddy crop is harvested between June and July and the second crop between October and November. In Ban Buon and Ban Bo, all investigated farms used rice bran for pigs throughout the year. Rice bran is available in farms in Ban Bo, Ban Buon and Ban Keo from July to April and it is lacking from April to May. when rice bran is nearly finished, farmers will reduced the daily amount feed for pig. When rice bran is finished, farmers in Ban Bo and Ban Buon will buy more. In Ban Keo, after rice bran has finished, farmer will feed more fresh cassava, banana stem, and vegetable. In Na Huong, after rice ran has finished, farmer use banana stem or vegetables with few farmers bought more. In Na Huong, rice bran was used in investigated households for 8 months of the year from October to March and from June to July. Rice bran was abundant from June to July in families who plant paddy rice and from October to November in families who plant upland rice or buy upland rice for family consumption. Other months, they do not feed rice bran. In Ban Keo, rice bran was used during 9 months of the year from July to March. Rice bran is abundant from July to October and lacking from April to early June.

Cassava is generally harvested between October and April to produce dry cassava but not with big amounts. Farmers said that at that time they can get an optimum cassava meal amounts because of dry weather, and cassava itself provides more starch than cassava in other seasons. Big amounts cassava was used often in the season of feed shortage, especially when the stored maize is short or finished. In Ban Buon, only dry cassava is used. When in Ban Bo, Ban Keo and Na Huong, both dry and fresh cassava are used. Fresh cassava is often used when dry cassava is finished or fresh cassava is harvested for drying and thus, available at home for some days. In Ban Keo, farmers do not use cassava after harvesting maize, because available maize, but use at the time of feed shortage as main pig feed, especially fresh cassava.

Soybeans are harvested between June and August. Soybeans were used throughout the year in Ban Bo and Ban Buon, but are mainly purchased. Farmers in Na Huong used only soybeans they have produced themselves. The time of soybean feeding for feed lasts from July to September in investigated households in Na Huong. None of the investigated farms in Ban Keo plant soybeans and also do not use soybeans for pig feeding.

Two main farm-grown vegetable resources used in the selected villages for pig feeding are sweet potato vines and banana stem. Harvesting sweet potato vines lies between April and October. It can be prolonged or shortened depending on the available water resources for watering the plants. Sweet potato vines were used in Ban Bo and Ban Buon for 8 and 7 months of the year, respectively. The time for using sweet potato vines was shorter in Na Huong (6 months) and shortest in Ban Keo (only 2 months).

Banana stem was used throughout the year in Ban Keo and was considered as one of the main feed resources. Especially in the time of feed shortage and in the main cultivation period (May to July), some families in Ban Keo feed only banana stem and fresh cassava for their pigs. In Na Huong, banana stem is also a main vegetable for pigs, and used for 10 months of the year. In Ban Bo and Ban Buon, farmers use banana stem as an alternative vegetable, when sweet potato vines are lacking or when they cannot collect forest vegetables.

Some kind of forest vegetables used as feed for pigs are Wild Taro and Rau Duong. In some families, Wild Taro was planted in their home garden in very small areas where water is available or it grows by itself. Collecting this vegetable in forest/upland is more common. The time of using forest vegetables was longer in Ban Keo and Na Huong than in Ban Bo and Ban Buon. In Ban Buon and Ban Bo, farmers rely more on the farm-produced vegetable resources such as sweet potato vines than farmers in Na Huong and Ban Keo. The time of using Wild taro is slightly different between Ban Bo and Ban Buon. In Ban Bo, farmers collect Wild Taro from May to August, when they are working in their fields. In contrast, farmers in Ban Buon collect Wild Taro only from March to May because they can use sweet potato vines from May onwards.

Table 28: Overview over harvesting times of main feedstuffs, times of using produced vs. purchased feed, by village.

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Ban Bo and Ban Buon*												
Maize	FF	F	F	P	PP	PP	PP	F	FF	FF	FF	FF
Rice bran	FF	F	F	PP	PP	F	**FF**	FF	FF	**FF**	FF	FF
Cassava	F	F	F	**F**	P	P	P			F	F	F
Soybean	P	P	P	P	P	P	P	P	P	P	P	P
Sweet potato vines				F	F		F	F	F	F		
Banana stem	F	F	F								F	F
Wild taro				F		F	F		F	F		
Rau Duong**		F	F	F								
Na Huong												
Maize	F	F	F					F	FF	FF	FF	FF
Rice bran	FF	F	F			F	F			F	F	FF
Cassava	F	F	F	**F**		F	**F**	F			F	F
Soybean							**F**	F	F	F	F	
Sweet potato vines				F	F	F		F	F			
Banana stem	F	F	F	F	F	F			F	F	F	F
Wild taro						F	F	F	F			
Rau Duong**		F	F	F	F	F	F					
Ban Keo												
Maize									FF	FF	FF	F
Rice bran	FF	F	F				FF	FF	**FF**	**FF**	FF	FF
Cassava	F	F	F	F	F	F	F	F			F	F
Soybean												
Sweet potato vines							F	F				
Banana stem	F	F	F	F	F	F	F	F	F	F	F	F
Wild taro			F	F	F	F	F	F	F			
Rau Duong**			F	F	F	F	F	F				

"F" farm -produced or forest feeds are used. "P" purchased feeds are used
"FF" farm -produced feeds are abundant. "PP" feed resources are in heavy shortage
Grey colour in the table shows harvesting time of crops
* results for Ban Buon and Ban Bo were identical and are therefore presented together.
**No English translation. Household interview and calendar tool

Table 29 shows the time of feed shortage in the investigated households. Maize is lacking for 4 months in Ban Bo, Ban Buon and Na Huong from April to July due to big amount of maize left for pigs in one year and they often harvest some maize sooner for their pigs. Actually, among Ban Bo, Ban Buon and Na Huong was different: farmers in Na Huong do not leave so much for their pigs but they also keep less number of pigs. In Ban Keo, the time of maize shortage is longer, 8 months (from January to August) due to small amount of maize left for pigs in one year and they do not harvest young maize for pigs.

Maize shortage is finally over with the new harvesting start of maize (end of September to early of October). Rice bran is in shortage when the stored rice amount finished (produced and purchased) and farmers need to buy more rice for family consumption. In Ban Bo and Ban Buon, the time of rice bran shortage is from February to June and heavy shortage is from April to May. Farmers harvest rice in late of June or July, after that, rice bran is abundant. In Na Huong, the time of rice bran shortage differs because they consume upland rice, and its harvesting is from September to November, depending on varieties. In Ban Keo, heavy rice bran shortage is from April to June and rice bran comes from upland rice and paddy rice.

Vegetables (mainly sweet potato vines) are in the shortage when the vegetation period is over. Vegetable shortage is released when the vegetation period starts. So, vegetable sources are lacking from November to February in Ban Bo and Ban Buon and from November to March in Na Huong and Ban Keo.

Table 29: Time of shortage of the main feed resources used for pig feeding in investigated households, by village

Months	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Ban Bo and Ban Buon villages												
Maize				x	x	x	x					
Rice bran		x	x	x	x	x						
Vegetables	x	x									x	x
Na Huong village												
Maize				x	x	x	x					
Rice bran				x	x	x	x	x				
Vegetables	x	x	x								x	x
Ban Keo village												
Maize	x	x	x	x	x	x	x	x				
Rice bran				x	x	x						
Vegetables	x	x	x								x	x

Household interview and calendar tool

Farmers strategies to overcome the time of feed shortage are shown in table 30.

Table 30: Different feeding strategies in different seasons in investigated households, by village

Season	**Season of feed shortage (March-July)**	**Season of feed abundance (September-November)**
Village		
Ban Bo	- Reduce amount of maize and/or rice bran - Buy more maize and rice bran in heavy shortage time - Few farmers bought cassava. More farms feed cassava and same or more cassava fed	- Feed more maize and rice bran - Reduce amount of or do not feed cassava
Ban Buon	- Reduce amount of maize and/or rice bran - Buy more maize and rice bran in heavy shortage time - Few farmer bought cassava. More farms feed cassava and same or more cassava fed	- Feed more maize and rice bran - Reduce amount or do not feed cassava
Na Huong	- Reduce amount of maize - Feed cassava only if stored maize amount finished (some farms feed dry cassava produced, some farms feed fresh cassava and other farms feed both). Few farms purchased cassava	- Feed more maize and less cassava
Ban Keo	- Feed no maize and less rice bran till stored rice bran amount finished - Feed more cassava, vegetables (banana stem, Wild Taro and Rau Duong).	- Feed more maize and rice bran (until stored amount finished) - Feed less/no cassava

Calendar tool and household interview

Using commercial feedstuff for pigs

As indicated in table 27 above, concentrate feed and fish are used by most investigated households in Ban Bo, Ban Buon, and Na Huong, however, with low amounts. No farm in Ban Keo bought concentrate feed.

In Ban Bo and Ban Buon, one to two months before selling fattening pigs for slaughter, more concentrate and fish were bought to be mixed with other feed (rice bran, maize, cassava, and soybean) to feed for fattening pigs.

In general, farmers in Son La province often buy more concentrate feed between September and January to mix with the maize. Farmers want to feed pigs with better quality feed to shorten the time of keeping and sell pigs for the New Year festival. From February to August, farmers Son La province prefer to buy complete feeds (which can be fed directly without additional feeds) since their maize has been finished. From February to April, the purchased amount of concentrate is declined because farmers have sold their pigs for New Year, and start again keeping young animals with lower weight and lower feed requirement.

Competition between animal species regarding feed resources

In investigated households, feed resources and capital resources are scarce and it was therefore assumed that there is a competition between different animal species regarding the available feed resources or regarding the capital to buy additional feed. The main species to be considered are pigs, ruminants and poultry.

Ruminants in smallholder farms are often kept free ranging; cut-and-carry is practiced especially in time of ploughing. In Ban Bo and Ban Buon, buffaloes were kept in fields for grazing. In Ban Keo and Na Huong, buffaloes and cattle are kept at home and during the field work farmers bring them to the field and let them graze there. Crop residues such as sugar cane top, rice straw, cassava peels, and young maize

leaves are used directly after harvesting. Sugar cane tops are just used for ruminant after harvesting. Rice straw was used in winter when forage is lacking. Cassava peels are available during the preparing drying of cassava. Young maize leaves are used during maize growing (farmers need to remove some maize leaves so the maize can grow better and has higher performance). In the time of ploughing fields (March to May), ruminants were also supplemented with some maize, banana stem and a bit salt.

Poultry in the investigated households is kept free ranging in the garden. Sometimes, poultry gets additional feed including maize, rice bran and cassava; but only small amounts because of the poultry's capacity to find feed. It seems that the predicted competition among animals regarding feed resources is limited mainly to maize. However, during the time of feed shortage, the remaining maize is in investigated farms given with priority to pigs.

All farmers in Ban Bo, Ban Buon and Ban Keo use maize for pig, 80% of farms in Ban Keo use maize. All farms in Ban Bo and Na Huong use maize for other animals, 90 and 70% farms use maize for other animals in Ban Buon and Ban Keo. All farms in Na Huong and Ban Keo sell maize to get cash, while only 40% of farms in Ban Buon and Ban Buon sell maize (table 31).

Annual harvested maize amounts in four villages differ greatly with 2980, 1060, 15940 and 2430 kg/hh/year in Ban Bo, Ban Buon, Na Huong and Ban Keo, respectively.

The total annual amount of maize fed to other animal species (excluding pigs) occupies a small part of the maize produced (10% in Ban Bo, 16% in Ban Buon, 1.3% in Na Huong and 3.2% in Ban Keo), and a small part compared to the maize used for pigs in one year (percentages of maize fed for animals (excluding pigs) are 21%in Ban Bo, 18% in Ban Buon, 18% in Na Huong and 25% in Ban Keo in the total maize left for animals). The total amount of maize used for pigs was largest in Ban Bo, with nearly 1700kg, accounting for 59% of total maize harvested; followed by Ban Buon with 715 kg, accounting for 72% of total maize harvested; 852 kg maize was used for pigs in Na Huong and calculating for 5% of the harvested amount; and lowest in Ban Keo with 300 kg, accounting for 11% of the harvested maize (figure 15). In comparison to Ban Buon and Ban Bo, investigated farmers in Na Huong and Ban Keo prefer getting cash directly from selling maize than getting cash indirectly from pig production or animal production based on the produced maize.

Table 31: Percentage of investigated households using maize for different purposes in the last 12 month , by village (% of households)

Villages	**Ban Bo**	**Ban Buon**	**Na Huong**	**Ban Keo**
N households	10	10	10	10
% hh used maize for pigs	100	100	100	80
% hh used maize for other animals	100	90	100	70
% hh selling maize	40	40	100	100

Household interview

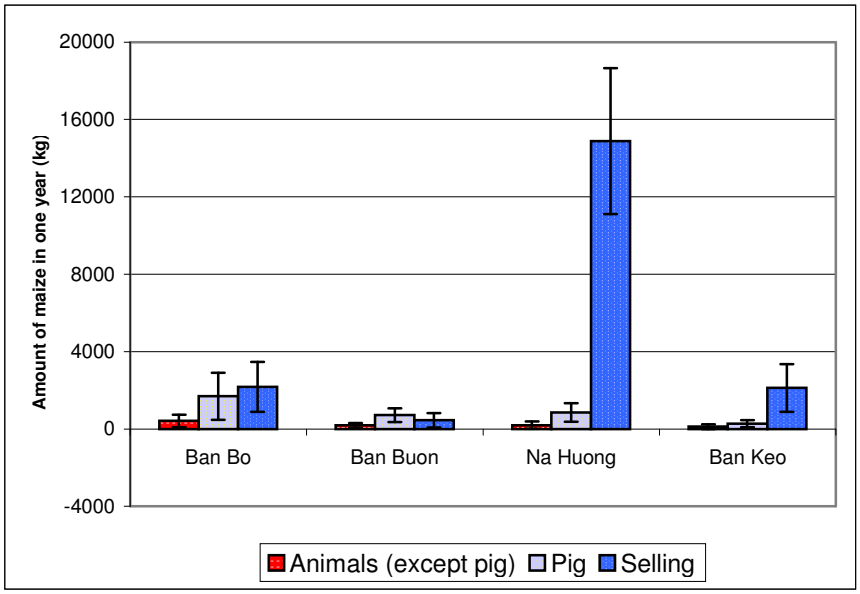


Figure 11: Amount of maize used for different purposes in the last 12 months in investigated households, by villages (mean ± SD)

Means were calculated only for households using maize for the respective purpose. Household interview

4.3.2 Quantitative composition of feeding rations

Feed use in season of feed shortage, assessed by interviewing

In the time of feed shortage, most of farmers have not enough feed and need to reduce feed amount for pigs or purchase more to compensate the shortage, or replace by other feeds. This time usually last from March to July.

The qualitative and quantitative composition of rations for pigs in the season of feed shortage, assessed by interviewing, is presented in tables 32 (empty and pregnant sows), 33 (lactating sows) and 34 (fattening pigs). The day of interview was in the time of feed shortage.

Maize and rice bran was as the main feed resources in the time of feed shortage. 100 % of sows in Ban Buon and Ban Bo and 80% of sows in Na Huong were fed with maize. The amount of maize feed for one sow in Ban Bo, Ban Buon and Na Huong was 1 kg, 0.8 kg and 0.7 kg per day; maize was not fed in Ban Keo. Rice bran was fed to 100% of investigated sows in Ban Buon and Ban Bo, and to almost all sows in Na Huong (80%) and Ban Keo (64%). Amounts of rice bran fed for one sow/day were also similar in Ban Bo and Ban Buon (0.5 and 0.6 kg), in Na Huong and Ban Keo, only 50 % of these amounts were fed (table 32).

In Ban Buon, Ban Bo and Na Huong, mainly dry cassava was fed (73% of sows in Ban Bo, 100% of sows in Ban Buon and 60% of sows in Na Huong). In Ban Keo, only 27% of sows received dry cassava. Fed amounts varied between 0.2kg/sow/day (Na Huong) and 0.9kg/sows/day (Ban Buon). Fresh cassava was mainly fed in Ban Keo (73% of sows), but was less common in the other villages (27% of sows in Ban Bo, 40% of sows in Na Huong, and was not used in Ban Bo).

Vegetables are fed to all investigated sows with about 3kg/sow/day in Ban Buon and Ban Bo, 1.4kg/sow/day in Na Huong and 2.1kg/sow/day in Ban Keo. In comparison, farmers in Ban Keo and Na Huong use more banana stem than farmer in Ban Buon and Ban Bo: In Ban Keo and Na Huong, 100% of

sows were fed on banana stem with high amounts (2.6kg and 4.5kg); while only about half of the sows in Ban Buon and Ban Bo received banana stem with lower amounts (2.7kg and 1.4kg).

Dry fish was fed to a varying number of sows in the villages: 69% of investigated sows in Ban Buon, 18% of sows in Ban Bo and 30% of sows in Na Huong received fish. Fish was not used in Ban Keo. Amounts were higher in Ban Bo and Ban Buon (about 60g and 80g/sow/day) and lower in Na Huong (ca. 30g/sow/day).

Soybean was used only for few sows (9% in Ban Bo, 15% in Ban Buon, 20% in Na Huong) and was not used in Ban Keo. Amounts were equally low with 40 to 50g/sow/day. Concentrate was used mainly in Ban Bo (91% of investigated sows), but was also used in Ban Buon (62% of investigated sows) and to a lesser extent in Na Huong (20% of investigated sows). It was not fed to investigated sows in Ban Keo. Fed amounts were similar with about 100 to 120g/sow/day.

The total feed amount of energy and protein-rich feed (excluding vegetables) per sow and day was two to three times higher in Ban Buon and Ban Bo (2.0 and 1.8kg/sow/day) compared to Na Huong and Ban Keo (0.9 and 0.6kg/sow/day). The feed intake of roughage was varying with higher amounts in Ban Bo (5.8kg/sow/day) and Ban Keo (6.6kg/sow/day) and lower in Ban Buon (4.4kg/sow/day) and Na Huong (6.6kg/sow/day).

Table 32: Quantitative composition of feeding rations for empty and pregnant sows on test day in the time of feed shortage, by village (kg feedstuff/sow/day) (% of sows getting the respective feedstuff, mean ± SD of kg feedstuff/sow/day)

Village	**Ban Bo**		**Ban Buon**		**Na Huong**		**Ban Keo**	
N sows	11		13		10		11	
	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
Maize (kg/sow/day)	100	1.0 ± 0.4	100	0.8 ± 0.4	80	0.7 ± 0.2	0	
Rice bran (kg/sow/day)	100	0.5 ± 0.2	100	0.6 ± 0.4	80	0.2 ± 0.2	64	0.3 ± 0.3
Rice (kg/sow/day)	0	-	8	0.1	10	0.5	0	-
Dry cassava (kg/sow/day)	73	0.6 ± 0.4	100	0.9 ± 0.4	60	0.2 ± 0.1	27	0.6 ± 0.2
Fresh cassava (kg/sow/day)	27	1.5 ± 0.5	0	-	40	1.1 ± 0.3	73	1.3 ± 0.8
Vegetables (kg/sow/day)	100	3.1 ± 1.8	100	3.0 ± 1.7	100	1.4 ± 0.5	100	2.1 ± 1.5
Banana stem (kg/sow/day)	55	2.7 ± 1.3	54	1.4 ± 0.6	100	2.6 ± 1.0	100	4.5 ± 1.1
Dry fish (g/sow/day)	18	60.0 ± 28.3	69	77.5 ± 16.0	30	33.4 ± 16.7	0	-
Soybean (g/sow/day)	9	40.0	15	55.0 ± 7.1	20	36.7 ± 4.7	0	-
Concentrate (g/sow/day)	91	102.0 ± 23.3	62	113.4 ± 51.9	20	123.5 ± 61.5	0	-
Feed amount (kg/sow/day)*	100	2.2 ± 0.8	100	2.4 ± 0.5	100	1.1 ± 0.4	100	0.7 ± 0.4

Means were calculated for sows that were fed respective feedstuffs
*calculated by total amount of feedstuffs except vegetables and banana stem. Household interview

Feed amount supplied per lactating sow per day was also higher than for empty/pregnant sows in Ban Bo, Ban Buon and Na Huong. However, in Ban Keo, farmers do not consider that there was a difference between the two reproductive stages and therefore did not adapt the feeding. Fish, soybean and concentrate for lactation sow were fed higher in amount for lactating sows than those for empty/pregnant sows in Ban Bo, Ban Buon and Ban Keo.

Maize and rice bran were the main feed resources in the time of feed shortage. 100% lactating sows in Ban Bo and Ban Buon and 80% of lactating sows in Na Huong were fed with maize. Maize was not fed for lactating sow in Ban Keo. The amount of maize feed for one sow in Ban Bo, Ban Buon and Na Huong was 1.2 kg, 0.9 kg and 0.9 kg per day. Rice bran was fed to 100 investigated sows in Ban Bo and Ban Buon and to 80 and 64% of investigated lactating sows in Na Huong and Ban Keo. Rice bran amount was fed similar for lactating sows in Ban Bo, Ban Buon and Na Huong (0.6 to 0.7 kg/sow/day), in Ban Keo, only 0.3 kg/sow/day was fed for lactating sows. A very small proportion of investigated sows was fed with rice 818%, 8% and 10% in Ban Bo, Ban Buon and Na Huong, with 1kg, 0.1 and 0.5 kg/sow/day, respectively) (table 33).

In Ban Bo, Ban Buon and Na Huong, high percentage of investigated lactating sows was fed with dry cassava (73%, 100 and 70%, respectively). In Ban Keo, only 27% of lactating sows were fed dry cassava. Amount of cassava varied between 0.2 kg in Na Huong and 1kg in Ban Buon. Fresh cassava was mainly used in Ban Keo (73% of lactating sows) , but is less common in other villages (27% in Ban Bo and 40% in Na Huong), and is not used in Ban Buon.

Vegetables are used for all investigated lactating sows. In comparison, lactating sows in Ban Bo and Ban Buon were fed more vegetables with about 3 kg/sow/day than sows in Na Huong and Ban Keo with 1.4 kg per sow per day in Na Huong and 2.1 kg/sow/day in Ban Keo. In Ban Keo, all farmers used banana stem with high amount (4.5 kg/sow/day); all of farmers used banana stem for their lactating sows with 2.6kg/sow/day; while only half of lactating sows in Ban Buon and Ban Keo were fed on bananas stem with lower amounts (2.4 and 1.4 kg/sow/day).

Dry fish was fed to 77% lactating sows in Ban Buon, 40% in Na Huong and 18% in Ban Bo. Fish was not used in Ban Keo. Amounts of fish fed for lactating sows were higher in Ban Buon and Na Huong (ca. 90g/sow/day) and lower in Ban Bo (60g/sow/day).

Soybean was used for few pigs only (27% in Ban Bo, 39% in Ban Buon and 40% in Na Huong) and was not used in Ban Keo. Amount fed for lactating sows was high in Ban Bo with about 180 g/sow/day. It is lower for lactating sows in Ban Buon and Na Huong (ca. 100g/sow/day).

Concentrate was used in Ban Bo (100% of lactating sows), in Ban Buon (73% of lactating sows) and in Na Huong (20% of investigated lactating sows). It was not used for lactating sow in Ban Keo. The concentrate amount was 120g in Ban Bo, 130 g in Ban Buon and highest in Na Huong with 180 g/sow/day.

The total feed amount per lactating sow per day was 2 times higher in Ban Buon and Ban Bo (3.0 and 2.7kg/sow/day) as compared to Na Huong (1.5kg/sow/day) and about 4 times higher than in Ban Keo (0.7kg/sow/day). Roughage amounts were highest in Ban Keo (6.6kg/sow/day), 5.4 kg/sow/day in Ban Bo, and the lowest in Ban Buon and Na Huong (4.4kg and 4.0 kg/sow/day).

Table 33: Quantitative composition of feeding rations for lactating sows on test day in the time of feed shortage, by village (kg/sow/day) (% of sows getting the respective feedstuff, mean ± SD of kg feedstuff/sow/day)

Village	Ban Bo		Ban Buon		Na Huong		Ban Keo	
N sows	11		13		10		11	
	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
Maize (kg/sow/day)	100	1.2 ± 0.6	100	0.9 ± 0.4	80	0.9 ± 0.5	0	-
Rice bran (kg/sow/day)	100	0.7 ± 0.4	100	0.7 ± 0.4	70	0.6 ± 0.4	64	0.3 ± 0.3
Rice (kg/sow/day)	18	1.0 ± 0.7	8	0.1	10	0.5	0	-
Dry cassava (kg/sow/day)	73	0.8 ± 0.2	100	1.0 ± 0.4	70	0.2 ± 0.1	27	0.6 ± 0.2
Fresh cassava (kg/sow/day)	27	1.5 ± 0.5	0	-	40	1.1 ± 0.3	73	1.3 ± 0.8
Vegetable (kg/sow/day)	100	3.1 ± 1.8	100	3.0 ± 1.7	100	1.4 ± 0.5	100	2.1 ± 1.5
Banana stem (kg/sow/day)	46	2.4 ± 1.2	54	1.4 ± 0.6	100	2.6 ± 1.0	100	4.5 ± 1.1
Dry fish (g/sow/day)	18	60.0 ± 28.3	77	89.7 ± 41.6	40	95.9 ± 75.0	0	-
Soybean (g/sow/day)	27	183.3 ± 189.3	39	102.0 ± 59.3	40	118.4 ± 124.8	0	-
Concentrate (g/sow/day)	100	120.0 ± 45.3	73	132.2 ± 72.2	20	183.5 ± 23.3	0	-
Feed amount (kg/sow/day)*	100	3.0 ± 1.3	100	2.7 ± 0.4	100	1.5 ± 0.8	100	0.7 ± 0.4

Means were calculated for sows that are fed on the respective feedstuffs
*calculated by total amount of feedstuffs except vegetables and banana stem. Household interview

Table 34 does not distinguish between feeding rations for fattening pigs of different age- or weight-groups, but gives the average values for the feeding rations of the fattening pigs existing on the investigated farms at time of interview.

100% of fattening pigs in Ban Bo and Ban Buon and 90% in Na Huong received maize. The amount of maize was around 0.2 to 0.3 kg/pig/day. Maize was not used for pigs in Ban Keo. Rice bran was fed for 100% of fattening pigs in Ban Bo and Ban Buon and over half of pigs in Na Huong and Ban Keo. The amount of rice bran fed was similarly in all investigated villages (0.1kg/pig/day).

A varying percentage of dry cassava was fed for pigs (75% in Ban Bo, 86% in Ban Buon and 67% in Na Huong), a lower percentage of pigs was fed dry cassava in Ban Keo (17%). The dry cassava amount for each pig was 0.1 kg/pig/day in Na Huong, 0.2kg/pig/day in Ban Bo and Ban Buon and 0.3kg/pig/day in Na Huong. Highest percentage of pigs fed fresh cassava was in Ban Keo (83%). A low percentage of pigs was fed fresh cassava in other villages (25% in Ban Bo and 33% in Na Huong), fresh cassava was not used in Ban Buon.

Vegetables were used for all of fattening pigs with an amount from 0.4kg/pig/day in Ban Keo and 0.8kg/pig/day in Ban Bo. All fattening pigs in Ban Keo were fed with high amount of banana stem (1.4kg/pig/day) compared to 0.4kg/pig/day in Ban Buon 0.6 kg/pig/day in Ban Bo and 0.8kg/pig/day in Na Huong.

74% of fattening pigs in Ban Buon were fed with fish, while only 38% in Ban Bo and 41% in Na Huong. The amount of fish used was similarly in Ban Bo and Ban Buon (ca. 15g/pig/day). The amount of feed used was lower in Na Huong with 8g/pig/day.

Low percentage of pigs was fed with soybean. (7% in Ban Bo, 20% in Ban Buon and 2%in Na Huong), the soybean amount was fed similar in Ban Buon and Na Huong (ca. 30g/pig/day). All of fattening pigs in

Ban Bo were fed with concentrate, while only 33% in Ban Buon and 12% in Na Huong received concentrate. The concentrate amount fed for pigs was rather similar (ca. 30g/pig/day)

The total feed amount of energy and protein-rich feed without vegetable per pig was highest in Ban Bo (0.6kg/pig/day) and lowest in Na Keo (0.2kg/pig/day). The amount of roughage was highest in Ban Keo (2kg/pig/day) and lowest in Ban Buon (1kg/pig/day).

Table 34: Quantitative composition of feeding rations for fattening pigs of all ages on test day in the time of feed shortage, by village (kg feedstuff/pig/day) (% of pigs getting the respective feedstuff, mean ± SD kg feedstuff/pig/day)

Village	**Ban Bo**		**Ban Buon**		**Na Huong**		**Ban Keo**	
N fatteners	56		49		51		41	
	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
Maize (kg/pig/day)	100	0.3 ± 0.2	100	0.2 ± 0.1	90	0.2 ± 0.1	0	-
Rice bran (kg/pig/day)	100	0.1 ± 0.1	100	0.1 ± 0.1	57	0.1 ± 0.1	68	0.1 ± 0.1
Rice (kg/pig/day)	0	-	0	-	14	0.1 ± 0.0	0	-
Dry cassava (kg/pig/day)	75	0.2 ± 0.1	86	0.2 ± 0.2	67	0.1 ± 0.1	17	0.3 ± 0.1
Fresh cassava (kg/pig/day)	25	0.3 ± 0.2	0	-	33	0.3 ± 0.3	83	0.4 ± 0.4
Vegetables (kg/pig/day)	100	0.8 ± 0.6	100	0.6 ± 0.7	100	0.4 ± 0.3	100	0.6 ± 0.6
Banana stem (kg/pig/day)	64	0.6 ± 0.4	33	0.4 ± 0.4	100	0.8 ± 0.6	100	1.4 ± 0.8
Dry fish (g/pig/day)	38	15.2 ± 5.1	74	14.6 ± 16.6	41	7.9 ± 2.7	0	-
Soybean (g/pig/day)	7	10.0	20	30.3 ± 25.6	2	33.3	0	-
Concentrate (g/pig/day)	100	39.1 ± 54.3	33	33.9 ± 33.5	12	37.5 ± 10.9	0	-
Feed amount (kg/pig/day)*	100	0.6 ± 0.5	100	0.5 ± 0.4	100	0.3 ± 0.2	100	0.2 ± 0.1
Age (months)		4.3 ± 1.7		2.6 ± 1.1		5.0 ± 3.0		9.1 ± 3.4

Means were calculated for fattening pigs that were fed on the respective feedstuffs
*calculated by total amount of feedstuffs except vegetables and banana stem. Household interview

Feed use in season of feed abundance, assessed by interviewing

In the time of feed abundance, feed is available in all farms and pigs can be fed enough feed. This time corresponding to the period after harvest (September to November).

The qualitative and quantitative composition of rations for pigs in the season of feed abundance, assessed by interviewing, is presented in tables 35 (empty and pregnant sows), 36 (lactating sows) and 37 (fattening pigs). Results do not represent the ration on any test-day, but rather an average ration composition.

The increased use of commercial feed components in the rations (fish, soybean) in Ban Buon during the time of feed abundance seems to indicate that farmers have more cash available after selling the harvested crop and invest the cash in pig production.

All investigated sows were fed maize in Ban Bo, Ban Buon and Na Huong, and 82% of investigated sows received maize in Ban Keo. The maize amount fed for sows was similar in Ban Bo and Ban Buon (1.5 – 1-6 kg/sow/day), and lower in Na Huong and Ban Keo (1.0 kg and 0.7 kg/sow/day) (table 35).

All investigated sows in Ban Bo, Ban Buon and Ban Keo were fed by rice bran, only half of sows in Na Huong were fed rice bran. The amount of rice bran was 0.3kg in Na Huong, 0.4kg in Ban Keo, 0.5kg in Ban Bo and 0.6 kg in Ban Buon.

A varying percentage of investigated sows was fed dry cassava (55% in Ban Bo, 62% in Ban Buon, 20% in Na Huong and 9% in Ban Keo). Sows in Ban Bo and Ban Buon were not fed with fresh cassava. 10% of sows in Na Huong and 64% of sow in Ban Keo were fed with fresh cassava at a similar amount (0-6 – 0.7 kg). The highest amount of dry cassava fed for sows was 1.1kg in Ban Buon and the lowest was 0.4kg in Ban Keo.

Nearly all sows were fed with vegetables. The vegetable amount was similar in Ban Bo and Ban Buon (1.8kg/sow/day) and higher than those in Na Huong and Ban Keo. The highest percentage of investigated sows fed with banana stem were in Ban Keo (91%), around a half of investigated sows was fed with banana stem in Ban Bo, Ban Buon and Na Huong and with ca. 2.5kg/sow/day. Whereas, up to 4.4 kg/sow/day of banana stem was used for sows in Ban Keo.

No sow in Ban Bo was fed with fish, concentrate or soybean. Highest dry fish was fed for sow in Ban Buon (ca. 130g/sow/day), which was two to 3 times higher than in Ban Bo and Na Huong (60g, and 40g/sow/day). In Ban Buon and Na Huong, sows were fed the same soybean amount for pig (100g/sow/day), sows in Ban Buon received 40g/sow/day. Concentrate was fed similarly for sows in Ban Bo, Ban Buon and Na Huong (ca. 100g).

Feed amount without vegetables was highest in Ban Buon (2.9kg/sow/day) and lowest in Ban Keo and Na Huong (1.2 – 1.3kg/sow/day). Roughage feed for sows was similar in Ban Bo, Ban Buon and Ban Keo (ca. 6kg/sow/day), but was lower in Na Huong (4.1kg).

Table 35: Quantitative composition of feeding rations for empty and pregnant sows in the time of feed abundance, by village (kg FM/sow/day) (% of sows getting the respective feedstuff, mean ± SD kg feedstuff/sow/day)

Village	**Ban Bo**		**Ban Buon**		**Na Huong**		**Ban Keo**	
N sows	11		13		10		11	
	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
Maize (kg/sow/day)	100	1.6 ± 0.5	100	1.5 ± 0.8	100	1.0 ± 0.3	82	0.7 ± 0.6
Rice bran (kg/sow/day)	100	0.5 ± 0.2	100	0.6 ± 0.3	50	0.3 ± 0.2	100	0.4 ± 0.3
Dry cassava (kg/sow/day)	55	0.6 ± 0.5	62	1.1 ± 0.8	20	0.5 ± 0.0	9	0.4
Fresh cassava (kg/sow/day)	0	-	0	-	10	0.7	64	0.6 ± 0.3
Vegetables (kg/sow/day)	100	3.5 ± 2.4	100	3.5 ± 1.4	100	1.8 ± 1.2	91	1.8 ± 1.2
Banana stem (kg/sow/day)	55	2.1 ± 1.0	46	2.9 ± 1.2	60	2.3 ± 1.0	91	4.4 ± 1.0
Dry fish (g/sow/day)	18	60.0 ± 28.3	69	127.9 ± 71.4	30	33.4 ± 16.7	0	-
Soybean (g/sow/day)	9	40.0	23	95.6 ± 55.9	30	107.8 ± 132.2	0	-
Concentrate (g/sow/day)	91	102.0 ± 23.3	46	92.9 ± 38.7	20	103.5 ± 89.8	0	-
Feed amount (kg/sow/day)*	100	2.4 ± 1.0	100	2.9 ± 1.8	100	1.3 ± 0.4	100	1.2 ± 0.7

Means were calculated for sows that are fed on the respective feedstuffs only
*calculated by total amount of feedstuffs except vegetables and banana stem. Household interview

Figures in table 35 and table 36 indicate that the feed amount is not much different between lactation and pregnancy, both in component structure and quality. The increase of total feed intake comes mainly from the increase of maize and rice bran.

All investigated lactating sows in Ban Bo, Ban Buon and Na Huong were fed maize, 82% of lactating sows in Ban Keo were received maize. Investigated sows in Ban Bo and Ban Buon were fed the same amount of maize (1.6kg/sow/day). Sows in Na Huong received 1.2 kg and and sows in Ban Keo received lower amount of maize was fed in Ban Keo (0.7/sow/day) (table 36).

100% of sows in Ban Bo, Ban Buon and Ban Keo, and 70% of lactating sows in Na Huong were fed rice bran. The amount of rice bran was lower in Ban Keo (0.4 kg) and the highest in Ban Buon (0.7 kg). Rice was not fed in Ban Buon, Ban Keo and Na Huong, but 27% of investigated households in Ban Bo fed rice with 0.7kg/sow/day.

A low percentage of lactating sows in Ban Keo and Na Huong was fed dry cassava (9% in Ban Keo and 20% in Na Huong). A higher percentage of lactating sows in Ban Bo and Ban Buon received dry cassava (73% in Ban Bo and 62% in Ban Buon). The highest dry cassava amount for sows was 1.3 kg in Ban Buon, and the lowest amount was 0.4 kg in Ban Keo. Fresh cassava was not fed for lactating sows in Ban Bo and Ban Buon, but 10% of sows in Na Huong and 64% of sows in Ban Keo received fresh cassava. The fresh cassava amount fed for lactating sows was similar in Na Huong and Ban Keo (0.6-0.7 kg/sow/day).

All lactating sows in Ban Bo, Ban Buon and Na Huong, and 91% sows in Ban Keo were fed on vegetables. In Ban Bo and Ban Buon, lactating sows were fed on the same amount (3.4-3.5kg), but sows in Na Huong and Ban Keo received low (2.1kg and 1.8kg/sow/day).

Varying percentages of lactating sows were fed banana stem(46%, 23%, 60 and 91% in Ban Bo, Ban Buon, Na Huong and Ban Keo). Lactating sows in Ban Keo were fed on the high amounts of banana stem (4.4kg) followed by 3.5 kg in Ban Buon and 2.1-2.3kg in Ban Bo and Ban Keo.

No farm in Ban Keo fed fish, soybean or concentrate for lactating sows. In the other villages, varying percentages of investigated sows were fed with fish (18% in Ban Bo, 91% in Ban Buon and 40% in Na Huong). Around 60g, 140g and 100g fish were used in Ban Bo, Ban Buon and Na Huong. 37%, 46% and 50% of investigated sows received soybean (ca. 150g/sow/day). All sows in Ban Bo were fed with concentrate feed and 55% sows in Ban Buon, 20% sows in Na Huong received it. The amount of concentrate varied from 120-180 g/sow/day.

Feed amount (without vegetables) for lactating sows was similar in Ban Bo and Ban Buon (3.0kg-3.2kg), it is lower in Na Huong and Ban Keo (1.8kg and 1.2kg). Roughage amount fed for lactating sow was highest in Ban Buon (6.9kg) and lowest in Na Huong (4.4 kg).

Table 36: Quantitative composition of feeding rations for lactating sows in investigated households in the time of feed abundance, by village (kg/sow/day) (% of sows getting the respective feedstuff, mean ± SD of kg feedstuff/sow/day)

Village	**Ban Bo**		**Ban Buon**		**Na Huong**		**Ban Keo**	
N sows	11		13		10		11	
	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
Maize (kg/sow/day)	100	1.6 ± 0.5	100	1.6 ± 0.8	100	1.2 ± 0.4	82	0.7 ± 0.6
Rice bran (kg/sow/day)	100	0.6 ± 0.3	100	0.7 ± 0.3	70	0.6 ± 0.4	100	0.4 ± 0.3
Rice (kg/sow/day)	27	0.7 ± 0.8	0	-	0	-	0	-
Dry cassava (kg/sow/day)	73	0.7 ± 0.3	62	1.3 ± 0.8	20	0.5 ± 0.0	9	0.4
Fresh cassava (kg/sow/day)	0	-	0	-	10	0.7	64	0.6 ± 0.3
Vegetables (kg/sow/day)	100	3.5 ± 2.4	100	3.4 ± 1.3	100	2.1 ± 1.5	91	1.8 ± 1.2
Banana stem (kg/sow/day)	46	2.1 ± 1.0	23	3.5 ± 0.9	60	2.3 ± 1.0	91	4.4 ± 1.1
Dry fish (g/sow/day)	18	60.0 ± 28.3	91	135.1 ± 70.0	40	95.9 ± 75.0	0	-
Soybean (g/sow/day)	37	183.3 ± 189.3	46	137.3 ± 88.5	50	144.7 ± 123.0	0	-
Concentrate (g)	100	120.0 ± 45.3	55	117.9 ± 78.0	20	183.5 ± 23.3	0	-
Feed amount (kg/sow/day)*	100	3.0 ± 1.3	100	3.2 ± 1.7	100	1.8 ± 0.8	100	1.2 ± 0.7

Means were calculated for lactating sows that were fed on the respective feedstuffs only.
*calculated by total amount of feedstuffs except vegetables and banana stem. Household interview

All fatteners in Ban Bo, Ban Buon and Na Huong, and 73% of fatteners in Ban Keo were fed maize. The maize amount was from 0.2kg in Ban Keo and Ban Buon to 0.3 kg in Na Huong and 0.4 kg in Ban Bo. 100% of fatteners in Ban Bo, Ban Buon, Ban Keo and 69% of fatteners in Na Huong were fed with rice bran on a similar amount (0.1-0.2kg) (table 37).

Varying percentages of fatteners received dry cassava (61% in Ban Bo, 78% in Ban Buon, 29% in Na Huong and only 5% in Ban Keo) with a rather similar amount (0.1 – 0.2kg). Fresh cassava was not fed for fatteners in Ban Bo and Ban Buon, only 6% fatteners in Na Huong and 71% of fatteners in Ban Bo were fed fresh cassava with 0.2kg/pig/day.

All fatteners in Ban Bo, Ban Buon and Na Huong, and 76% of fatteners in Ban Keo were fed with vegetables. Fatteners in Ban Bo and Ban Keo received the same amount of vegetables (0.6kg/pig/day). Fatteners in Ban Buon and Na Huong also received a rather similar vegetables amount (0.2-0.3kg/pig/day) but lower than in Ban Bo and Ba Keo. Over a half of fatteners in Ban Bo, Ban Buon and Na Huong were fed banana stem with around 0.4 kg/pig/day, while 100% of pigs in Ban Keo were fed with banana stem with high amount (1.4kg/pig/day).

Varying percentage of fatteners received fish, soybean and concentrate (2-100% of households). Non of fatteners in Ban Keo were fed with these feeds. Low amounts of fish were fed for fatteners in villages, about 10g/pig/day. Soybean and concentrate were fed in lightly higher amounts 20 - 50 g/pig/day in Ban Bo, Ban Buon and Na Huong.

Feed amount was lightly higher in Ban Bo than in other villages (0.7kg/pig/day), while in Ban Buon, Na Huong and Ban Keo was lower with 0.4 to 0.5 kg/pig/day. The highest amount of roughage used for fatteners was 2.0kg in Ban Keo and lowest amount was around 0.6-0.7 kg in Ban Buon and Na Huong.

Table 37: Quantitative composition of feeding rations for fattening pigs in the time of feed abundance, by village (% of pigs getting the respective feedstuff, mean ± SD of kg feedstuff/pig/day)

Village	Ban Bo		Ban Buon		Na Huong		Ban Keo	
N fatteners	56		49		51		41	
	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
Maize (kg/pig/day)	100	0.4 ± 0.3	100	0.2 ± 0.2	100	0.3 ± 0.2	73	0.2 ± 0.2
Rice bran (kg/pig/day)	100	0.1 ± 0.1	100	0.1 ± 0.1	69	0.1 ± 0.1	100	0.2 ± 0.1
Dry cassava (kg/pig/day)	61	0.2 ± 0.2	78	0.2 ± 0.2	29	0.1 ± 0.1	5	0.2 ± 0.0
Fresh cassava (kg/pig/day)	0	-	0	-	6	0.2 ± 0.0	71	0.2 ± 0.2
Vegetables (kg/pig/day)	100	0.6 ± 0.7	100	0.3 ± 0.5	100	0.2 ± 0.4	76	0.6 ± 0.3
Banana stem (kg/pig/day)	59	0.4 ± 0.3	63	0.3 ± 0.3	65	0.5 ± 0.5	90	1.4 ± 0.8
Dry fish (g/pig/day)	20	10.9 ± 3.0	69	14.4 ± 8.5	39	8.3 ± 2.1	0	-
Soybean (g/pig/day)	25	17.1 ± 4.7	49	35.2 ± 25.8	2	33.3	0	-
Concentrate (g/pig/day)	100	50.1 ± 69.0	67	33.2 ± 34.0	6	32.8 ± 1.4	0	-
Feed amount (kg/pig/day)*	100	0.7 ± 0.5	100	0.5 ± 0.4	100	0.4 ± 0.2	100	0.4 ± 0.3

Means were calculated for fattening pigs that fed respective feedstuffs
*calculated by total amount of feedstuffs except vegetables and banana stem. Household interview

Feed use in season of feed shortage, assessed by measuring

The qualitative and quantitative composition of rations for pigs in the season of feed shortage was parallel to the household interviews assessed by measuring. Results are presented in tables 38 (empty, pregnant sows) and 39 (lactating sows) and 40 (fattening pigs).

Maize, rice bran and dry cassava are main components of feed fed for pigs in Ban Bo, Ban Buon and Na Huong, while rice bran and fresh cassava are main feed components for pig in Ban Keo. All of sows in Ban Bo and Ban Buon were fed with maize (around 1kg/sow/day), and 78% of sows in Na Huong received maize with 0.7kg/sow/day. Maize was not used for sows in Ban Keo. All sows in Ban Bo were fed rice bran, and varying percentages of sows received rice bran in the other villages (82% in Ban Buon, 33% in Na Huong and 60% in Ban Keo). Rice bran amounts fed for pigs were about 0.3-0.6kg/sow/day in all villages. Rice was not fed for sow in Ban Bo and Ban Keo. Few sows in Ban Buon and Na Huong were fed with rice (0.2 and 0.6kg) (table 38).

All sows in Ban Buon, 57% sows in Ban Bo, 44% sows in Na Huong and 30% sows in Ban Keo were fed dry cassava, with around 0.5kg/sow/day. The highest percentage of sows fed fresh cassava was 80% in Ban Keo, and lower in Ban Bo and Na Huong (27% and 22% of sows). Fresh cassava was not used in Ban Buon. Fresh cassava amount fed was about 1.5 kg for each pig. All sows in Ban Bo and Ban Keo, 73% sows in Ban Buon and 89% sows in Na Huong was fed with vegetables. Sows in Ban Buon were fed with a high amount of vegetables (3.4kg), sows in Ban Keo were fed with lowest amount (1.1kg/sow/day). All sows in Ban Keo and Na Huong, and over a half of sows in Ban Bo and Ban Buon were fed with banana stem. The highest amount of banana stem fed for sows was 3.4kg in Ban Bo, sows in Ban Buon and Na Huong were fed the same amount (2.7kg/sow/day). Sow in Ban Keo were fed lower amount (2.2kg/sow/day).

The percentages of sows, which were fed fish, soybean and concentrate were varied except in Ban Keo, no sows were fed with fish, soybean or concentrate, and sows in Na Huong were not fed soybean. The amount of fish fed for sows was high in Ban Bo (150g/sow/day) and lower in Ban Buon (50g/sow/day)

and Na Huong (34g/sow/day). Amount of soybean received about 200g/sow/day in Ban Bo and two time higher than in Ban Buon (100g/sow/day). Concentrate amount was fed similarly for sows in different villages (100-150g/sow/day).

The highest feed amount for sows was 2.2 kg in Ban Buon followed by Ban Bo (1.9kg/sow/day) and 1.1kg/sow/day in Na Huong and lowest feed intake was 0.7kg/sow/day in Ban Keo. Roughage feed fed for sows was highest in Ban Buon (6.1kg/sow/day) followed by 5.2kg/sow/day in Ban Bo, and 4.3kg/sow/day in Na Huong, and the lowest amount was 3.3 kg/sow/day in Ban Keo.

Table 38: Quantitative compositions of feeding rations for empty sows and sows in investigated households on test day in the time of feed shortage, assessed by measuring (kg/sow/day), by village (% of sows getting the respective feed stuff, mean ± SD of kg feed/sow/day)

Village	**Ban Bo**		**Ban Buon**		**Na Huong**		**Ban Keo**	
N sows	7		11		9		10	
	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
Maize (kg/sow/day)	100	0.9 ± 0.3	100	1.0 ± 0.3	78	0.7 ± 0.3	0	-
Rice bran (kg/sow/day)	100	0.5 ± 0.3	82	0.6 ± 0.2	33	0.3 ± 0.1	60	0.4 ± 0.4
Rice (kg/sow/day)	0	-	18	0.2	11	0.6	0	-
Dry cassava (kg/sow/day)	57	0.4 ± 0.1	100	0.7 ± 0.3	44	0.5 ± 0.3	30	0.6 ± 0.4
Fresh cassava (kg/sow/day)	29	1.3 ± 0.5	0	-	22	1.8 ± 0.4	80	1.2 ± 0.6
Vegetables (kg/sow/day)	100	1.9 ± 0.1	73	3.4 ± 1.4	89	1.6 ± 0.8	100	1.1 ± 0.7
Banana stem (kg/sow/day)	57	3.3 ± 1.7	55	2.7 ± 0.9	100	2.7 ± 1.1	100	2.2 ± 0.9
Dry fish (g/sow/day)	14	150.0	27	50.0 ± 0.0	11	34.1	0	-
Soybean (g/sow/day)	14	223.9	9	100.0	0	-	0	-
Concentrate (g/sow/day))	86	148.5 ± 123.8	55	113.7 ± 92.3	22	101.3 ± 49.5	0	-
Feed amount (kg/sow/day)*	100	1.9 ± 0.7	100	2.2 ± 0.6	100	1.1 ± 0.4	100	0.7 ± 0.5

Means were calculated for sows that are fed on the respective feedstuffs only
*calculated by total amount of feedstuffs except vegetables and banana stem. Measuring feed

The number of lactation sows in studied villages was very few at the time of interview (table 39).

Maize, rice bran and dry cassava are main components of feed fed for lactating sows in Ban Bo, Ban Buon and Na Huong. Main feed used for lactating sow in Ban Keo were rice bran and fresh cassava. All lactating sows in Ban Bo, Ban Buon were fed with maize (around 1kg/sow/day), lactating sow in Na Huong received maize with very low amount (0.2kg/sow/day). Maize was not used in Ban Keo. All lactating sows in Ban Bo, Ban Buon, and Ban Keo were fed rice bran. Rice bran amount fed for sows was 1kg/sow/day in Ban Bo, 0.7kg/sow/day in Ban Buon and very low amount was fed for a sow in Ban Keo (0.1kg). A lactating sow in Na Huong was not fed rice bran. One lactating sow in Ban Bo was fed with rice only.

Lactating sows in Ban Buon and Na Huong and two lactating sows in Ban Bo were fed dry cassava with amount was from 0.5-1.0 kg/sow/day. A lactating sow in Ban Keo was fed fresh cassava. All lactating sows in Ban Buon, Na Huong and Ban Keo and two sows in Ban Bo were fed with vegetables. Higher amount of vegetables was fed for lactating sows in Ban Bo and Ban Buon (2.3 and 3.1kg/sow/day). lower amounts of vegetables were use for lactating sow in Na Huong and Ban Keo (0.5kg and 0.7kg/sow/day).

Only one lactation sow in Ban Buon was fed with fish and soybean. Lactating sows in other villages were not fed fish and soybean. Two lactating sows in Ban Bo, one in Ban Buon and one in Na Huong were fed concentrate. Low amount of concentrate was fed for lactating sow in Ban Bo (60g/sow/day), while about 100g/sow/day in Na Huong and 200 g/sow/day in Ban Buon.

The highest feed amount for sows was 3kg/sow/day in Ban Buon, followed by Ban Bo (2.4kg/sow/day) and lower with 1.5kg/sow/day in Na Huong and lowest feed intake was 0.3kg/sow/day for sows in Ban Keo. Roughage feed fed for sows was highest in Ban Buon (5.7kg/sow/day) followed by 3.6kg/sow/day in Na Huong, and 2.3kg/sow/day in Ban Bo, and the lowest was 1.6 kg/sow/day in Ban Keo.

Table 39: Quantitative compositions of feeding rations for lactating sows in investigated households on test day in the time of feed shortage, assessed by measuring (kg/sow/day), by village (% of sows getting the respective feed stuff, mean ± SD of kg feed/sow/day)

Village	**Ban Bo**		**Ban Buon**		**Na Huong**		**Ban Keo**	
N sows	3		2		1		1	
	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
Maize (kg/sow/day)	100	1.0 ± 0.3	100	1.2 ± 0.0	100	0.2	0	-
Rice bran (kg/sow/day)	100	1.0 ± 0.4	100	0.7 ± 0.5	0	-	100	0.1
Rice (kg/sow/day)	33	1.0 ± 0.0	0	-	0	-	0	-
Dry cassava (kg/sow/day)	67	0.6 ± 0.3	100	1.0 ± 0.7	100	0.5	0	-
Fresh cassava (kg/sow/day)	0	-	0	-	0	-	100	0.7
Vegetables (kg/sow/day)	67	2.3 ± 1.1	100	3.1 ± 1.3	100	0.5	100	0.7
Banana stem (kg/sow/day)	0	-	100	2.6 ± 0.6	100	3.1	100	0.9
Dry fish (g/sow/day)	0	-	50	100.0	0	-	0	-
Soybean (g/sow/day)	0	-	50	91.4	0	-	0	-
Concentrate (g/sow/day))	67	60.0 ± 28.3	50	200.0	100	119	0	-
Feed amount (kg/sow/day)*	100	2.4 ± 0.8	100	3.0 ± 1.2	100	1.5	100	0.3

Means were calculated for fattening pigs that were fed on the respective feedstuffs only
*calculated by total amount of feedstuffs except vegetables and banana stem. Measuring feed

All fatteners in Ban Bo, Ban Buon and 90% of fatteners in Na Huong were fed maize. The maize amount was 0.2kg in Na Huong and 0.3 kg in Ban Buon and Ban Bo. Fattening pigs in Ban Bo were not fed maize. 100% of fatteners in Ban Bo, 57% of fatteners in Ban Buon, 23% of fatteners in Na Huong and 66% of fatteners in Ban Keo were fed with similar amount (0.1-0.2kg) rice bran. Very low percentages of fatteners received rice (4-14%) (table 40).

Varying percentages of fatteners received dry cassava (75% in Ban Bo, 91% in Ban Buon, 51% in Na Huong and 29% in Ban Keo) with rather similar amount (0.1 – 0.2kg). Fresh cassava was not fed for fatteners in Ban Buon, only 18% of fatteners in Ban Bo and Na Huong received, but up to 88% of fattening pigs in Ban Keo were fed fresh cassava with 0.4-0.5kg/pig/day.

96% of fatteners in Ban Bo, 86% of fatteners in Ban Buon, 84% of fatteners in Na Huong, and 83% of fatteners in Ban Keo were fed with the same vegetable amount (0.4kg/pig/day). 100% pigs in Ban Keo and Na Huong were fed with banana stem and with 0.7kg/pig/day. Lower percentages of fatteners were fed banana stem (57% in Ban Bo and 14% in Ban Buon) and with 0.6kg/pig/day.

Low percentage of pigs were fed fish in Ban Bo, Ban Buon and Na Huong (2-16%). No fatteners in Ban Keo were fed fish. Very low percentages of pigs were fed with soybean (2%in Ban Buon, 8% in Ban Keo). Farmers in Ban Keo and Na Huong did not feed soybean to pigs. Nearly all fatteners in Ban Bo were fed concentrate (98%), rather low percentages of fatteners were fed concentrate in Ban Buon and Na Huong (37% and 28%) and amount of concentrate was fed quite similar (30-50g/pig/day).

Feed amount was the same in Ban Bo and Ban Buon (0.6kg/pig/day) and two to three times higher in Na Huong and Ban Keo (0.2-0.3 kg/pig/day). The roughage used for fatteners was rather similar with 1.0-1.2kg/pig/days in all villages.

Table 40: Quantitative composition of feeding rations for fattening pigs in investigated households on test day in the time of feed shortage, assessed by measuring, by village (kg/pig/day) (% of pigs getting the respective feed stuff, mean ± SD of kg feed/pig/day)

Village	**Ban Bo**		**Ban Buon**		**Na Huong**		**Ban Keo**	
N fatteners	56		49		51		41	
	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
Maize (kg/pig/day)	100	0.3 ± 0.2	100	0.3 ± 0.2	90	0.2 ± 0.1	0	-
Rice bran (kg/pig/day)	100	0.1 ± 0.1	57	0.2 ± 0.1	26	0.1 ± 0.1	66	0.1 ± 0.1
Rice (kg/pig/day)	4	0.2 ± 0.0	14	0.1 ± 0.1	14	0.1 ± 0.0	0	-
Dry cassava (kg/pig/day)	75	0.2 ± 0.2	92	0.2 ± 0.2	51	0.1 ± 0.1	29	0.2 ± 0.2
Fresh cassava (kg/pig/day)	18	0.4 ± 0.2	0	-	18	0.4 ± 0.5	88	0.5 ± 0.4
Vegetables (kg/pig/day)	96	0.4 ± 0.3	86	0.4 ± 0.4	84	0.4 ± 0.3	83	0.4 ± 0.3
Banana stem (kg/pig/day)	57	0.6 ± 0.3	14	0.6 ± 0.5	100	0.7 ± 0.5	100	0.8 ± 0.6
Dry fish (g/pig/day)	2	50.0	16	93.8 ± 47.7	16	10.2 ± 0.0	0	-
Soybean (g/pig/day)	2	76.1	8	20.0 ± 5.8	0	-	0	-
Concentrate (g/pig/day)	98	50.9 ± 83.7	37	49.6 ± 58.3	28	33.2 ± 10.9	0	-
Feed amount (kg/pig/day)*	100	0.6 ± 0.6	100	0.6 ± 0.5	100	0.3 ± 0.2	100	0.2 ± 0.2
Age (months)	100	4.3 ± 1.7	100	2.6 ± 1.1	100	5.0 ± 3.0	100	9.1 ± 3.4

Means were calculated for fattening pigs that were fed on the respective feedstuffs only.
*calculated by total amount of feedstuffs except vegetables and banana stem. Measuring feed

4.2.3 Nutritive values of feeding rations

Based on the ration compositions for different types of pigs and in different seasons with different methods (see table 32 to table 40), the respective nutritive values (g CP/pig/day and kcal ME/pig/day) were calculated. Nutritive values of feeding diets for pigs including crude protein CP amount in the daily ration (calculated as g CP/pig/day) and metabolic energy available ME (calculated as kcal ME/pig/day) are shown for different types of pigs, different reproductive stages, for different seasons and assessed by different methods in the tables 41 to 46.

At the time of interview (defined as time of feed shortage), sows in Ban Bo and Ban Buon had a similar protein intake with 267 and 275 g CP/sow/day. Protein intake for sows in Na Huong was lower with 139 g CP/sow/day, and lowest in Ban Keo (105 g CP/sow/day) (table 41).

Compared to the crude protein intake in the time of feed shortage, average daily crude protein intake was increased in all investigated villages in the time of feed abundance (Ban Bo 317 g CP/sow/day equal to

119% of CP-intake in time of feed shortage; Ban Buon 363 g CP/sow/day = 132%, Na Huong 179 g CP/sow/day = 129%, and Ban Keo 156 g CP/sow/day = 149%).

When comparing the daily CP-intake assessed for the time of feed shortage by different methods, it can be shown that daily CP-intakes were slightly overestimated by interviewing in Ban Buon, Ban Bo and Na Huong (Ban Bo: CP intake assessed by interviewing corresponding to 105.1% of the CP intake assessed by measuring, Ban Buon: 102.2%, Na Huong: 103.0%). However, in Ban Keo the CP intake assessed by interviewing was corresponding to 159.1% of the CP intake assessed by measuring.

Table 41: Daily intake of crude protein in the ration supplied for empty and pregnant sows at different seasons and assessed by different methods in investigated households, by village (mean ± SD g CP/sow/day)

	Time of feed shortage, interview (CP g/sow/day)			**Time of feed abundance, interview (CP g/sow/day)**			**Time of feed shortage, measuring (CP g/sow/day)**		
	N sows	Mean	SD	N sows	Mean	SD	N sows	Mean	SD
Ban Bo	11	267	95	11	317	118	7	255	87.7
Ban Buon	13	275	79	13	363	168	11	242	71.9
Na Huong	10	139	40	10	179	50	9	129	39.5
Ban Keo	11	105	50	11	156	85	10	69	42.3

*During the survey time one family sold a sow because of its low reproductive performance
Household interview and measuring feed

At the time of interview, sows in Ban Bo and Ban Buon had a similar energy intake with 6930 and 7390 kcal/sow/day. Energy in take in Na Huong and Ban Keo was lower with 3690 and 2770 kcal/sow/day.

In comparing to the energy intake in the time of feed shortage, average daily energy intake was increased in all of investigated households in the time of feed abundance (7930 kcal in Ban Bo equal to 114.4% of energy intake in time of feed shortage; 9220 kcal in Ban Buon = 124.8%; 4530 kcal in Na Huong = 122.8%; 3790 kcal in Ban Keo= 136.8%) (table 42).

Compared to the daily ME-intake assessed for the time of feed shortage by different methods, it can be seen that daily energy intakes were slightly overestimated by interviewing in Ban Buon (energy intake assessed by interview corresponding to 105.6% of the energy intakes assessed by measuring), and in Na Huong the energy intake assessed by interviewing was lightly underestimated (corresponding to 96.6% of the energy intake assessed by measuring). However, in Ban Bo and Ban Keo the energy intakes were relatively higher when assessed by interviewing than by measuring (122.9% and 118.9%), and it show the different between two methods.

Table 42: Daily intake of metabolizable energy in the ration supplied for empty and pregnant sows at different seasons and assessed by different methods in investigated households, by village (mean ± SD kcal ME/sow/day)

	Time of feed shortage, interview (ME kcal/sow/day)			Time of feed abundance, (ME kcal/sow/day)			Time of feed shortage, measuring (ME kcal/sow/day)		
	N sows	Mean	SD	N sows	Mean	SD	N sows	Mean	SD
Ban Bo	11	6,930	2550	11	7,930	3240	7	5640	1690
Ban Buon	13	7,390	1,580	13	9,220	5650	11	7000	1920
Na Huong	10	3,690	1,100	10	4,530	1040	9	3820	1340
Ban Keo	11	2,770	1,120	11	3,790	2190	10	2330	1460

*During the survey time one family sold a sow because of its low reproductive performance
Household interview and measuring feed

At the time of feed shortage, lactating sows in Ban Bo and Ban Buon were supplied with 349 and 324gCP/sow/day, respectively. In Na Huong lactating sows had lower protein intakes with 205g/sow/day and 105g/sow/day in Ban Keo (table 43).

When comparing the daily CP intake in the time of feed shortage, average daily crude protein intake was increased in all investigated households in all villages in time of feed abundance (379g/day/sow in Ban Bo, equal with 108.6% of CP-intake in the time of feed shortage; 416g in Ban Buon = 128.4%; 262g in Na Huong = 127.8%; 155g in Ban Keo = 147.6%).

Compared to the daily-intake assessed for the time of feed shortage by different methods, it can be seen that daily-intake were overestimated in Ban Bo and Ban Buon (CP-intake assessed by interviewing in Ban Bo corresponding to 138.4% of the CP-intake assessed by measuring; Ban Keo: 300%. In Na Huong, CP-intake were lightly overestimated (105.7% of the CP intake assessed by measuring). However, CP in take for lactating sows in Ban Buon was underestimated (91% of the CP-intake assessed by measuring).

Table 43: Daily intake of crude protein in the rations supplied for lactating sows in different seasons and assessed by different methods in investigated households, by village (mean ± SD g CP/sow/day)

	Time of feed shortage, interview (CP g/sow/day)			**Time of feed abundance, (CP g /sow/day)**			**Time of feed shortage, measuring (CP g /sow/day)**		
	N sows	**Mean**	**SD**	**N sows**	**Mean**	**SD**	**N sows**	**Mean**	**SD**
Ban Bo	11	349	152	11	379	180	3	252	89.1
Ban Buon	13	324	112	13	416	162	2	356	164.4
Na Huong	10	205	139	10	262	147	1	194	-
Ban Keo	11	105	50	11	155	85	1	35	-

Household interview and measuring feed

At the time of interview, sows in Ban Bo had the highest ME-intake with 9140kcal and lightly higher than in Ban Buon with 8210kcal. Energy in take in Na Huong and Ban Keo was lower with 4690 and 2770 kcal/sow/day (table 44).

When comparing to the energy intake in the time of feed shortage, average daily energy intake was increased in all of investigated households in the time of feed abundance (9620 kcal in Ban Bo equal to

105.3% of energy intake in time of feed shortage; 10230 kcal in Ban Buon = 124.6%; 5780 kcal in Na Huong = 123.2%; 3790 kcal in Ban Keo= 136.8%)

Compared to the daily ME-intake assesses for the time of feed shortage by different methods, it can be seen that daily energy intakes were highly overestimated by interviewing in Ban Buon and Ban Keo (energy intake assessed by interview corresponding to 124.2% of the energy intakes assessed by measuring; Ban Keo: 251.8%), and in Na Huong and Ban Buon the energy intake assessed by interviewing was highly underestimated in corresponding to of the energy intake assessed by measuring; (in Na Huong: 77.1%; in Ban Bo: 86.4%). These differences reveal when compare between two methods.

Table 44: Daily intake of metabolizable energy supplied for lactating sows in different seasons and assessed by different methods in investigated households, by village. (mean ± SD kcal ME/sow/day)

	Time of feed shortage, interview (ME kcal/sow/day)			**Time of feed abundance, (ME kcal/sow/day)**			**Time of feed shortage, measuring (ME kcal/sow/day)**		
	N sows	Mean	SD	N sows	Mean	SD	N sows	Mean	SD
Ban Bo	11	9,140	3710	11	9,620	4330	3	7360	2440
Ban Buon	13	8,210	1600	13	10,230	5280	2	9500	3830
Na Huong	10	4,690	2190	10	5,780	2050	1	6090	-
Ban Keo	11	2,770	1120	11	3,790	2190	1	1100	-

Household interview and measuring feed

Nutritive values of feeding rations for fattening pigs in different seasons and assessed by different methods are shown in tables 45 and 46.

At the time of interview (defined as time of feed shortage), fatteners in Ban Bo had highest protein intake with 78g/pig/day. Fatteners in Ban Buon had 59g CP/pig/day. Protein intake of fatteners in Na Huong was lower with 40 g CP/pig/day, and lowest in Ban Keo (32 g CP/pig/day) (table 45).

Compared to the crude protein intake in the time of feed shortage, average daily crude protein intake was increased in all investigated villages in the time of feed abundance (Ban Bo 90g CP/pig/day equal to 119% of CP-intake in time of feed shortage; Ban Buon 62 g CP/pig/day = 105.1%, Na Huong 45 g CP/pig/day = 112.5%, and Ban Keo 47 g CP/sow/day = 146.9%).

When comparing the daily CP-intake assessed for the time of feed shortage by different methods it can be shown that daily CP-intakes were slightly overestimated by interviewing in Ban Bo and Na Huong (Ban Bo: CP intake assessed by interviewing corresponding to 113% of the CP intake assessed by measuring, Na Huong: 111.1%). daily CP-intakes were slightly underestimated by interviewing in Ban Buon (90.8% of the CP intake assessed by measuring). However, in Ban Keo the CP intake assessed by interviewing was corresponding to 133.3% of the CP intake assessed by measuring. This disparity shows the different between two methods.

Table 45: Daily intake of crude protein supplied for fattening pigs at different seasons and assessed by different methods in investigated households, by village. (mean ± SD g CP/pig/day)

	Time of feed shortage, interview (CP g/pig/day)			Time of feed abundance, interview (CP g/pig/day)			Time of feed shortage, measuring (CP g/pig/day)		
	N fatteners	Mean	SD	N fatteners	Mean	SD	N fatteners	Mean	SD
Ban Bo	56	78	57	56	90	61	56	69	64
Ban Buon	49	59	52	49	62	50	49	65	68
Na Huong	51	40	24	51	45	23	51	36	21
Ban Keo	41	32	21	41	47	47	41	24	19

Household interview and measuring feed

At the time of interview, fatteners in Ban Bo had highest energy intake with 2000 kcal/pig/day, followed by 1460 kcal in Ban Buon. Energy in take in Na Huong and Ban Keo was lower with 1090 and 840 kcal/pig/day, respectively (table 46).

When comparing to the energy intake in the time of feed shortage, average daily energy intake was increased in all of investigated households in the time of feed abundance (2120 kcal in Ban Bo equal to 106% of energy intake in time of feed shortage; 1130 kcal in Na Huong = 103.7%; 1130 kcal; 1130 kcal in Ban Keo= 134.5%), except in Ban Buon average daily energy intake was lightly reduced in investigated households (1410 kcal equal to 96.6%). It may be explained by lightly reducing of vegetables resources.

Compared to the daily ME-intake assesses for the time of feed shortage by different methods, it can be seen that daily energy intakes for fattening were slightly overestimated at the time of interview in Ban Buon, Na Huong and Ban Keo (energy intake assessed by interview corresponding to 110.5% of the energy intakes assessed by measuring in Ban Bo; Na Huong: 110.1%; Ban Keo: 101.2%). However, in Ban Buon the energy intake assessed by interviewing was highly underestimated corresponding to 80.2% of the energy intake assessed by measuring thus it shows the difference between two methods.

Table 46: Daily intake of metabolizable energy supplied for fattening pigs at different seasons and assessed by different methods in investigated households, by village. (mean ± SD kcal ME/pig/day)

	Time of feed shortage, interview (ME g/pig/day)			Time of feed abundance, interview (ME g/pig/day)			Time of feed shortage, measuring (ME g/pig/day)		
Village	N fatteners	Mean	SD	N fatteners	Mean	SD	N fatteners	Mean	SD
Ban Bo	56	2000	1440	56	2120	1600	56	1810	1580
Ban Buon	49	1460	1310	49	1410	1350	49	1820	1360
Na Huong	51	1090	720	51	1130	660	51	990	650
Ban Keo	41	840	570	41	1130	910	41	830	670

Household interview and measuring feed

The feed amount, crude protein and energy for different pig genotypes during different season and assessed by different methods were presented in table 47 and shown no considerable different between season and by different methods. The average weight of different genotypes was rather the same with around 10 kg and a range between 3kg and 35kg of weight. Feed intake, CP and ME received by LW x

MC was highest. Fattening pigs of other genotypes were received rather similarly amount of feed, CP and ME in different seasons and assessed by different methods.

Table 47: Daily feed intake, crude protein and metabolizable energy supplied for fattening pigs at different seasons and assessed by different methods in investigated households, by genotypes. (mean ± SD kcal ME/pig/day)

	n	Feed amount*	CP g/pig/day	ME kcal/pig/day
In time of feed shortage, assessed by interviewing				
MC	46	0.32 ± 0.20	41.3 ±28.2	1080 ± 680
LW x MC	47	0.78 ± 0.57	96.9 ± 63.4	2440 ± 1670
LW x Ban/CW x Ban	34	0.30 ± 0.07	42.1± 15.2	1050 ± 310
Ban	67	0.26 ± 0.24	34.8 ± 24.5	960 ± 750
In time of feed abundance, assessed by interviewing				
MC	46	0.34 ± 0.22	43.6 ± 32.0	1070 ± 630
LW x MC	47	0.88 ± 0.57	102.9 ± 66.9	2640 ± 1750
Y x Ban/CW x Ban	34	0.30 ± 0.09	42.1 ± 12.8	980 ± 370
Ban	67	0.37 ± 0.28	42.4 ± 32.7	1150 ± 880
In time of feed shortage, assessed by measuring				
MC	46	0.30 ± 0.17	32.3 ± 24.3	940 ± 510
LW x MC	47	0.89 ± 0.62	60.4 ± 103.6	2620 ± 1730
Y x Ban/CW x Ban	34	0.33 ± 0.15	37.3 ± 11.2	1090 ± 400
Ban	67	0.28 ± 0.25	29.3 ± 23.5	930 ± 760

*including total amount of feed except vegetables. Household interview and measuring feed

4.3.4 Pig feeding management and feeding techniques

Feeding management for different types of pigs

Feeding management for different pig types, different age groups of pigs and different reproductive stages is shown in table 48. For sows, the ration for empty and pregnant sows was used as basis for comparison.

In the first week of lactation, farmers in Ban Bo and Ban Buon give rather similar feeding rations for the sows. Special feed components like rice soup, papaya are added to the ration and amount of soybean, fish and concentrate in the ration are increased. Especially rice soup, more rice bran and concentrate are fed by almost all of the investigated households, while the feeding of soybean, fish and papaya or pumpkin is less common. Farmers said that lactating sows fed with papaya can produced more milk and better milk quality. In Na Huong, during the 1st week after farrowing, all interviewed farmers fed more rice bran like farmers in Ban Bo and Ban Buon and also in Ban Keo. However, less farmers in Na Huong used rice soup (50% of interviewed farmers) or concentrate (30% of interviewed farmers). On the other hand, the similar farmers in Ban Bo or Ban Buon used soybeans or fish as in Na Huong. 80% of interviewed farmers in Na Huong used papaya or pumpkin. In Ban Keo, the feeding ration of lactating sows in the first week after farrowing was the same as for pregnant sows, despite an higher rice bran amount and occasional feeding of papaya or pumpkin (20% of interviewed farmers) and 10% of interview farmers fed rice soup. In addition, 30% of farms in Ban Bo fed pig bone for sows and the same percentage of farms in Ban Bo and Ban Buon (30%) were fed vitamins for sows during this time.

From the 2nd week of lactation onwards, sows in Ban Keo and Na Huong got the same feed like during pregnancy, while sows in Ban Bo, and Ban Buon got additional soybean (50%, 80% of interviewed farms, respectively), sows in Ban Buon and feed concentrate to the sows (20%, and 30% of interviewed farms, respectively).

Regarding weaners, in Na Huong and Ban Keo, investigated households did not give different feed in the weaning time, they let piglets eat whichever their mother sows eat. Whereas, in Ban Bo and Ban Buon, farmers often cook separated feed for weaners and add more rice bran and maize. There were 80% of household fed their weaning piglets with rice soup in Ban Bo but only 20% in Ban Buon. A half of farms in Ban Bo and Ban Buon fed fish and soybean for their pigs. Over a half of household in Ban Bo and Ban Buon fed concentrate for weaners. In addition, high percentage of farms did not feed cassava for their piglets in these villages (80%). In some other families, they fed more soybean, fish and concentrate than other pigs.

Regarding fattening pigs, in Na Huong and Ban Keo, they fed normal ratios while in Ban Bo and Ban Buon farmers feed normal ratios in the early phase of fattening period and before finishing 1-2 months, they mixed feed including maize, rice bran, dry cassava, fish, soybean and concentrate to feed for fatteners.

Table 48: Overview over feeding practices for different types, age groups and reproductive stages of pigs, by village

Village	**Ban Bo**	**Ban Buon**	**Na Huong**	**Ban Keo**
N households	10	10	10	10
Dry and pregnant sow	Normal ration *		Normal ration *	
1st week of lactation				
% hh feed cooked rice	100	90	50	10
% hh feed/feed more fish	40	60	50	-
%hh feed/feed more soybean	50	50	40	-
% hh feed/feed more concentrate	70	20	30	-
% hh feed additional rice bran	100	100	100	100
% hh feed papaya/pumpkin	30	-	80	20
%hh feed pig bone	30	-	-	-
%hh fed vitamins	30	30	-	-
After 1st week of lactation till weaning	More maize, rice bran		Normal ration *	
% hh feed/feed more soybean	30	50	-	-
%hh feed/feed more fish	-	30	-	-
% hh feed/feed more concentrate	20	30	-	-
Weaning piglets**			Normal ration **	
% hh feed rice soup	80	20	-	-
% hh feed fish	50	50		
%hh feed soybean	50	50		
% hh feed concentrate	60	70		
%hh fee less or no cassava	80	80		
Fattening pig (1-2 months before finishing)****	Fed mix feeds (maize, rice bran, dry cassava, concentrate, fish, and soybean)		Normal ration **	

*as described in table 32. **as describe in table 34

*** ~1 week before and after weaning. **** 5 to 6 months of age. Household interview and calendar tool

Feed collection and acquisition

There are two sources of vegetables used for pig production in investigated villages including farm-produced vegetables (mainly sweet potato vines and banana stem) and forest vegetables (mainly Wild Taro and Rau Duong). Sweet potato vines, which are grown in gardens or in fields near the residential area, is usually cut once or even twice every day in harvesting season. Banana stem also cut every day or two to three days depending on big or small stems and number of pigs kept. Forest vegetables are often collected at the time farmers go to field (that means on the way to the field or back from the field or during the time working in their fields). Wild Taro and Rau Duong sources are not available throughout the whole year. Wild taro grows well during the rainy season or where water is available such as in stream banks. Rau Duong can be collected for pig feed when it is young, but pigs can not eat when leaves are old (yellow and hard). Actually after May, farmers in Ban Bo and Ban Buon do not collect due to its hardness and roughness. In Na Huong and Ban Bo, farmers collect them later. However, their collection depends on the time, which farmers go to work in field (farmers do not collect vegetables for pigs if they do not have to work in field).

During the time of vegetable shortage (winter), farmers often replace by banana stem or winter vegetables if available from the garden. Banana stem is a vegetable available throughout the year, but of poor nutritive value, hard and rich of raw fibre, which is not suitable for pigs and especially for young pigs.

However, in winter, garden vegetables such as cabbage, water dropwort, and watercress are sometimes used, but their use is not often in the study villages. In Ban Buon, they are used more often than in Ban Bo and other villages far from town because these vegetables were planted in their garden. Some families bought old cabbage leaves for pigs in the local market if the price is cheap.

In harvesting season of maize and rice, they will be dried by sun several times and stored in containers. The feed quality is unchanged during the stored time because of well drying. Soybean, fish and concentrate are bought in small amount and do not need to store.

Preparation of feed

In all investigated households, feed for pigs is cooked. The way of preparing feedstuffs and cooking them is almost the same in all investigated villages. Farmers usually chop vegetable into small pieces. To cook feed, farmers first boil water, then add the vegetables into the boiling water and stir until vegetables are done. Then farmers add maize, cassava, and rice bran, and continue to cook till all of the feed mixture is done. Some of the interviewed farmers do not cook dry cassava and rice bran but feed them directly to the pigs. Soybean and concentrate are also usually fed to pigs without cooking. Farmers usually cook feed in the evening and use the ration for feeding the evening of the same day and for morning and lunch of the next day. Normally, time of cooking often prolongs from 1-2 hours depend on the amount of feed cooked.

After cooking, farmers take a certain amount for each types of pigs or different stable and then add more water and mix until watery feed and put in to trough for pigs. Water amount used more or less depends on pigs, some pigs like to eat feed with a lot of water, some pigs like to eat feed with less water. Before giving maize to cooked pot, farmers often mix with some water and stir it, then put to pot. They explained that it can make maize is done better without lumping. Dry cassava, rice bran are prepared the same in case cook together with other feed. Fish often cook separate with water. Fresh cassava is peeled and chop small pieces and cook together with vegetables. Farmers often measuring feed ingredients by big bowl, and they can estimate how many bowls should they cook for one day. They usually use big pot for cooking feed. Because sediment of feed after cooking can make pots being out of order, they often cook vegetables first and then give other feed later but without stirring for short time and stir later. In Ban Bo, Ban Buon and Na Huong, stables are built by concrete, troughs are built inside of stables, exception in farms, which stable is made by bamboo, they often use bucket to feed for pigs. In Ban Keo, farmers often use bamboo trough or a half of care tire to feed for pigs.

Feeding techniques

Interviewed farmers in Ban Bo, Ban Buon and Na Huong usually feed their pigs three times per day: morning, lunch and afternoon. During the farrowing, lactation and weaning periods, pigs are fed more often, up to 4 – 5 times per day. Increased feeding frequencies is mainly practised in villages near to town with 90% of investigated farms in Ban Bo and 70% of investigated farms in Ban Buon, while only 40% of investigated farms in Na Huong. On the other hand, during the harvesting time of maize (September to October) or land preparation (March to May) or in other times with a heavy workload, farmers feed the pigs less often, often twice per day (but with increased amount per meal). In Ban Keo farmers feed the pigs less often per day than in the other villages, usually twice per day. When farmers are busy with field work, they even feed the pigs only one time per day.

Water used for pigs stems from water pipes or from waterfalls coming from the upland or from families' well. Farmers usually give water to pigs by adding the water to the cooked feeding ration. However,

around 60% of investigated farmers in Ban Bo and 80% of investigated farmers in Ban Buon offer additional water to pigs in summer afternoon (for further details see table 49). That is, however, not practiced in Na Huong and Ban Keo. Those farmers, who were asked why they would not supply additional water to pigs in summer, answered that pigs would not drink when farmers supply additional water. 50% of interviewed farmers in Ban Buon and Ban Bo said that during the time using farm own mixed feeds, they would give extra water because of the dry consistence of the feed. In Ban Keo and Na Huong, water resources used for family consumption and animals come from upland, therefore in dry season water is not abundance. However, water is not shortage because the using of rubber/plastic water pipes to get water from waterfall.

Table 49: Water using for pigs in the investigated farms, by village

Village	**Ban Bo**	**Ban Buon**	**Na Huong**	**Ban Keo**
N households	10	10	10	10
% hh give extra-water*	60	80	-	-
% hh give water in feed only	40	20	100	100
Total hh (%)	100	100	100	100

*In summer lunch time and/or afternoon. Household interview

4.3.5 Monetary input in pig feeding

Prices of feedstuffs in different seasons

Purchasing prices of different feedstuffs at the time of interview are shown in table 50. The average maize price recorded in 15 households was 2033.3 VND with a range from 1200 to 2500 VND. However, average price, which farmers in different villages bought were lightly different: about 1914 VND/kg maize in Ban Bo, but lightly higher in Ban Buon with 2214 VND and low in Na Huong with only 1600 VND.

19 farms gave information on rice bran prices. There are two kinds of rice bran, which can be distinguished by their quality and can be called first grade and second grade. Interviewed farmers usually buy second grade rice bran with a lot of husks and a lower price. Rice bran of second grade prices vary from 1000 – 1500 VND. Farmers rarely buy the first grade rice bran due to the higher price (1800 – 2500 VND).

The price of cassava is almost unchanged during the time of feed shortage. In villages near town the price for dry cassava was varying from 1200 – 1300 VND, while in Na Huong, the price was lower with only 1000 VND.

The soybean price depends on the harvesting season and ranges from 4000 – 6000 VND.

Prices of dry fish and concentrate are rather constant throughout the year, except in the rainy season: In the rainy season, transportation of goods is difficult due to bad roads, and therefore prices of goods transported from elsewhere are higher. Prices for fish and concentrate also depend on the product quality. Fish price varies from 4000 – 8000 VND depending on the big fish or small fish and concentrate price varies from 6000 – 8000 VND depending on amount of protein content.

Table 50: Purchasing price of different feed components at time of interview (mean, minimum and maximum)

Feedstuffs	Current price*			
Ban Bo	**N households**	**Mean**	**Minimum**	**Maximum**
Maize (VND/kg)	7	1914	1200	2600
Rice bran (VND/kg)	7	1214	1200	1300
Dry cassava (VND/kg)	2	1100	1000	1200
Dry fish (VND/kg)	7	5929	4000	8000
Concentrate (VND/kg)	10	7000	6000	8000
Soybean (VND/kg)	7	4957	4000	6200
Ban Buon	**N households**	**Mean**	**Minimum**	**Maximum**
Maize (VND/kg)	7	2214	1500	2800
Rice bran (VND/kg)	7	1543	1000	2300
Dry cassava (VND/kg)	3	1300	1300	1300
Dry fish (VND/kg)	10	4800	4000	7000
Concentrate (VND/kg)	9	6967	6000	8000
Soybean (VND/kg)	9	5056	4000	6000
Na Huong	**N households**	**Mean**	**Minimum**	**Maximum**
Maize (VND/kg)	1	1600	-	-
Rice bran (VND/kg)	4	1050	1000	1200
Dry cassava (VND/kg)	2	1000	1000	1000
Dry fish (VND/kg)	7	6100	5000	7500
Concentrate (VND/kg)	5	6840	6400	7200
Soybean (VND/kg)	-	-	-	-

*Current prices were calculated for investigated households purchasing feeds in Ban Buon, Ban Bo and Na Huong
Exchange rate: 15,400 Vietnamese Dong (VND) = 1 USD (2003). Household interview and calendar tool

Table 51 presents seasons of price maxima and price minima in one year. Feed prices are highest during the time of feed shortage. Periods of high prices in general last from February to July. Feed prices are lowest after harvest; and remain on a low level until December.

Table 51: Seasons of price maxima and price minima

Calendar	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**
Maize	2000–2800 (VND/kg)							1300–1500 (VND/kg)				
Rice bran		1500–2300 (VND/kg)								1000–1300 (VND/kg)		
Soybean			6000–8000 (VND/kg)								4000–5000 (VND/kg)	
Dry fish	4000 – 8000 (VND/kg) depending on rainy/dry season and fish quality											

Dark grey parts represent the time of high feed prices; light grey parts represent the time of low feedstuff prices
Exchange rate: 15,400 Vietnamese Dong (VND) = 1 USD (2003). Household interviews and calendar tool

Input-output-assessments of pig production

Table 52 presents the relation between input in pig production (in terms of crude protein CP and metabolizable energy ME utilised in pig production for all kept pigs in one year) and output (total weight extraction of pig production in one year) for four villages. The CP and ME values utilised for one kg pig weight extracted were highest in Ban Keo with 1.1 kg CP and 67.5Mcal, respectively; and lowest in Ban Buon with 0.8kg and 23.9Mcal, and in Ban Bo with 0.80 and 29.8Mcal, respectively. Values for Na Huong lie with 1.0 kg CP and 34.9 Mcal between those extremes. These disparities give a hint on a greater feed resource use efficiency in Ban Bo and Ban Buon compared to Na Huong and Ban Keo.

Table 52: Amount of crude protein (CP) and metabolizable energy (ME) (excluding vegetables) to produce 1 kg of pig extracted in investigated households, by village (mean ± SD)

Village	**Ban Bo**		**Ban Buon**		**Na Huong**		**Ban Keo**	
N households		10		10		10		10
	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD	%	Mean ± SD
CP (kg)	100	0.8 ± 0.8	100	0.8 ± 0.3	100	1.0 ± 0.9	100	1.1 ± 0.9
ME (Mcal)	100	29.8 ± 31.1	100	23.9 ± 8.8	100	34.9 ± 31.8	100	67.5 ± 50.4

Household interview

Table 53 shows the input-output-assessment in economic terms for pig production in one year.

Ban Bo shows the highest feed costs in one year (2.5 million VND/year), followed by Ban Buon (2.0 million VND/year) and Na Huong (0.8 million VND/year). The lowest feeding costs were recorded with only 6500 VND/year in Ban Keo. A similar trend can be observed for other costs including mating fees, buying pigs and veterinary services, with highest costs in Ban Bo (1.1 million VND/year), followed by Ban Buon (0.4 million VND/year), Na Huong (0.1 million VND/year) and then Ban Keo with only 6100 VND/year. The resulting total costs are thus highest in Ban Bo, followed by Ban Buon; Na Huong and lowest in Ban Keo.

Regarding the cash revenue from pig production, investigated households in Ban Bo earned 7.5 million in one year, while farmers in Ban Buon earned only 62% of that revenue (4.7 million VND/year). Investigated households in Na Huong received an average revenue of 1.7 million VND/year, and farmers in Ban Keo received only 0.5 million VND/year.

Despite their high costs, investigated farmers in Ban Bo received the highest benefit from pig production with 3.8 million VND, farmers in Ban Buon received 2.2 million VND, farmers in Na Huong received 0.8 million VND, while Ban Keo achieved only 0.5 million VND in one year.

Considering the input-output-ratio, farmers in Ban Bo, Ban Buon and Na Huong received between 1.9 and 2.0 VND for each VND invested. On the contrary, investigated farmers in Ban Keo received 38.3 VND for each VND invested, again hinting at a higher production efficiency without investment.

The same can be concluded from the production costs for 1 kg extracted pig. Production costs for one kg pig extracted were highest in Ban Buon with 7,900 VND/kg pig, followed by Ban Bo with 6,100 VND/kg pig. However, in Na Huong farmers needed only 3200 VND to produce one kg of pig, and the lowest production costs for pig production were only 200 VND/kg pig in Ban Keo.

Table 53: Annual feed costs, annual total costs, annual revenue, benefit for one year, and input and output relation from pig production, calculated for the last 12 month, by village

Village	**Ban Bo**	**Ban Buon**	**Na Huong**	**Ban Keo**
N households	10	10	10	10
Purchasing feed costs/year (VND/hh/year)	2,546,050	2,093,600	768,500	6,500
Other costs (VND/hh/year)*	1,117,700	371,500	122,450	6,100
Total costs/year (VND/hh/year)**	3,663,750	2,465,100	890,950	12,600
Total extracted pig weight/year (kg/hh/year)	577	347	203	61
Total revenue/year (VND/hh/year)	7,462,600	4,695,000	1,721,100	494,950
Benefit/hh/year (VND/hh/year)***	3,798,850	2,229,900	830,150	482,350
Input-output ratio****	2.0	1.9	1.9	38.3
Production costs/kg pig extracted (VND/kg weight)*****	6134	7897	3188	206

*including mating costs, costs for buying pigs, veterinary services
**costs of farm-produced feeds and labour costs are not considered
***calculated by total revenues minus total cost from pig production in one year
**** Total revenue per year/total cost per year
*****calculated by total costs per year divided by total extracted pig weight per year
Exchange rate: 15,400 Vietnamese Dong (VND) = 1 USD (2003)
Household interview

5 Discussion

5.1 Discussion of results

5.1.2 Smallholder production systems in Son La

The significant characteristics of smallholder production systems in Son La are labour-intensive form of farming with low capital input and limited accessed to resources, diversified agriculture and resources used as defined by Waters-Bayer and Bayer (1992), and Devendra and Thomas (2002b). The farming systems are mixed and farmers yield profit from the integration of cropping and livestock production. These features has already been described by Kaufmann and Valle Zárate (2002), and Valle Zárate *et al.* (2003) in Son La province.

Household members, family structure, and work force

The members of households in the present study was between 5 and 7 persons. Correspondingly, other authors also found that the size of smallholder households in Son La province lied between 5.0 and 7.5 members (Dufhues, 2000; Valle Zárate *et al.*, 2003). Rodrguez and Preston (1997), and Astrom (2000) found that the average family size was from 5.0 to 7.0 persons in smallholder farms in upland areas of Central Vietnam. The greater family size in Na Huong and Ban Keo (compared to Ban Bo and Ban Buon) is due to the higher number of children in the investigated households around 1.5 in Ban Bo and Ban Buon; but higher in Na Huong (2.1 children per family) and especially Ban Keo (2.8 children per family). Rodriguez *et al.* (1997) and Loc *et al.* (2003) found the numbers of children in smallholders in Central highland Vietnam was 2 to 3. The number of adult people in investigated households was lowest in Ban Bo (3.0 persons) and highest in Na Huong (4.4 people). In correspondence, Loc *et al.* (2003) found the similar mature members in the family in upland areas in Central Vietnam (3-4 persons/hh) (2003). Dufhues (2000) found number of family workers in each household was lightly lower, from 2.0 to 3.0 persons in Son La province.

Land ownership

The total land area per household in the present study ranges from 0.4 to 5.5 ha. In correspondence, other authors found average farm sizes per household between 0.4 and 4.6 ha in the highlands in Northern Vietnam (Tung, 1999; Dufhues, 2000; Valle Zárate *et al.*, 2003). The average agricultural land area per household in the studied villages was ranging from 1 to 3 ha. Correspondingly, Dufhues (2000) found that the agricultural land per household was 2.0 ha in average with a range from 1.5 to 2.6 ha in Son La province. When compared to upland areas of household, the amount of flat land is very small in all selected villages. Flat land is used to plant paddy rice in Ban Bo and Ban Keo while it is used to grow paddy rice and/or sugar cane in Ban Buon and Na Huong. The area of flat land per household was from 0.1 to 0.4 ha/hh in the studied villages. In correspondence, Dufhues (2000) found that the average paddy rice area per household was 0.1 ha in smallholder farms in Son La .

Cropping activities

In recent times, cropping patterns in the selected villages have been changed because of the socio-economic situation. Nearly all smallholders in Ban Bo, Ban Buon and Ban Keo grow paddy rice, but only for home consumption. In Na Huong, only 40% of investigated households grow paddy rice because they plant sugarcane instead. Tung (1999) also discovered that paddy rice cultivation was mainly conducted on flat land plots in the highland villages. Paddy rice is planted in two crops per year in Ban Bo, Ban Buon and Ban Keo, with the first crop gives higher yield than the second. Upland rice was an important crop in the highland for family consumption in former time but now it was given up by most farmers. This is also found by Kaufmann and Valle Zárate (2002) and Valle Zárate *et al.* (2003). According to farmers, they

did not plant upland rice because of low yields. An exception is Ban Keo, where 90 % of investigated households still grow upland rice but the cultivation areas have been narrowed.

Maize is a typical crop in Son La province in general and in the selected villages in particular. Maize area is much larger compared to the area for other crops. However, in Ban Keo maize is a new crop and has been planted only since 1999. The average maize yield of investigated households was low, ranging from 1 to 3 tons/hh/year in Ban Bo, Ban Buon and Ban Keo. An exception is in Na Huong with a maize yield of 16 tons/hh/year. In report of Dufhues (2000) the average maize yield was between 9.0 and 12.0 tons/hh/year in Son La province. It may be explained that land areas for maize in this study were higher (2.5ha/hh) than those in study of Dufhues (1.1ha/hh).

Cassava is still a predominant crop in the investigated households with the exception of some families in Na Huong and a family in Ban Buon. Cassava is rarely sold, but is used for family consumption, alcohol making, and animal feeding.

In the investigated villages near town, vegetables are grown in home gardens for family consumption, for animal feeding and for sale. In Ban Bo and Ban Buon, all households grow sweet potatoes to get vines for their animals, but only 80 % of households in Na Huong and 20 % of households in Ban Keo plant sweet potato. In villages near to town, farmer pay more attention to the vegetable sources for their pigs, whereas in villages far from town, they pay less attention and depend more on the forest vegetable sources and banana stem. In Ban Keo, famers said that vegetables are available in forest/upland areas and they can use banana stem when lack of vegetables.

Similar cropping patterns like in this study have been found in smallholder farms in the Northern highland (Tung, 1999; Kaumann and Valle Zárate, 2002; Valle Zárate *et al.*, 2003) and in upland region in Central Vietnam (Astrom, 2000).

Livestock husbandry

The investigated households keep different domestic animal species. The same range of animal species kept in smallholder farms was also observed by Tung in Tuyen Quang province in Northern Highlands (1999), Kaufmann and Valle Zárate (2002) and Valle Zárate *et al.* (2003).

The main criteria for selection of household is keeping sows with offspring. Therefore, all of interviewed farmers keep pigs. The herd size was between 6 and 11 pigs/hh, counting for all kinds of pigs (including piglets). In correspondence, Tung (1999) found that 93% of households in highlands in North Vietnam raised pigs, with an average herd size of 4 pigs per household. Lower percentage of households was found because of selected households with random sampling. Kaufmann and Valle Zárate (2002) and Valle Zárate *et al.* (2003) found between 90 and 100% of households keep pigs in Son La province. With lightly smaller herd size from 6-8 pigs/investigated household. It is due to increasing number of fattening pigs kept in Ban Bo.

Less than half of the investigated farms near town keep buffaloes, but more than half of investigated farms farer from town keep buffaloes. Farmers keep buffaloes for draft power. The keeping cattle is less frequent. The numbers of cattle were from 1/hh head in Ban Keo, 1.5/hh head in Na Huong and 2 heads/hh in Ban Buon. The numbers of buffaloes were 1.5/hh in Ban Bo, Na Huong and Ban Keo, and 2/hh heads in Ban Buon and with ranging between one and two animals. Correspondingly, Kaufmann and Valle Zárate (2002) and Valle Zárate *et al.* (2003) found average of about 1.7 buffaloes and 2 cattle were kept in smallholder farms in Son La province. Tung (1999) found also average of 2.5 heads of cattle and 1.9 heads of buffaloes kept in smallholder farms and he also found that cattle is less often kept in upland areas in Tuyen Quang province. However, number of cattle and buffaloes are lightly higher in Tuyen Quang due to keeping for sale. One of the main reasons, which households give up keeping ruminants, is

the shortage of pasture areas. Valle Zárate *et al.* also observed the same constraint for ruminant keeping (2003). Ruminants are now mainly fed on crop residues, free ranging in the fields after harvest, or cut-and-carry is practiced. Ogle and Phuc found already in 1997 that ruminants are fed only crop residues and are allowed to graze only at roadsides and on fallow land. In villages far from town, more draught animals were kept because can not use mechanization of tillage in upland fields and transportation due to bad road, and farmers in this region may also not afford to pay for mechanizing. In addition, buffaloes were kept more in upland villages due to they are stronger than cattle in working. The same reasons for reducing numbers of ruminants in study villages and the predominant keeping of buffaloes in upland villages were also observed by Valle Zárate *et al.* (2003).

Chickens were raised in most of the interviewed families. In correspondence, Valle Zárate *et al.* found about 97% of smallholder farms kept chicken (2003). Correspondingly, Tung (1999) found out that 91% of investigated households in Tuyen Quang province in northern highland kept chicken. The purpose of keeping poultry in the investigated households was mainly family consumption, sometimes also selling in case cash shortage. Chickens are kept under free-ranging conditions and sometimes supplemented with small amounts of rice, rice bran, maize and cassava. This management has also been observed by Tung (1999). The average number of chicken per household was 20 birds in investigated households. In correspondence, Kaufmann and Valle Zárate (2002) and Valle Zárate *et al.* (2003) found in villages far from town, number of chicken were also about 20 birds/hh, but chicken herd size was much higher (70 birds in average) in villages near to town than the present results due to the heavy losses of epidemic diseases happened before interviewing. Tung found on average 35 birds per household in Tuyen Quang province (1999) because keeping chicken was considered as a cash animal in this region.

Keeping duck is linked with the availability of water resources. Therefore, a very low percentage of families kept them in study area. Average of 30% of investigated farms in Ban Bo and Ban Buon and 60% in Ban Keo keep ducks with a small flock size of 5 to 10 birds. Correspondingly, Kaufmann and Valle Zárate (2002) and Valle Zárate *et al.* (2003) found about 30% of investigated households keep duck in Son La province and with average of 10 birds. On the other hand, Tung (1999) found 24% of households keeping ducks with an average flock size of 10 birds in Tuyen Quang province in Northern highland in Vietnam.

Revenue from agricultural activities

To evaluate the role of agricultural activities to farm economy, revenues from crop production, livestock production (excluding pigs) and pig production are taken in to account.

In Na Huong and Ban Keo, revenue from crop production plays a more important role compared to revenue from animal production or from off-farm activities due to less scarce land area. In correspondence, Lemke *et al.* (2002) and Valle Zárate *et al.* (2003) observed that crop revenue also plays very important role in villages far from town, where land is less scar. Main cash crop in Na Huong and Ban Keo was maize (accounting for over 80% of total crop revenue). Correspondingly, Dufhues (2000) and Huan *et al.* (2002) found about 90% of total crop revenue come from maize. In Ban Bo and Ban Buon, revenue from crop production plays minor role in the total annual revenue. In Ban Bo, in 40% of farms, which sold maize, it was also the main cash crop (=63% of total annual revenue), in other farms revenue from cropping comes mainly from selling fruits and vegetables. In Ban Buon the main cash revenue comes mainly from sugarcane, and selling vegetables. Only few households get cash revenue from fruits. The main revenue source for investigated farmers in Central Vietnam was also cropping (Astrom, 2000). Land area in Na Huong is larger than other villages and investigated farms was gained 26.9 million VND from crop production. Lemke, et al (2002) found household in Na Huong got 23 million VND from crop production in 2002. The cash revenue from cropping was 4.7 million VND in

Ban Keo. The cash revenue from crops in Ban Bo, and Ban Buon was 4.7 and 2.4 million VND per year, respectively. Correspondingly, Lemke *et al.* (2002) and Kaufmann and Valle Zárate (2002) found the cash revenue earned from crop production in Ban Bo was about 4 million VND. However, Lemke *et al.* (2002) found that cash revenue from crop in Ban Buon was higher than in this study (4 million VND). It may explained by the reducing revenue from selling fruit in this villages because of low costs and low yield.

The main cash revenue in livestock production (excluding pigs) comes from chicken. The cash revenue from livestock production was rather similar in Ban Bo, Ban Buon and Na Huong with around 1.5 million VND per household and year. In Ban Keo, the cash revenue from livestock was very low with only 0.4 million VND per household. Correspondingly, Tung (1999) found revenue comes from livestock production (excluding pigs) in highland was 1.2 million VND.

The cash revenue from pigs in Ban Buon and Ban Bo was accounted for 63 and 59 % in total family revenue, respectively and much higher than in Na Huong and Ban Keo (with only 8.0% and 12%, respectively). This strongly difference shows that farmers could earn higher income by more investment in pig production in scarce land area. Tung found 39% of total farm revenue comes from pig production in households in Tuyen Quang province in Northern Vietnam because farmers can yield more revenue from selling ruminants and poultry. The annual revenue from pig production were 7.5 and 4.7 million VND in Ban Bo and Ban Buon, respectively. The revenue from pig production in the two villages was thus two to three times higher than in Na Huong (2.2 million VND) and around 10 to 15-fold higher than in Ban Keo (0.5 million VND). This may be explained by different pig genotypes kept, better veterinary care, better pig keeping management and especially better feeding management as well as more investment in feeding in these villages than those in Na Huong and Ban Keo. Especially in Ban Keo, poor keeping management as well as scarce feed amount has resulted in very low revenue from pig production. Correspondingly, Kaufmann and Valle Zárate (2002) found farmers in Ban Bo, Ban Buon and Na Huong yielded about 7 million VND, 5.5 million VND and 2 million VND from pig production, respectively. However, the pig production revenue determined in the study was higher than the revenue reported by Lemke *et al.* (2002): 4.6 million VND in Ban Bo, 3.9 million VND in Ban Buon, 1.1 million VND in Na Huong. According to farmers in villages, the higher revenue in pig production in 2003 than in 2002 was due to higher number of fattening pigs kept. In Na Huong, revenue from pigs was two times higher than in last year due to increasing aware of farmers from potential revenue from pig production as well as improving their feeding management skill in pig production, and the limited number of pigs slaughtered and paying for hired labour.

The impact of pig production on household economy reflects characteristics of demand drive and resource driven production system (Lemke *et al.*, 2002): Production system in Ban Bo and Ban Buon has revealed as demand driven due to strongly impact of pig production to the household economy, but impact of pig production play a minor role in Na Huong and Ban Keo and reflects characteristics of resource driven production system.

5.1.2 Pig production

Average number of sows kept in studied villages was about 1.2 and a range of 1-2 sows are kept per household with an exception of one farm in Ban Buon (kept 3 sows). Correspondingly, Kaufmann and Valle Zárate (2002) and Valle Zárate *et al.* (2003) found average of 1.3 sows were kept and with a range of 1-2 sows kept in smallholder farms in Son La province. In correspondence, Peters found that average of 1 sow kept in households in Thanh Hoa province in Northern Vietnam (1998).

Nearly all investigated farms kept fattening pig with 4 to 5 pigs per household in Na Huong and Ban Keo and about 6 pigs per household in Ban Bo and Ban Buon. The number of fattening pigs are increasing in all villages in recently. Valle Zárate *et al.* (2003) found that in villages near town, higher numbers of fatteners were kept per household (about 5 pigs/hh in Ban Buon and Ban Bo), compared to lower numbers in villages farer from town (1 pig per family in Na Huong, 4 pigs per household in Bo Duoi). Other authors found lightly lower number of pigs per household in North Vietnam (2.0 to 5.0 fattening pig/hh) (Rodriguez *et al.* 1997), 2 to 3 fattening pigs in smallholder farms in Central Vietnam (Astrom, 2000). In general, a higher number of fatteners kept requires a higher resource input in absolute terms. Households, which are richer in resources (cash, labour and feed resources) can afford to keep more fattening pigs. The same has been shown for smallholder farms in the study area (Thuan *et al.*, 2000; Valle Zárate *et al.*, 2003).

Pig breeds

For this study, households were selected either keeping Ban sows (local breed in Son La, still kept in Na Huong and Ban Keo) or households keeping Mong Cai (improved Vietnamese breed, kept in Ban Buon, Ban Bo, and increasingly in Na Huong). Ban breed is often kept in extensive production systems with low-input keeping conditions. Ban pigs have been almost completely replaced by MC or crossbreds in villages closed to towns, but are still predominantly kept in villages farer from town and in remote areas.

MC sows are predominant kept in Ban Bo and Ban Buon because of introducing of MC gilts from The Uplands Program and also because of their high fertility and the adaptation to a poor feeding. It is expected that keeping Mong Cai sows will further spread due to its performance and adaptation traits (Doanh, 1994; Rodríguez and Preston, 1997; Astrom, 2000).

The use of mating boars was different in the studied villages. In Ban Keo, pure Ban boars mate the sows, without control from farmers due to free-ranging. Therefore, a high percentage of inbreeding in the pig population of the village cannot be avoided. In Ban Bo and Ban Buon, MC and LW boars are used. The same is true in Na Huong, with additional use of Ban boars. The same facts have already been described earlier (Valle Zárate *et al.*, 2003). However, farmers in study area who are raising pure-bred MC offspring face a problem: females are usually sold as for breeding, and there is a high demand for MC gilts in the area. However, males are usually not used for breeding (at least not on a large scale), but also have a low fattening performance and obtain low market prices. Therefore, farmers usually prefer to raise crossbred off-spring (LW x MC). However, the use of MC boars for mating was influenced by D2-subproject and in addition, the small sample size in this study could not show representatively. Tjallden found in Hanoi and Bavi, that farmers did not used MC boars, but only Landrace or Yorkshire boars due to tending to keep higher performances and higher lean meat pigs for required market (2000).

Input in pig production

To evaluate efficiency of pig production, evaluation of input in pig production is required. The highest input in pig production was determined in villages near to town with 3.7 million VND/hh/year in Ban Bo but high number of pigs sold: 8 weaners and 9 fatteners. Farmers in Ban Buon spent 2.5 million VND input per year and yielded 10 weaners and 5 fatteners sold. In Na Huong, costs of pig production was at a lower level than Ban Bo and Ban Buon with nearly 0.9 million VND/hh/year and yielded lower number of pigs sold: about 5 weaners and 3 fatteners sold, while in Ban Keo, cash inputs were very low with 15,750 VND/hh/year and also yield very low number of pigs: 2 weaners and 2 fatteners sold.

In Ban Bo, Ban Buon and Na Huong, buying pigs accounted for 15%, 21% and 7% of the total expenses in pig production in one year in investigated households, respectively because most of them left some pigs to keep fatteners. No farms in Ban Keo bought pigs. Manh *et al.* found that 62% of the total costs in

pig production was buying fattening pigs, while farmers used farm-produced feed resources for feeding under semi-intensive production systems. Investment in buying pigs was only 34% in the total costs when invest more in commercial feed (2000). In the present study, veterinary services' costs only accounted 5 to 6% of the total costs of pig production per household and year in Ban Bo and Ban Buon, but for 20% in Na Huong. That can be explained by the fact that the total investment in pig production and the investment in feeding is lower in Na Huong, therefore, the relative fraction of the costs for veterinary care in the total costs is higher. Manh *et al.* found that veterinary expenses were very low in smallholder farms under semi-intensive production systems in Central Vietnam, accounting for 5 to 9% of the total costs (2000).

The biggest fraction of the total costs in pig production was feeding; which was 2.6, and 2.1million VND/hh/year in Ban Bo and Ban Buon and 0.9 million VND in Na Huong, and occupied more than 80% of the total pig production costs in these villages. Lan (2000) found input in feeding was 88% (1.5 million VND) in smallholders under intensive production systems. In other hand, input in feeding in smallholder farms in northern Vietnam was up to 94% (1.7 million VND) of the total costs in families keep sows to produce weaners in an intensive production system (Thuy, 2001). Buying feed occupied nearly 70% of the total costs for producing fattening pigs (Thuy, 2001). Manh *et al.* (2000) found that the feeding costs per fattening pig were low (29% in the total costs) in a production system with low investment in commercial feed under semi-intensive production systems. On the contrary, Manh *et al.* also found that in the same production systems, when farmers investment in commercial feed, the feeding costs were higher than 1 million VND per fattening pig and occupied 62% of total production costs. The input in pig production in this study was high because including input of keeping sows and fatteners. In Ban Keo, input in feeding was not considerable because most farmers could not afford to buy feed due to lack of money or do not want to spend money in pig production.

Pig production in resources and demand driven production systems show the differences in many characteristics including differences in input requirement (Lemke *et al.*, 2002). Farmers in Ban Bo and Ban Buon have invested more in feeding as well as costs of buying pigs and services in pig production. This reveals as characteristics of demand driven system: resources are reserved for the desired production level. In Ban Keo, low level of input in pig keeping, which typical for resource driven production system: only use available resources. The production in Na Huong was determined by the using of available resources in former time (Lemke *et al.*, 2002). Today, farmers in Na Huong invest more in buying feed and more input in buying pigs and higher investment in other services as well and these characteristics could be considered as transition between demand and resource driven production system.

Reproductive performance

The average age of MC and Ban sows in this study was 24 and 45 months, respectively. Valle Zárate *et al.* found in the same research area an average age of Mong Cai and Ban sows of 24 and 31 months, respectively (2003). The average age of Ban in this study was higher because the fact that the selection of Ban sows in Ban Keo, a new village..

The number of MC piglets born alive was 10.0 with a range from 5 to 14. Correspondingly, Thuy *et al.*, (2002) found litter size of MC sows kept in smallholders smallholder farms in Son La province was 10.0. Correspondingly, Doanh *et al.* (1985) found that the number of piglets born alive of MC sows was 10.0 with ranging between 10-12 piglets per litter under intensive production conditions. In other hand, Valle Zárate *et al.* found MC piglets born alive was 11.2 per litter in smallholders in Son La province. In addition, Astrom (2000) found MC sows kept in smallholder farms in central upland was 8.3 and lower than in this study, may be the reason of keeping old sows (over 5 years of age).

The number of piglets born alive of Ban sows in the study was 7.8. Correspondingly, Kaufmann and Valle Zárate (2002) found a litter size of 7.3. Tjallden found that number born alive per litter of Ban sow was 6.5 (2000) and lightly lower than study result. The number of piglets born alive was even lower with only 6.0 in the study of Thuy *et al.* (2002). This is may be due to the peak reproductive performance of Ban sows at 3-4 years old in the present study.

The mortality of piglets from born to weaning of Ban pigs in the study was 16%, but much higher in Mong Cai (29%). Anh and Dzung (1994) found that the mortality until weaning in Ban pigs was about 20% in smallholders under extensive pig production in mountainous regions of Nghe An province. Doanh et al found that the mortality rate of MC piglets until weaning was between 15 and 20 % under intensive keeping conditions (1985). In many investigated households, farmers said that their Ban pigs never suffer from diseases until now. This might be explained by a higher resistance to diseases as well as the greater adaptation of Ban pigs in poor keeping condition. Ban pigs were considered as the breed has strong resistance with diseases (Anh and Dzung, 1994).

Because of high mortality rate, the number of MC piglets weaned per litter was 7.4 for Mong Cai and 6.2 for Ban, thus corresponding with 7.5 and 5.8 piglets found by Thuy *et al.* (2002). Tjallden found 9.8 piglets under semi-intensive keeping conditions (1999). Doanh *et al.* found 8 to 9 weaned piglets per litter for MC under intensive keeping conditions (1985).

The average number of litters per MC sow per year is higher than in those of Ban pigs (1.3 litters for MC, 0.8 litters for Ban. Valle Zárate *et al.* found higher litter numbers per sow and year with 1.8 for MC and 1.2 for Ban (2003). In the study of Astrom (2000), the average litter number per sow per year was 2.0 in upland village in MC sows. Differences in the number of litters per sow and year can partly be explained by different ways of calculation (age at first litter considered or not considered, parameter determined from the total age and total number of litters or determined via the time interval between the last 2 litters, which was done in this study). In addition, the keeping condition as well as management skill also affect the interval between two litter (e.g. poor feeding gives a consequence of delay heating).

Growth performances of pigs

Age and weight of all pigs measured in two time measuring of different genotypes were shown in the plots. LW x MC shows the highest growth performance with first pigs reached 20 kg after 100 days. In correspondence, Lemke *et al.* (2002) found the same performance in LW x MC pigs with growth performance up to 20 kg weight after 100 days of age.

LW x Ban and CW x Ban also show high growth performance with first pig reached 20 kg after about 110 days and some pigs gained 20 kg between 110 and 160 days, and the first LW x Ban reach 20 kg at 140 days. Correspondingly, Lemke *et al.* (2002) found that LW x Ban shows the medium weight with the first pig reached 20 kg after 150 days.

MC show the medium growth performance with gained 20 kg after 150 days. On the contrary, Valle Zárate *et al.* (2003) found the some MC even gained nearly 20 kg after 95 days but this result was accounted with small sample size.

Ban pigs show very low growth performance with the first pigs gained 20 kg weight after 320 days and few pig reaches 10 kg of weight after 150 days. Lemke *et al.* (2002) found that first Ban pig reached 10 kg of weight after about 125 days. In contrary, few pigs between age of 120 and 200 days nearly reached the weight of 20kg was found by Valle Zárate *et al.* (2003). That is may be due to many Ban pigs were weighed at old age and kept in poor keeping condition as well as poor management in Ban Keo.

The weight of pigs recorded was ranging from 1 to 30kg. The daily weight gain of LW x MC crossbreds was 81.2g/day. Valle Zárate *et al.* (2003) found LW x MC gained 165g/day (age period 8-189 days) in

smallholders in Son La province. In other hand, Kaufmann and Valle Zárate (2002) found LW x MC gained 190g/day. Pigs in present study grew slowly due to measuring in the time of feed shortage as well as strongly effect of diarrhoea after weaning. Otherwise, Lemke *et al.* found in MC crossbreds a higher daily gain of 370g/day (2000) and was calculated from age and weight at sale.

The daily weight gain of LW x Ban and CW x Ban crossbreds was 107.1g and this result was correspondent with the 115 g/day determined a range of age from 29-292 days by Valle Zárate *et al.* (2003) and 100g/day by Kaufmann and Valle Zárate (2002). High daily weight gain of LW x Ban and CW x Ban may hint the potential of Ban crossbreds kept under appropriate keeping condition.

The daily gain of MC in this study was determined to be 67.3g/day. Valle Zárate *et al.* (2003) found daily weight gain of MC was higher (166g/day with ranging from 42-132 days of age). Otherwise, another author found for MC in smallholder farms 180 to 200 g/day during the time from growing to first oestrus under semi-intensive pig production (Lai, 1998).

Ban pigs in the present study showed the lowest daily weight gain with 27.2 g/day. This result was much lower than result found by Valle Zárate *et al.* (2003) with 61 g in the age range of 38-407 days (2003) and 70g/day in study of Kaufmann and Valle Zárate (2002). This is due to serious shortage of feed in time of measuring and poor management conditions. When comparing the first and second measurements for individual pigs in Ban Keo, it came out that for 40% of weighed pigs there was no weight gain or even a negative weight development.

The very low growth rates determined for all genotypes may be explained by the fact that measuring was conducted in extremely shortage season of feeds, when nutritional requirements of pigs are hardly fulfilled.

In addition, most studies on the growth performance of MC and MC crossbreds were conducted in semi-intensive or intensive production systems. Therefore, growth rates reported in those studies are much higher than the daily weight gain of pigs in the present study, determined under on farm conditions in semi-intensive and extensive production systems. E.g., the growth rate of MC under semi-intensive condition on smallholder farms was determined to be 411g/pig/day (Quac *et al.*, 2002). The growth rate for LW x MC determined by Loc (1996) was 204 g/day in smallholder farms under extensive production condition and was up to 375g/pig/day with the supplementation of protein under smallholder keeping conditions of on – farm trial (Loc *et al.*, 1997).

As described by Lemke *et al.* differentiation between demand driven and resource driven system also determined by production performances (2002). MC sows kept in Ban Bo and Ban Buon showed show higher reproductive performance than Ban sows such as higher litter size, more prolificacy, shorter interval between two litters and higher number of litters per sows per year and higher numbers of piglet weaned. In addition, pigs kept in Ban Bo and Ban Buon shows the highest growth performance, pigs kept in Na Huong show the medium growth level, while pure Ban pigs in Ban Keo reveal the lowest growth performance. This differences show not only different performance of genotypes themselves but also because of better management in general and better feeding management in particular.

Output from pig production

Different performances as well as different input levels and different ways of management have resulted in a variation of total numbers of pigs sold, different total weight sold per year as well as different total weight extraction, and higher annual cash revenue from pig production. Especially, higher performances of pigs result in a higher output from pig production, reflected by the weight extraction level per household per year, as was also shown by Lemke *et al.* (2002) and Valle Zárate *et al.* (2003).

The highest total weight extraction was 630kg/year in Ban Bo. Correspondingly, Thuy *et al.* (2002) found the total weight extraction in Ban Bo was about 610 kg/hh/year. The highest weight extraction from selling pigs was also recorded in Ban Bo (average 580kg/hh/year) and also lightly higher than results found by Lemke *et al.* (2002), Thuy *et al.* (2002) and Valle Zárate *et al.* (2003) (around 500kg). Total of about 48kg/hh/ year was used for family consumption and other occasion as well as gift in this villages. Correspondingly, Valle Zárate *et al.* (2003) found about 50kg weight extraction was used for slaughtered and as gift in Ban Bo.

Ban Buon yielded the medium weight extraction per year (340kg/hh/year). Correspondingly, Lemke *et al.* (2002) and Valle Zárate *et al.* (2003) was recorded the same total weight extraction in Ban Buon (342kg/hh/year). In this village, only about 20kg of pig weight was used for slaughtering and gifting. This results also recorded by Lemke *et al.* (2002) and Valle Zárate *et al.* (2003).

The total annual extraction from the pig herd per household in Na Huong was 220kg/hh/year and lightly lower result found by Lemke *et al.* with 298kg/hh/year (2002). The total weight of slaughtered pigs was about 30 kg and about 15 kg of pigs given as a gift. This result was much lower than results found by Lemke *et al.* (about 200 kg/hh/ year) (2002) because farmers in Na Huong have paid for hired workers in pigs and more pigs were slaughtered in former time.

The smallest annual extraction was recorded in Ban Keo with 98 kg/hh/year. It is lower than result Lemke et al found in Bo Duoi (160 kg annual weight extraction). This is may be due to low farmers in Ban Keo invest in buying feed, poorer management as well as keeping less maize for pigs. About 30 kg weight extraction was used for family consumption, in other occasion as well as for present in Ban Keo. It is also correspondent with result from Lemke *et al.* found in Bo Duoi (2002).

The live weight of slaughtered pigs per sow per year for whole Vietnam was as high as 750 kg in 1995, however, including the intensive pig producers as well (Hai and Nguyen, 1997). In other hand, one sow could produce total weight extraction of about 180 kg (Lan, 2000) and 200 kg (Thuy, 2001) from weaners in smallholder farm under intensive pig production systems in Northern Vietnam. Present results obtained higher weight extraction due to including weight of weaners and fattening pigs.

In Ban Bo, Ban Buon and Na Huong, pigs are sold mainly at two phases: at weaning age or after fattening. However, in Ban Keo, farms rarely sold weaners, and fattening pigs were sold lower weights than the weight considered elsewhere to be optimum. Farmers in Ban Bo and Ban Buon often sell pig after weaning and at about 60 kg of weight and about 7-8 months of age. Farmers in Na Huong often sold fattening pig at 60 kg weight and 10 months of age. Whereas, in Ban Bo, farmers often sell pigs at about 40 kg weight and about 12 months of age. As described by Lemke *et al.* in demand driven production systems, farmers sell their pigs at defined age or weight (weaners or fattening pigs); while in the resource driven production system, pigs are sold at varying ages when cash is required (2002).

In Ban Bo, the total extraction per year is 1.7-fold higher than in Ban Buon, due to strongly investment in feeding for fattening pigs and increasing numbers of fatteners kept in recently. The lower weight extraction in Na Huong as compare to Ban Bo and Ban Buon may be caused by lower investment in feeding (purchased and farm produced feed) and poorer management skill even a relatively high percentage of farms using Ban crossbreds with LW or CW. The annual household extraction in Ban Keo was very low. The reason for the different extraction levels in this villages include poor feed resources, low other inputs, low performance, low numbers of pig kept per households, keeping pure Ban pigs, and purposes of keeping pigs.

Farmers in villages near town get revenue from selling vegetables, because they have good and daily access to market. That might be a reason, why pig manure plays a more important role in Ban Bo and Ban

Buon compared to Na Huong and Ban Keo. In the investigated households, pig manure was not considered as primary reason for keeping pigs. Farmers said that pig manure is rarely used for upland crops due to the long and difficult transportation to the upland fields, and chemical fertilizers are more suitable. Reh (1993) found that manure is sometimes not used at all because the means for transportation of the fertilizer are not available. However, other authors have reported that getting manure for crop production is one of the main reasons for keeping pigs in smallholder farms in low land and delta areas (Peters, 1998; Tung, 1999; Lehane, 2000; Astrom, 2000). Because in lowland and delta areas, pig manure is a main important fertilizer for maintaining and improving soil fertility (Peters, 1998).

The output of pig production also reveals the differences between resource driven and demand driven system (Lemke *et al.* 2002). The characteristic of demand driven production: resources were made available or reserved for desired production level. This is revealed in Ban Bo and Ban Buon: the higher input in feeding, buying pigs, and other services, the higher total annual weight extraction and higher weight extraction sold per year were attained. The characteristic of resource driven production system: use of available resources only was shown in Ban Keo: the lower input in complete term, the lower output was attained. Whereas, In Na Huong, farmers were invest in medium level of feeding, buying pigs as well as the total weight extraction were medium and they yielded the medium total weight extraction as well as medium weight extraction sold. This characteristics revealed the transition trend between demand and resource driven production systems.

5.1.3 Pig feeding

Farm-grown feeds, forest feeds and seasonality of production

Farm produced feed resources in study areas are diverse but quantity of farm-produced feed resources in study areas is not stable and not balanced throughout the seasons. For instance, in harvesting of maize and rice, maize and rice bran are often used for animals but the using of these feed is limited in off-season. Correspondingly, Hai and Pryor (1996) found local feed resources in Vietnam are available but they are limited amounts in the off-season.

Maize, rice bran, and cassava are considered to be the main energy rich farm-produced feed resources for pig production in the study area, while sweet potato vines, Wild Taro, Rau Duong, and banana stem are the main green fodder resources for pigs. In correspondence, Valle Zárate *et al.* (2003) found the main farm-produced feed components fed for pigs include rice bran, green vegetables, maize, cassava in smallholders in Son La province. Correspondingly, Giang *et al.* (2002) found the main farm-produced feed resources for pigs were maize, sweet potato vines, and various kinds of vegetables in smallholder farms in Northern Vietnam. Farmers in Bavi (Northern Vietnam) feed their sows on rice by-products, vegetables, sweet potatoes, maize, cassava roots and leaves (Tjallden, 1999).

Almost all interviewed farmers use maize for their pigs. However, 20% of farms in Ban Keo do not use maize because all maize was sold to get cash. According to farmers, they have no capability to afford maize to their pigs because they need cash to buy more rice for family consumption. Amount of maize was used more for pigs in Ban Bo and Ban Buon than in Na Huong, and lowest in Ban Keo. Nearly all farms use rice bran for pigs with exception of 30% of farms in Na Huong because their families do not plant rice and they buy milled rice for family consumption.

Nearly all investigated households are using cassava for pigs except 30% of households in Na Huong because they did not plant cassava and do not want to spend cash in buying cassava. One farm in Ban Buon was bought cassava during a year. 20% of farms in Ban Buon, Ban Bo and Na Huong was bought cassava during the time of feed shortage. Farmers harvest cassava all year round, especially from October

to April for drying but harvest in small amount per time because cassava can not keep long time (fast perishable).

A high percentage of farms in Ban Bo and Ban Buon purchased soybean for pig but with small amount. Few farmers in Ban Buon have planted small soybean areas and used for pigs. Few farmers in Na Huong planted soybean and they kept some for their pigs, but they do not purchase. Soybean was mainly used in time of lactation, weaning and/or several months before selling fattening pigs.

Tjallden also found that farmers in Hanoi bought for their pigs soybean, maize; and farmers in Bavi bought maize, rice and rice by–products, soybean and cassava roots (1999). This results were rather correspondent with studied results. However, farmers in Ban Bo, Ban Buon and Na Huong did not buy fresh fish, cassava roots and rice but used cassava roots and rice from their own farm-produced products.

The main vegetable used in Ban Bo and Ban Buon was sweet potato vines. In Ban Buon, more garden vegetable were used such as watercress, water plant, water dropwort and cabbage. Farmers in Ban Bo and Ban Buon were not often used forest vegetables for pigs. In the time of scarcity of vegetables (in winter), most households fed banana stem to the pigs. 80% farmers in Na Huong and 20% farm in Ban Keo were planted sweet potato vines but with small area and main vegetables are still forest vegetable. Other farms do not plant because according to them, they can collect in forest and use banana stem. In Na Huong and Ban Keo, banana stem was used nearly throughout the year.

In the time of feed abundance, all investigated farms had the same feeding strategy: they fed more maize and/or more rice bran and a lower amount of cassava or no cassava. Correspondingly, Lemke *et al.* (2002) found that during the time of feed abundance, farmers in investigated villages also increasing the feed amount (maize) but lower amount of cassava. In the time of feed shortage, farmers in Ban Bo and Ban Buon reduced the amount of maize and/or rice bran in the ration and purchase more maize and rice bran for their pigs when feed run out. Few farmers buy more dry cassava. Correspondingly, Lemke *et al.* (2002) and Valle Zárate *et al.* (2003) recorded in Ban Bo and Ban Buon farmers bought additional maize, fed the same or smaller cassava amount per day. Farmers in Na Huong reduced the feed amount but few of them bought more feed, some other farms replaced good quality feed by cassava when stored feed run out. Lemke *et al.* (2002) and Valle Zárate *et al.* (2003) found in Na Huong maize was fed lower amount/pig/day but cassava amount/day was increased and no buying cassava purchased. This is lightly different with the present study may be due to more farmer have given up planting cassava. In Ban Keo, during the time of feed shortage, farmers use cassava and banana stem and other vegetables to compensate the shortage. No feed is bought in Ban Bo during this time.

Using commercial feedstuffs for pigs

Dry fish and concentrate feed of different types are used in Ban Bo, Ban Buon and Na Huong. However, not all of the interviewed farms used commercial feed for pigs. Investigated farmers in Ban Bo, Ban Buon and Na Huong bought concentrate and fish throughout the year.

All of investigated farms in Ban Buon were bought fish, 70% investigated farm in Ban Buon and Na Huong, and only 10% in Ban Keo bought fish because of sick pigs (1kg only). Higher percentage of farms in Ban Buon bought fish and with highest amount of fish per year due to they said that it is very good for pigs, especially for fattening pigs in last several months, lactating sows and post weaning piglets.

All of interviewed farms in Ban Bo bought concentrate for pigs, 90% in Ban Buon and only 50% in Na Huong. In addition, the total amount of commercial feed used per year is very low. All of farms in Ban Bo bought concentrate. However, all of them said concentrate and fish are very expensive and cash is not usually available. No farm among the investigated farms in Ban Keo was using concentrate feed for pigs.

Correspondingly, Lemke *et al.* (2002) found that farmers bought concentrate for pigs, especially they bought more in time of feed shortage in villages near to town in Son La. In correspondence, Valle Zárate *et al.* (2003) also found that farmers in Son La were purchased concentrate and fish for pigs. Tjallden found that farmers in Hanoi and Bavi bought for their pigs fish, and concentrate (1999). Tung (1999) found that farmers in highlands in Northern Vietnam was bought low quality fish for pigs.

The strategies of using feed throughout year and the feed resource used and the purchasing behaviour of farms reflect the characteristics of demand driven and resource driven production system (Steinfield and Mack, 1997). In Ban Bo and Ban Buon, the fraction of farmers buying farm-produced feed and commercial feed for pigs was big, and purchased amounts were high. All of farmers purchasing of feed during time of feed shortage, keep produced-maize for pigs. These show the characteristics of demand driven: resources are made available or reserved for the desired production level.

Whereas, in Ban Keo, only one farms bought 10 kg of rice bran and 1 kg fish, a low amount of farm grown feedstuff was left for pig, and low quality of feed such as cassava and banana stem are used to replaced the shortage of maize and rice bran. These show the typical characteristics of resource driven: production is adjusted to use of available resources.

Some years ago, pig production systems in Na Huong had been considered as resource driven production systems because the production is determined by the use of availability of resources (Lemke *et al.*, 2002). Today, in Na Huong higher percentage of farms bought feed for pigs (but still less than Ban Bo and Ban Buon). However, farm-produced maize was left for pig production but still low amount, few farm bought more feed for pig during the time of feed shortage (cassava, maize). Few farmers still use poor quality feed such as cassava and vegetables feed for pigs when feed resource finished. Pig production system in Na Huong, therefore, reflects the transition between demand and resource driven production systems.

Competition among species regarding feed resources

In the investigated households, the competition between different animal species seems to be of minor importance.

Chickens are mainly scavenging and can find their feed by themselves. Supplementary feeding is not very much common. Correspondingly, Tung found chicken in highlands were kept under scavenging systems and only dry or boiled cassava are supplement (1999).

Ruminants are grazing or are fed on collected green forage and available crop residues. The same feeding for ruminant was observed by Tung (1999). Maize is fed to ruminants only in a short period (during ploughing fields).

Thus, the feed resources used for pigs were not affected by the feed demand for other animal species. The only feed resource, which was used for different species and could be subject to competition among species was maize. Nearly all of farm left some maize or even all maize for animals (except 20% in Ban Keo). 5% of maize yield in Na Huong and 11% of maize in Ban Keo was kept for animals. Dufhues (2002) also observed 10% of maize yield was left for animals in smallholder farms in Son La. In Ban Bo and Ban Buon, amount of maize was left for animal was higher with 59 and 72%, respectively.

In all investigated farms the greatest maize amount was used for pigs, and little maize is used for other animals: 79% of total fed maize is fed for pigs in Ban Bo, 82% in Ban Buon, 82% in Na Huong and 75% in Ban Keo. However, no articles mention about the competition among animal species in smallholders in feed resources up to now.

5.1.4 Quantitative composition and nutritive values of feeding rations in different seasons

The quantitative composition and nutritive values of rations for pigs varies among farms and between seasons. In general, in the time of feed abundance is after harvest, feed resources in all investigated households are available, especially maize. In this time, cassava was used in small amounts, or was not used. It was assumed that the availability of maize after harvest caused a reduced use of cassava. Feed intake, CP and ME for pigs in time of feed abundance in all cases were higher than in the time of feed shortage.

Feeding for breeding sows

In time of feed shortage, the amount of maize used for pregnant sows and empty sows was lightly higher in Ban Bo than in Ban Buon and Na Huong. It is may be explained by greater amount of maize used for pigs in this village. The amount of dry cassava and rice bran used for pregnant sows and empty sows was higher in Ban Bo, Ban Buon, and Ban Keo than in Na Huong. Farmers in Ban Buon do not feed their pig by fresh cassava throughout year because that is considered to be harmful for pigs. In both seasons, vegetables were fed more in Ban Buon and Ban Bo than in other villages.

Huynh and Diem recommended for local empty and pregnant sows (from 30 to 120 kg body weight of I and MC) fresh matter intake of 0.7 to 1.2 kg/sow/day (1980). Other authors suggest higher feed intake fresh matter for local sows of genotypes I and MC of 1.0 to 1.5kg/sow/day (Nghi *et al.* 1980; Thuong *et al.*, 1992;. Viet and Len, 2003) or even 1.1 to 2.1kg/sow/day (Nghi *et al.*, 1985).

The feed intake of sows in the time of feed shortage assessed by interviewing in Ban Bo and Ban Buon was quite high compared to the suggestion from literatures (with 1.8 to 2.0 kg/sow/day). Whereas, feed intake for breeding sows was 2 to 3 times lower in Na Huong and Ban Keo (1.1 kg and 0.7 kg/sow/day) than in Ban Bo and Ban Buon. Feed intake for sows in Na Huong can be considered as according to requirement. Breeding sows in Ban Keo were fed lower than the feed intake recommended by authors above with except with the lowest feed intake level recommended by Huynh and Diem (1980).

During the time of feed abundance, the amount of feed fed for sows in all villages were higher than in time of feed shortage. It may be explained by increasing maize amount in all villages. Amount of feed for sows in Ban Bo and Ban Buon was still two to three times higher than for sows in Na Huong and Ban Keo (2.4 kg and 2.9 kg/sow/day versus 1.3 kg and 1.2 kg/sow/day). When compare to literature, amount of feed fed for sows in Ban Bo and Ban Buon was very high, over requirement, but sows in Na Huong and Ban Keo were fed enough with their requirement.

Regarding to the nutrient requirement, Thuong *et al.* (1992) recommended for an empty and pregnant local sow (I and MC) a daily protein intake of 119 to 179 g CP/day depending on weights of sows. Viet and Len recommended for breeding MC sows a rather similar CP intake of 144 to 180 g CP/day (2003) depending on pregnant status, and gilts or sows. It was found out that MC pigs have a lower N demand than Large White pigs (Ly *et al.*, 2003). In addition, local sows can be fed on a level 30% lower than the nutritional level required for exotic breeds (Nghi *et al.*, 1985). The CP demand for gestating sows was estimated to be 127 g CP/day at 125 kg body weight (adapted from Trottier and Johnson, 2001). Pond *et al.* recommended that lactating sows and gilts should be fed with 160 g CP/day (adapted for Vietnamese local pig breeds) (1995). According to Serres (1992), a gestating sow under tropical conditions needs 218 g protein/day at a weight of about 150 kg (adapted for Vietnamese local pig breeds).

In time of feed shortage, MC breeding sows in Ban Bo and Ban Buon were fed highest CP with 267g and 275g CP/sows/day as compared to CP received by Ban sows in other villages. Ban sows in Na Huong were fed medium CP with 139g/sow/day. Ban sows in Ban Keo were fed very low CP with 105g/pig/day. Comparing to literature, CP received by MC sows in Ban Bo and Ban Buon was too high, over

requirement. Ban sows in Na Huong were fed on daily CP amounts corresponding to the recommendations of Thuong *et al.* (1992) and Trottier and Johnston (2001). Ban sows in Ban Keo were fed very low CP, under their requirement, which recommended by literature.

The crude protein intake of breeding sows during the time of feed abundance was higher than in the time of feed shortage. CP received by sows in Ban Buon and Ban Bo was very high with 363g and 317g/sow/day and two time higher than CP received by sows in Na Huong and Ban Keo. During the time of feed abundance, Ban sows in Na Huong and Ban Keo were fed enough CP requirement (according to the quoted requirements). MC sows in Ban Bo and Ban Buon were fed nearly two times higher than their requirement: from 167-300% higher than requirement in Ban Buon and from 145-266% in Ban Bo.

Thuong *et al.* recommended for pregnant and empty local sows a daily energy intake of 2507 to 4084 kcal/day depending on the body weight (50-90kg) (1992). Viet and Len recommended a daily energy intake of 3540 to 4425 kcal/day for pregnant MC sows depending on the first or second gestation periods (2003). Energy requirements of gestating sows were estimated to be 3000 kcal at 125kg body weight (adapted from Trottier and Johnson, 2001). Pond et al recommended for breeding sows and gilts 4300 kcal/day at a weight of about 150 kg (adapted for local sows in Vietnam) (1995).

In time of feed shortage, MC sows in Ban Buon and Na Huong were fed around 7000 kcal ME. Compared to the energy intake recommendations, sows in Ban Bo and Ban Buon received nearly 200% of the required amount. Sows in Na Huong were fed 3690 kcal ME and considered as according to requirements (Thuong *et al.*, 1992; Trottier and Johnson, 2001; Viet and Len, 2003). Ban sows in Ban Keo received less energy per day as compared to sows in the other villages (2770 kcal/sow/day), but were still fed according to the requirements recommended by Thuong *et al.* (1992).

In time of feed abundance, sows are fed higher ME amount than in time of feed shortage in all villages. During this time, MC sows in Ban Bo were fed about 8000 kcal ME and MC sows in Ban Buon even fed higher with 9000 kcal and two to three times higher than ME fed for Ban sows in Na Huong and Ban Keo. MC sows in Ban Bo and Ban Buon were received too high ME comparing to their requirement (180-350% higher than ME recommended). In Na Huong sows were fed 4530 kcal ME and enough ME according to requirement in literature. In Ban Keo, sows were fed 3790kcal ME and also enough as according to the ME requirement recommended in literature.

The nutrient requirement of the pregnant sows are quite low as compared to lactating sows, particularly during the first two-third of gestation (Church, 1991). However, MC sows in Ban Bo and Ban Buon was fed too high amount of feed intake not only in time of feed abundance but also in time of feed shortage. In addition, in both seasons MC breeding sows were received too high CP (122%-300% higher than CP requirement) and ME. Ban sows in Na Huong were fed enough amount feed amount as well as CP and ME requirement. Ban sows in Ban Keo were fed enough of feed amount and CP in time of feed abundance only but too low CP amounts and feed intake in time of feed shortage while ME was according to requirement. Church (1991) showed that under- and over-feeding in pregnant period should be avoid. Because overfeeding is costly and waste, and over fat sows may have smaller litters and more farrowing difficultly. Otherwise, under feeding, sow will be smaller and weaker at births and sows may not have sufficient milk for large litter, and sows may be too thin and delay heating. It may be one explanatory factor for the low reproductive performance of Ban sows.

Feeding for lactating sows

Huynh and Diem recommended for lactating sows (I and MC) a daily feed intake of 2.7 to 3.9 kg (1980) according to their body weight (30-120 kg). Nghi *et al.* (1980) suggested lactating sows of MC and I could be fed 2.7-2.8 kg feed intake. Thuong *et al.* (1992) suggested that a lactating sow of local genotype

(I and MC) should be fed with 2.8 to 3.3 kg/day depending on body weight. Viet and Len suggested for lactating MC sows a daily feed intake of 3.0 to 3.5 kg/day (2003).

In both seasons, lactating sows were fed a lightly higher feed amount of almost all feedstuffs than empty sows in Ban Bo, Ban Buon and Na Huong. One lactating sow was fed with 3.0 kg/sow/day in Ban Bo, 2.7 kg/sow/day in Ban Buon and 1.5 kg/sow/day in Na Huong. Lactating sows in Ban Keo were fed the same amount like empty sows (0.7 kg/sow/day). Comparing to feed amount recommended by authors above, MC lactating sows in Ban Buon and Ban Bo were fed rather enough with their requirement but Ban sows in Na Huong and Ban Keo were fed very low.

In the time of feed abundance, the intake of energy and protein-rich feed for lactating sows was lightly higher than for pregnant and empty sows. Lactating sows in Ban Bo and Ban Buon were fed with 3.0 kg/sow/day and 3.2 kg/sow/day, and only with 1.8 kg/sow/day in Na Huong and with 1.2 kg/sow/day in Ban Keo. In Ban Keo, the amount fed for lactating sows were the same with breeding sows. When compare to the feed amount requirement suggested by literature, feed amount for lactating sows in Ban Bo and Ban Buon were enough according to requirement. Lactating sows in Na Huong and Ban Keo were still fed very low (only 30-70% of CP requirement).

Nghi *et al.* recommended lactating sows (I and MC) could be fed 339-351g/pig/day (1980). Another author suggested lactating I and MC sows could be fed 324-468g CP/sow/day (Huynh and Diem, 1980). Thuong *et al.* recommended lactating local sows (I and MC) should be fed 384-453g CP/sow/day (1992). In other hand, Viet and Len (2003) recommended that MC lactating sows should fed from 420-490g CP/day. Lactating sows, gilts may be fed with 482 g CP/day (adapted from Pond *et al.* (1995) for local Vietnamese sows).

During the time of feed shortage, lactating sows in Ban Bo and Ban Buon were fed with 349g and 324g CP/sow/day and much higher than CP received by Ban lactating sows in Na Huong and Ban Keo. Ban lactating sows in Na Huong were fed nearly two time CP higher than Ban sows in Ban Keo (205g and 105 g/sow/day). Comparing to recommendation above, all lactating sows in Na Huong and Ban Keo were fed only about 30 to 50% their requirement. However, when compare to the lowest CP level recommended by Nghi *et al.* (1980) and Huynh and Diem (1980), lactating sows in Ban Bo and Ban Buon were fed according to their requirement.

During the time of feed abundance, lactating sows in all villages were fed higher than in time of feed shortage except in Ban Keo, lactating sows and breeding sows were fed the same. MC lactating sows in Ban Bo were fed 379g CP and lactating sows in Ban Buon were fed with 416g/sow/day. Lactating sows in Na Huong were fed 262g/sow/day. In Ban Keo CP amount was 155g/sow/day. MC lactating sows in Ban Bo and Ban Buon were fed enough according to recommendation of Nghi *et al.* (1980); Huynh and Diem (1980); Thuong *et al.* (1992). Whereas, lactating sows in Ban Keo and Na Huong were fed very low as compared to CP requirement: 53-68% of sows requirement in Na Huong and about 30-40% of their requirement in Ban Keo.

Thuong *et al.* (1992) shown lactating local sows should be fed 7403-8621kcal/day depending to their body weight. Viet and Len (2003) said that MC lactating sow can be fed 9000-10500kcal/day. Estimated requirement of lactating sows, gilts was 11900 kcal/day (adapted from Pond *et al.* (1995) for Vietnamese local sows).

MC lactating sows in Ban Bo and Ban Buon was fed 9140 and 8210 kcal/sow/day during the time of feed shortage, and 9620 and 10230kcal/sow/day during the time of fed abundance. Lactating sows in these villages are considered receiving enough ME in both season. In other villages, ME used for lactating sows was received under their requirement, only reached 32-50% in Ban Keo and 54-78% in Na Huong.

According to Church (1991), the nutrient requirements of sows during lactation are three to four times higher than the requirements during gestation because high demand for milk production. But lactating sows were fed too low CP in all villages and in both seasons in Na Huong and Ban Keo. Lactating sows in Ban Bo and Ban Buon were fed enough CP during the time of feed abundance but lightly lower than requirement in time of feed shortage. Lactating sows in Ban Bo and Ban Buon were fed enough ME requirement but lactating sows in Ban Buon and Ban Keo were fed too low energy. The poor feeding during this time, sows may have extended to delay to oestrus (Church, 1991). It may be a reason for the low number of litters per year of Ban sows.

Feeding for fattening pigs

In the present study, MC and LW x MC fattening pigs are kept in Ban Bo and Ban Buon, LW x Ban; CW x Ban and Ban are kept in Na Huong, and Ban fattening pigs are kept in Ban Keo. In the time of survey fattener weights lied from 5-35 kg of weight (estimated from measuring weight).

Huynh *et al.* recommended that crossbred fattening pigs from 8-35 kg should be fed from 0.8-1.5kg feed amount (FM) (1980). Thuong *et al.* (1992) recommended fattening pigs from 10-30 kg should be fed 0.8-1.5 kg feed (FM).

In the time of feed shortage, fattening pigs in Ban Bo and Ban Buon had roughly the same feed intake (0.6 kg/pig/day in Ban Bo, 0.5 kg/pig/day in Ban Buon), and fattening pigs in Na Huong and Ban Keo were fed on rather similar total amounts (0.3 kg/pig/day in Na Huong and 0.2 kg/pig/day in Ban Keo). Comparing with literature, feed amount fed for all fatteners are very low.

During the time of feed abundance, fattening pigs in Ban Bo, Ban Buon and Na Huong were fed on higher amounts than in the time of feed shortage (Ban Bo 0.7 kg/pig/day, Ban Keo 0.4 kg/pig/day, Na Huong 0.4 kg/pig/day). Fattening pigs were fed equal amounts in the time of feed shortage and in the time of feed abundance in Ban Buon (0.5 kg/pig/day). Comparing with feed amount recommended, feed amount for fattening pigs during the time of feed abundance was also low.

Huynh *et al.* recommended that crossbred fattening pigs from 8-35 kg should be fed from 112-208g CP (1985). Thuong *et al.* (1992) said that crossbred (exotic x local breeds) at 10-30 kg of weight should be fed 118-176 CP/day in average.

During the time of feed shortage, fatteners in Ban Bo were fed highest CP with 78g/pig/day. In Ban Buon, fattening pigs were fed 59g/pig/day. In Na Huong and Ban Buon, fattening pigs were fed 40 and 32 g CP/pig/day. During the time of feed abundance fattening pigs were fed 90g, 62, 45 and 47g/day in Ban Bo, Ban Buon, Na Huong and Ban Keo, respectively and higher than CP amount received by fatteners in time of feed shortage. Thus comparing to CP recommended in literature, CP was fed too low for fattening pig in present study not only in time of feed shortage but also in time of feed abundance.

Thuong *et al.* (1992) suggested that crossbred fattening at 10-30 kg of weight should be fed 2125-3988kcal/pig/day.

In time of feed shortage, fattening pigs in Ban Bo were fed highest ME with 2000 kcal. Fatteners in Ban Buon were received medium ME (1460 kcal/pig/day). Fattening pigs in Na Huong and Ban Keo were fed low ME (1090 and 840 kcal/pig/day). In time of feed abundance, ME was 2120 kcal, 1130, 1130 in Ban Bo, Na Huong and Ban Keo, and lightly higher than those in time of feed shortage. In Ban Buon, fatteners were fed lower ME than in time of feed shortage may be due to strong reducing of dry cassava-rich energy feed but only small amount of maize was increased in diets. According to the ME recommended by Thuong *et al.* (1992), fattening pigs in Ban Bo were fed according to requirement. Fattening pigs in other villages were fed too low than requirement.

Regarding feed intake as well as nutrient values for different pig genotypes, all genotypes were fed rather similar in both seasons. LW x MC pig were fed about 0.8-0.9kg feed amount and correspondent with their requirement in the time of feed shortage and in the time of feed abundance. CP intake of LW x MC in time of feed shortage and abundance was rather similar (97 versus 103g). CP received by LW x MC pigs was not according to their requirement, which recommended by Thuong *et al.* (1992) and Huynh et al (1980). All fattening pigs of LW x MC genotype were fed correspondent with ME requirement in both season (LW x MC fattening pigs were fed 2440kcal during time of feed shortage and 2640 during the time of feed abundance).

Other pig genotypes such as MC, Ban and LW x Ban and CW x Ban were fed about 0.3 kg of feed intake during the time of feed shortage and from 0.3-0.4 kg feed intake in time of feed abundance. When compare to the recommendation of Huynh *et al.* (1980), MC, Ban, LW x B and CW x Ban pigs were not fed enough feed amount. In addition, CP intakes for them were also very low (about 35-45g/pig/day) as compared to the recommendations of Huynh et al (1980) and Thuong *et al.* (1992).

If adequate protein is lacking in a diet, the pigs suffer a reduction of growth or loss of weight (Cunha, 1977). It may be explained for the very low growth rate of pigs in this study. Proteins are considered to be essential dietary constituents in the feeding diets (Lewis and Lee Southern, 2001). Thus, the lack of protein is frequently a limiting factor in the diets. This is because farm grains and by-products are deficient in both quality and quantity of protein for swine. Supplementary feed such as fish, soybean and concentrate are the important sources of protein. However, amount used for pigs was low. Pig diets should be supplemented more protein sources. However, since protein supplements are expensive feeds, some farmers still tend to feed to little protein while pigs require a regular intake of protein.

5.1.5 Pig feeding management and feeding techniques

In the present study, during pregnant phase, sows are fed the same feed in the first two-third and last one-third of gestation period. However, in the last one-third of gestation, sows should be feed more than in the first two-third of gestation (Church, 1991; Thuong *et al.*, 1992). The same management way of sows during pregnancy was also observed by Quang in smallholder farms in Northern Vietnam (1997). Lactating sows need very high nutrient requirement but they were almost feed not enough especially, shortage of CP is serious in this time. The same problem in smallholder farms in Northern Vietnam was found by Quang (1997).

In Ban Bo and Ban Buon, fattening pigs were fed normal ratio in the first 5 to 6 months of the fattening period but received better feed in the last several months (one to two months before selling) including concentrate, fish and/or soybean, maize, cassava, rice bran. It was considered better feed to fatten in the final phase of fattening. Tjallden found fattening pigs in Bavi and Hanoi were fed on the same feed with other pigs, but with additional concentrate feed (1999). Fattening pigs in Na Huong and Ban Keo were fed the normal ratio as other pigs from the early fattening period to final fattening period. However, during the early of fattening period, nearly all fatteners were fed not enough CP and ME, and low amount of feed. Correspondingly, Quang (1997) found crude protein and energy of feeding rations used for weaning pigs and growing pigs were deficient in household in Hung Yen province.

All investigated farms cooked feed for pigs, which was also observed by Lan (2000). Nearly all farmers in Ban Bo, Ban Buon and Na Huong feed their pig three times per day. In Ban Keo, twice per day is practised more often and sometime pigs are only fed once. Feeding pigs twice daily tends to yield a better feed conversion than feeding only one time, but feeding three times seems to yield no advantage over feeding pigs twice regarding the feed conversion ratio (Devendra and Fuller, 1979).

5.1.6 Monetary input in pig feeding

Prices of feedstuffs

Since the study was conducted in the time of feed shortage in households, recorded feed prices were high.

Subsequent to the harvest of maize (from September onwards), maize is available in all farms and prices for maize are low. Until the next harvest maize is stored and stepwise used or sold. In the time between March and July, farmers nearly finish the stored amount, and with the increasing demand, prices in the market increase. Correspondingly, Huan *et al.* found shortage of maize supply often occurs between April and August, when there is no maize available from the Northern and Central region (2002). Huan *et al.* have also observed that the supply of maize is not stable throughout the year (2002). Maize prices fluctuate between harvested and other times of the year. It may be due to the lack of adequate processing and storage facilities to keep the crop (Tuyen *et al.*, 1998). Feed costs of maize range from 1200 to 2800 VND/kg depending on the seasons. After harvesting, price in the market go down. Normally, farmers sold maize at very low price but when they buy, they often buy very high price. Some farm, which cash is available, they bought more maize during the time of harvesting and store for animals. Huan *et al.* (2002) found the most expensive maize price in Northern Vietnam was about 2400-2500 VND and often in time from March to July. The cheapest price often about 1800 in September to December.

The price of maize in market is rather related to the other farm-produced products (Huan *et al.*, 2002). During the time of maize shortage, more farmers purchase rice bran, and the price of rice bran is increasing. During the time maize price is cheap, rice bran is also cheap (about 100-1200 VND/kg). The most cheapest price of rice bran was about 1000 VND and the most expensive price was 1500 VND (second grade) when the price of maize increases (often from March to June). This is limit the buying power of farmers and consequence, reducing the investment for pigs during this time, which consider very important for pig production.

Price of dry cassava is from 1000-1300 VND/kg. According to farmers, price of cassava do not increase during the time of feed shortage because few farms buy cassava. In market, price of fresh cassava was 300-400VND/kg (Rake *et al.*, 1993). Loc (1996) found that price of dry cassava in market was from 1600-1800 in Central Vietnam.

The price of soybean also depends in the other farm-produced feed. When the time maize and rice bran are expensive, price of soybean is increasing, too. The most expensive price of soybean was 6200. the cheapest price was 4000 after harvesting season of soybean.

Prices of fish, and concentrate were rather expensive (4000 – 8000 VND) and do not change according to seasons. Many farmers could not afford to buy more these feedstuffs for their pigs.

Feed costs and other costs

Feed is the main factor, which influences pig production. The highest costs for pig production was 3.7 million VND/hh/year in Ban Bo, while the lowest total costs was only 12600VND/hh/year in Ban Keo. Ban Buon invested about 2.5 million VND in pig production per household per year. Farmers in Na Huong expensed about 0.9 million VND. Lan (2000) found total costs for one sows, which produces weaners, was 1.7 million VND/year including feed costs, costs of replacement sows, mating costs, treatment costs in smallholders under intensive pig production systems. Thuy (2002) found total costs for one sows-produced weaners was 1.9 million VND/hh/year under intensive production systems. The total expense in present study was higher than results found by Lan and Thuy because total costs for pig per household in one year includes costs for sows produce weaners and costs for keeping fatteners. In other hand, Lan (2000) found that the total costs produced one fattening pigs was 0.6 million VND and Thuy

(2001) found expense for one fattening in whole life was 0.7 million VND/hh/fattening period under intensive pig production.

Ban Bo expensed the highest feed costs with 2.5 million VND/year (produced 630kg weight extraction), followed by Ban Buon: 2.0 million VND/year (produced 340kg weight extraction), then Na Huong: 0.8 million VND/year (produced 220 kg weight extraction), finally only 6500 VND/hh/year was expensed in Ban Keo (produced 98kg weight extraction). Lan (2000) found feeding costs for one sows was 1.5 million VND/year and Thuy (2001) found feeding costs for one sows was 1.8 million VND/year in smallholder farms under intensive production condition in Northern Vietnam. In addition feeding costs for one fattening pig was 0.4 million VND (Lan, 2000) and 0.5 million VND (Thuy, 2001) in smallholders under intensive pig production conditions. The expenses in Ban Bo and Ban Buon were higher due to farmers produce weaners and fattening pigs.

Other costs including costs for buying pigs, mating costs and veterinary fee were accounted for smaller part in the total costs. These costs consist of costs for keeping sows to produce weaners and keeping fatteners. In Ban Bo, other costs was rather high (1.1 million VND). Other costs were 0.4 million in Ban Buon, 0.1 million in Na Huong and only 6100VND in Ban Keo. Other costs for one sows produced weaners were 0.2 and 0.1 million VND/hh under intensive pig production (Lan, 2000; Thuy, 2001). In other hand, other costs for one fattening pigs were 0.2 million VND under extensive pig production (Lan, 2000; Thuy, 2001).

Production costs for one kg pig extracted were highest in Ban Buon with 7900 VND/kg pig. Production costs for one kg weight extraction were lower in Ban Bo with 6,100 VND/kg pig, then in Na Huong farmers needed only 3200 VND to produce one kg of pig, and the lowest production costs for pig production were only 200 VND/kg pig in Ban Keo. Correspondingly, Loc (1996) found that feeding costs per kg weight gain was determined to be between VND 7000 to 9000 for fattening pigs under semi-intensive pig production. This reveals that the higher investment, the higher production costs for one kg of weight extraction. To produce one kg weight of weaner, smallholder farms spent 9600 and 9700VND in under intensive pig production in Northern Vietnam (Lan, 2000; Thuy, 2001). In addition, to produce one kg fattening pig, farmers expensed 8600VND and 9000 VND (Lan, 2000; Thuy, 2001). The production costs in those researches above were very high as compared to study results due to high amount of feed was purchased. Manh *et al.* (2000) found that production costs per one kg fattening weight extraction was 9000 VND under semi-intensive production conditions because high costs of buying pigs. Hang (2000) found total costs expensed for one kg weight extraction from fattening pigs was 6300 VND under semi-intensive production due to using of ensiled cassava leaves.

Pig production efficiency

Relation between input (in terms of crude protein CP and metabolizable energy ME utilised in pig production for all kept pigs in one year) and output (total weight extraction of pig production in one year) for four villages was shown: the CP and ME values utilised for one kg pig weight extracted were highest in Ban Keo with 1.1 kg CP and 67.5Mcal, respectively; and lowest in Ban Buon with 0.8kg and 23.9Mcal, and in Ban Bo with 0.8 and 29.8Mcal, respectively. Values for Na Huong lie with 1.0 kg CP and 34.9 Mcal. These disparities give a hint on a greater feed resource use efficiency in Ban Bo and Ban Buon compared to Na Huong and Ban Keo when farmers invested more in feed resources.

Regarding the input-output-ratio, farmers in Ban Bo, Ban Buon and Na Huong received between 1.9 and 2.0 VND for each VND invested. In these villages, due to using high feed costs as well as other costs, the efficiency of these production systems is not so efficient. Correspondingly, Manh *et al.* found under semi-intensive production system, farmers can earn 1.83 VND when invest 1 VND in pig production under semi-intensive pig production. Lemke et al (2000) found the input-output ratio in farms, which keep MC

in Northern Vietnam, farmers can yield 5.7 VND for one VND input may be less investment in feeding. In other hand, Lan (2000) and Thuy (2001) found that input-output ratio in farms, which keep sow-weaner, was 1.3 and 1.2, respectively, and lower than results study results due to high investment in feed costs and buying pigs. On the contrary, investigated farmers in Ban Keo received 38.3 VND for each VND invested because of utilize farm-produced feed, keep sows' offspring to be fattening, mo matting costs and very low veterinary fees. Correspondingly, Lemke et al (2000) found farmers could earn 34.3 VND for 1 VND investment in pig production in smallholder farms, which keep Ban pigs under extensive keeping condition.

Benefit from pig production

Benefit from pig production was calculated by total revenue/year minus total costs/year. Despite the highest input, the investigated households in Ban Bo received the highest benefit from pig production with 3.8 million VND/hh/year, higher 1.7 times than in Ban Buon, 4.8 times than in Na Huong and 7.6 times higher than in Ban Keo. Investigated households in Ban Buon received 2.2 million VND. Farmers in Na Huong and Ban Keo received very low benefit with 0.8 million VND and 0.5 million VND per year. Lan (2000) and Thuy (2001) found benefit from keeping 1 sow to produce weaners were 0.6 million VND/year and 0.5 million VND/year in smallholders under intensive pig production excluding fattening pigs and high costs of feeding. In addition, Thuy (2001) found smallholder farms, which keep weaner-grower-fatteners obtained 1.1 million VND benefit. This benefit was lower than in study households in Ban Bo and Ban Buon because is high costs of feeding. In other hand, Manh *et al.* (2000) found that with using of farm-produced feed only, keeping one fattening pigs can yield about 0.8 million VND benefit in smallholder farm under semi-intensive production system with supplementary of distiller's grain. However, Manh *et al.* also found that with supplying more supplementary concentrate, farmers did not earn any benefit but also have to compensate about 17250 VND for one fattening pig.

5.2 Discussion of methods

5.2.1 Calculation methods

Calculation of number of litters per sow per year

There are different ways of calculation number of litters per sow per year such as calculation depending on the interval between two litters or calculation based on the age of sows. In this study the author calculated litters/sow/year = $\frac{Total\ litters\ per\ sow}{Age\ of\ sow\ (year)}$ (sow > 1 litters) without considering the first age of farrowing because almost of farmers do not remember the time of the first farrowing of gilt. Therefore, numbers of litters per sow per year in present study was low and do not reflect the real number of litters/sow/year. In other hand, if we calculate depending on the interval between two litters author could only find out about interval between the present litter and the litter before the last litter. Therefore the number of litters per sow per year in the year of interviewing known but may not represent for other years before or latter. Because of different changes would happen or will happen such as delayed heating in next time or piglets may be died before weaning and interval between two litters will be shorter.

Calculation daily weight gain

Because of the great variation of age in pigs measured: 6-200days in MC and 10-250 days in LW x MC and LW x Ban/CW x Ban, and 10-430 days in Ban pigs, only the data from pigs within the age range of 10 to 140 days were taken into calculation of the daily weight gain. Because growth rate of young pig very old pigs, and older pigs are different.

Input calculation.

In the present study, input in pig production was calculated in term of cash including costs of buying pigs, cost of buying feed, costs of matting as well as payment of veterinary treatment. Correspondingly, Lan (2000) and Thuy (2001) also used the same method of calculation. However, all of investment in feeding including opportunity costs, labour, farm-own resources such as feeding and pigs were not taken into calculation. Therefore, the evaluation of absolutely benefit in pig production will be limited in this study.

5.2.2 Quantitative composition and nutritive values of feeding rations assessed by different methods

The feeding amount and nutrient values fed for all types of pigs in investigated households were taken into evaluation by measuring and assessed by interviewing. Feed amount for pigs shows no great difference between two methods in Ban Bo (feed amount assessed by measuring equal with 96% of that assessed by interviewing). In Ban Buon and Na Huong, feed amount for all pigs assessed by measuring equal with 114 and 115% of those assessed by interviewing. This shows a difference between two methods. However, the great difference between two methods was shown in feed amount used for pigs in investigated households in Ban Keo (feed amount assessed by measuring equal with 121% of feed amount assessed by interviewing).

Regarding to CP assessed by different methods, CP was received for pigs in households in Ban Bo, Ban Buon and Na Huong was rather the same (CP assessed by measuring were 98.1%, 99.7%, 97.3% of CO assessed by interviewing). However, the great difference of CP was presented when assessed by two different methods in Ban Keo (CP assessed by measuring was 76.7% of CP assessed by interviewing).

Comparing to ME assessed by measuring, ME assessed by interviewing was 90% in Ban Bo, 107% in Ban Buon, 112% in Na Huong. ME assessed by interviewing is rather accuracy in Ban Keo with 98% of ME assessed by measuring.

Thus, the results assessed by interviewing and measuring were rather different regarding to nutrient values and feed intake. In the short term study, feed management assessed by interviewing shows optimum way of collecting data. However, measuring shows more accuracy feeding management situation of farmers. In present study, the measuring feed was conducted only one time and could not show representatively feeding management in smallholder farms. Because in the time of measuring, some farmers was run out of feed such as rice bran or maize because these feedstuffs often mill in small amount every time. In addition, some farmers said they feed their pigs by fish, concentrate and soybean but these feedstuffs were finished in the measuring time. In addition, feeding for pigs was also different even in the same season. Moreover, what people say and what people do may be different. These problems could be solved by measuring repeatedly in long period of time.

6 Conclusion

The input in pig production was assessed with the focus on feed resources and feeding management in pig production systems of different intensity levels in smallholder farms in Son La province. The following conclusions can be made:

- Pig production plays more important role in Ban Bo and Ban Buon than in Na Huong and Ban Keo.
- All of investigated households in Ban Bo and Ban Buon purchased feed with high amount. The percentage of farms in Na Huong purchasing feedstuffs was lower and with lower amount. The costs of purchasing feed account for the biggest part of the total costs in Ban Bo, Ban Buon and Na Huong (more than 80% of total costs). Very low percentage of farms bought feed throughout the year in Ban Keo with low costs.
- Feed resources used for pigs are high diversity in Ban Buon, Ban Bo and Na Huong but low diversity in Ban Keo. Main feed used for pigs in all villages are maize, rice bran and cassava. Cassava was a replacement feed in all four villages, when other feedstuffs are in shortage or not available. The shortage of feed is more serious in Ban Keo, followed by Na Huong. The shortage of feed was less serious in Ban Bo and Ban Keo.
- Period of vegetables shortage occurs in winter, when vegetables do not grow and have to be replaced by banana stem in all villages. The main period of feed shortage occurs before harvesting (before harvesting, from March to July). Feeding strategies were different, especially in the time of feed shortage: farmers in Ban Bo and Ban Buon reduced maize and/or rice bran amount in the daily ration and buy more maize and rice bran; in Na Huong, farmers also reduced the amount of maize and rice bran but few farms buy more feed; some families fed their pigs on cassava (fresh and dry) as replacement of high quality feed; in Ban Keo, investigated households fed less feed and used mainly cassava and banana stem.
- Feeding according to age and performance of pigs was mainly practised in households in Ban Bo and Ban Buon. Less farms in Na Huong and no farms in Ban Keo have applied this management.
- Empty and pregnant sows were shown to be fed over their nutrient requirements (CP and ME) in Ban Bo and Ban Buon, especially in the time of feed abundance. In Na Huong, empty and pregnant sows were fed according to requirements. Empty and pregnant sows in Ban Keo were fed sufficient protein and energy per day in the time of feed abundance. In time of feed shortage, they were fed sufficient energy but below their protein requirements.
- In Ban Bo and Ban Buon, lactating sows were only fed CP and ME according to their requirements in the time of feed abundance, but were fed correspondent or lightly lower than their protein requirement in time of fed shortage. In Na Huong and Ban Keo, lactating sows were fed below their protein requirement, with a more severe protein shortage in the time of feed shortage. Lactating sows in Na Huong and Ban Keo were fed sufficient ME in time of feed abundance but insufficient ME in time of feed shortage.
- All fattening pigs of different genotypes (5-35 kg of weight) in all investigated villages were fed below their protein requirements in both seasons. Fattening pigs in Ban Bo were fed sufficient energy, but fattening pigs in other villages were fed too low energy than their requirement.
- Feeding efficiency expressed as amount of CP/ME required per kg pig live weight extracted was higher in Ban Bo and Ban Buon than in Na Huong. Pig production in Ban Keo shows poorest feeding efficiency.

- In households which keep MC sows, farmers often use higher amount of high-quality feed, better feeding management, and better services. Therefore, farmers could yield higher output and higher benefit. In households, which keep Ban sows, farmers often invest low input in absolutely term, and poor feeding management, therefore they yield low output and low benefit.
- Keeping pigs in Ban Bo and Ban Buon showed characteristics of demand driven production systems: resources are made available or are reserved for the desired production level Pig production in Ban Keo presented characteristics of resource driven production systems: available farm-produced feed resources are used for pigs without further investment to reach a certain production level. Pig production in Na Huong showed as resource driven in past time but it is the transition between the demand and the resource driven production system to day.
- The differences between the results obtained by measuring feed, household interviews at the same time for the same animals e.g. daily amount of feed, CP and ME indicate measuring feed will be a useful method to achieve accuracy data if the measuring feed was done repeatedly.
- The role of pig production in household economy has a great potential. Effective feeding management is essential measure to performances of pigs. Feeding management for pigs is still a shortcoming, especially for lactating sows in smallholder farms not only in villages farer from town but even in villages near town. This may be improved by introducing of feedback results to farmers, a feeding production procedure that suitable with smallholder conditions and genotypes, and useful training courses in feeding. Especially, cassava is available feed in Son La province but the usage of its products for pig production is still limited. Therefore, the processing techniques of cassava roots and cassava leaves should be introduced to farmers to avoid unbalance feed resources and waste feed resources.
- The continue study in feeding management should be done by repeatedly measuring in longer time to yield the objective reality of feeding management under smallholder conditions. In addition, on-farm research on the affect of feeding management on performances should be done in order to show farmers on the importance of feeding management in pig production.
- Supplying credits to farmers at appropriate loan and suitable to their production systems can help to keep feed resources for pigs balanced throughout year.

7 Summary

Compared to the better-off lowland and delta areas of Vietnam, the situation of farmers in Vietnam' s mountainous areas is hampered because of poorly developed infrastructure, poor resources and unsteadily short and long-term availability of resources. The mountainous area is again separated in the mountain valleys and areas near towns, which are high population density, high land pressure, but have a better-developed infrastructure; and in the hillsides, hilltops with low population density, lower land pressure, but poor developed infrastructure. Proportion of local pigs in the total pig population in Vietnam is gradually decreasing due to replacement by exotic and crossbred pigs. However, Ban breed is still kept on hillsides, and in villages far from town and in resource driven production system, which is adjusted to the utilization of the available resources. Mong Cai breed is also kept in the mountain valleys and areas near town and in demand driven production systems, which resources are made available or are reserved for the desired pig production levels.

A survey on feed resources and feeding management in pig production at different intensity levels was conducted. Data were recorded in Son La province, in a region near town, characterised by demand driven production systems (2 villages); and in two regions farer away from town, characterised by resource driven production systems (2 villages). The objectives of the study were to describe the current feeding management and feed resources used in different pig keeping systems in order to measurement, analysis of constraints and potentials of feeding systems in the pig production systems in different regions. In the selected villages, 10 households were selected, respectively. Data collection was conducted from March to May, 2003. Data were collected by the household interviews using a structured questionnaire, by communication tools (seasonal calendar), by quantifying/measuring feeding rations at time of interview, by measuring pigs, and by key-person interviews.

The results show pig production in Ban Bo and Ban Buon shows characteristics of demand driven production systems: resources are made available or are reserved for the desired production level. In Ban Keo, available farm-produced feed resources are used for pigs without further investment to reach a certain production level. These characteristics showed in pig production revealed the transition between the demand and the resource driven production system in Na Huong.

Feed resources used for pigs are higher diversity in demand driven and transition production systems and lower diversity in resource driven production system. The shortage of feed in demand driven was not much serious but more serious in transition system, and very serious in resource driven production systems: Maize and rice bran were fed for pigs throughout the year in households in demand driven. In transition system, maize and rice bran are fed during a shorter period of the year. In resource driven system, maize is fed to pigs only a very short time of the year and rice bran is used during the time after rice harvesting. Cassava is a replacement feed in systems, when other feedstuffs are in shortage or not available.

All of investigated households in demand driven bought feed for pigs during the time of feed shortage. Lower percentage of households bought feed in transition system and almost no households bought feed in resource driven system. The total amount of feedstuffs used for pigs per year in Ban Bo was highest with partly purchased but yielded highest extraction from pig production (630kg weight of pigs/year), followed by Ban Buon with lower weight extraction (340kg/hh/year); a medium amount of total feed was used in Na Huong and with the medium weight extraction (220kg/hh/year) and the lowest amount of feed was used in Ban Keo with very low weight extraction (98kg/year). Feed shortage occurred mainly from March to July (before harvest) and shortage of vegetables occurred in winter. Feed was abundant after harvest (September to November). In the time of feed shortage, farmers in demand driven bought more

feed, in transition system, some farmers bought more feed and the others replaced high quality feed by poor quality feed; but in resource driven, farmers replaced better feed quality by poor feed quality.

Empty and pregnant sows were shown to be fed over their nutrient requirements and especially in the time of feed abundance in demand driven system. In transition system, empty and pregnant sows were received nutrient values according to requirement. Empty and pregnant sows in resource driven system were fed sufficient amounts of protein and energy per day in the time of feed abundance but insufficient in the time of feed shortage.

Lactating sows were fed crude protein according to their requirements in the time of feed abundance, but lightly lower protein requirement in time of feed shortage in demand driven production system. In transition and resources driven systems, lactating sows were fed below their protein requirements in time of feed abundance and feed shortage, with a more severe shortage of protein in the time of feed shortage. Regarding to energy, lactating sows in demand driven system were fed according to their requirement in both seasons. Lactating sows transition and resources driven systems were fed sufficient ME in time of feed abundance but insufficient in time of feed shortage.

All fattening pigs of different genotypes and in investigated villages are fed below their protein requirements in both seasons. Fattening pigs in Ban Bo were fed sufficient energy in both season but fattening pigs in other villages were fed too low energy than their requirement.

Ban Bo and Ban Buon expensed higher total costs as well as feeding cost/year. Farmers in Na Huong expensed lower total costs and feeding costs. Total costs and feeding costs in Ban Keo was very low. Despite the high expenses, investigated farmers in Ban Bo received the highest benefit from pig production per year, followed by farmers in Ban Buon, farmers in Na Huong received lower benefit, while Ban Keo achieved very low benefit in one year. Feeding efficiency in Ban Bo, Ban Buon and Na Huong was better because of high investment in feeding but caused lower input-output ratio as compared to Ban Keo.

8 Reference

Akinfala, E. O. and Tewe, O. O. (2001). Utilisation of whole cassava plant in the diets of growing pigs in the tropics. Livestock research for rural development 13 (5). Retrieved September 8, 2003, from

http://www.cipav.org.co/lrrd/lrrd13/5/akin135.htm

Anh, N. Q. and Dzung, H. S. (1994). Meo pig - Nghe an. In: On the results of the livestock genetic conservation in Vietnam. Agricultural Publishing House, Hanoi, Vietnam. pp. 38-41. Vietnamese.

Astrom, H. (2000). The Mong Cai pig: digestibility studies of fibrous feeds, and a survey of smallholder production systems in two agro-ecological zones of Vietnam. Minor Field Studies International Office, Swedish University of Agricultural Sciences No. 97, 24 pp.; 25.

Binh, D. V., Suc, N. Q. and Ly, L. V. (1996). Research and development of the goat in Vietnam. Pryor, W. J (Ed.). In: Exploring approaches to research in the animal sciences in Vietnam. A work shop held in the city of Hue, Vietnam. 31 July - 3 August, 1995. ACIAR Proceedings No. 68. Australia, Canberra. pp. 60-62.

Binh, N. T. (1996). Economic efficiency of duck-raising in the Mekong River Delta. Pryor, W. J. In: Exploring approaches to research in the animal sciences in Vietnam. A workshop held in city of Hue, Vietnam. 31 July - 3 August, 1995. ACIAR Proceedings No. 68. Australia, Canberra. pp.138-141.

Chinh, B. V., Oanh, B. T., Ha, N. N., Viet, T. Q., Khang, D. T., Tinh, N. T., Binh, L. H., Tao, N. H., Giang, V. D., Tien, H. V., Huyen, D. V., Nghi, N., Su, N. V. and Binh, L. T. (2001). Composition and nutritive value of animal feeds in Vietnam. Agricultural Publishing House, Hanoi, Vietnam. Vietnamese.

Church, D. C. (1991). High energy feedstuffs and Supplementary protein sources. Livestock feeds and feeding. Prentice-Hall International, Inc.- United State of America. pp. 101-163.

Cole, D. J. A., Haresign, W. and Garnsworthy, P. C. (1993). Recent developments in pig nutrition 2. Nottingham University Press. London.

Cunha, T. J. (1977). Swine feeding and nutrition. Academic press. New York.

Danh, L. T., Hoang, C. C., Cuong, N. K., Nghia, P. T., Phat, N. V. and Perkins J.(1996). Management and performance of village cattle and buffalo: a case study from Phuoc Thanh village, Saigon River Delta. Pryor W.J (Ed.). In: Exploring approaches to research in the animal sciences in Vietnam. 31 July - 3 August, 1995. ACIAR Proceedings No. 68, Australia. Canberra. pp. 90-93.

Devendra, C. (2002). Crop-animal systems in Asia: Implications for research. Agricultural System. 71: 169-177.

Devendra, C. and Fuller M.F. 1979. Nutrition: principles and application. In: S. E. Maule (Ed.). Pig production in the tropics. Oxford University Press. pp. 72-95.

Devendra, C. and D. Thomas. (2002a). Smallholder farming systems in Asia. Agricultural System. 71:17-25.

Devendra, C. and D. Thomas. (2002b). Smallholder farming systems in Asia. Agricultural System. 71:17-25.

Devendra, C., Thomas D., Jabbar, M. A. and Kudo, H. (1997a). Improvement of livestock production in crop- animal systems in rainfed agroecological zones of South-east Asia. International Livestock Research Institute ILRI, Nairobi, Kenya.

Devendra, C., Thomas, D., Jabbar, M. A. and Kudo, H. (1997b). Vietnam. In: C. Devendra, D. Thomas, M. A. Jabbar, and H. Kudo (Eds.) Improvement of livestock production in Crop-Animal systems in rainfed agro-ecological zones of South-east Asia. pp. 91-95. ILRI International Livestock Research Institute, Nairobi, Kenya.

Devendra, C., Thomas, D., Jabbar, M. A., and Kudo. H. (1997c). Characterization of farming systems and review of research. In: Devendra, C. Thomas, D. Jabbar, M. A. and Kudo, H. (Eds.) In:

Improvement of livestock production in Crop-Animal systems in rainfed agro-ecological zones of South-east Asia. pp. 15-54. ILRI. International Livestock Research Institute, Nairobi, Kenya.

Dixon, J., Gulliver, A. and Gibbon, D. (2001). Farming systems and poverty improving farmers' livelihoods in a changing world. FAO and World bank, Rome and Washington D.C.

Doanh, P. H. and *et al.* (1985). Some productive characteristics of the local pig breeds. In: The selected works of researches in animal production from 1969 – 1984 - National Institute of Animal Husbandry. Agricultural Publishing House, Hanoi, Vietnam. pp. 10-18. Vietnamese.

Doanh, P. H. (1994). The conservation of good genetic resources of Mong Cai pigs in Quang Ninh province. In: On the results of the livestock genetic conservation in Vietnam . pp. 33-36. Agricultural Publishing House, Hanoi.

Dong, D. D. and Hieu, L. T. (1996). Development of farming systems on high land based on livestock raising combined with credit programs. Pryor, W. J (Ed.). In: Exploring approaches to research in the animal sciences in Vietnam. A workshop held in city of Hue, Vietnam, 31 July - 3 August, 1995. ACIAR Proceeding. 68 Australia. Canberra. pp 203-206.

Dufhues, T. (2000). Discussion paper 09/2000: Economic appraisal of sugarcane production in peasant households in the Son La province, Northern Vietnam. Hohenheim University - Tropenzentrum, Germany.

Duong N.K. and Do, N. V. (2000). Reproductivity of crossbred F1 sow and productivity of crossbred wit 3/4 blood in Quang Tri province. In: The results of research on sciences and technologies of Agriculture-Forestry sectors. Agriculture Publishing House, Hanoi, Vietnam. pp 265-272. Vietnamese.

Duong, N. K. (1998). Preliminary determination of the growth and oestrus of Mong Cai pig. Report of the Agriculture, Forestry and fishery centre of College of Agriculture and Forestry, National Vietnam University, HoChi Minh city. Unpublished work. Vietnamese.

Duong, N. K., Ba, N. X. and Quan, H. M. (1996). Cattle production in Central Vietnam. Pryor, W. J (Ed.). In: Exploring approaches to research in the animal sciences in Vietnam. A workshop held in city of Hue, Vietnam., 31 July - 3 August, 1995. ACIAR Proceeding No.68. Australia. Canberra, pp 94-96.

Duong, N. K., N. X. Ba, N. T. Thanh, and H. N. Duyet. (2000). Some results of survey and research on the livestock production in Central region of Vietnam. The results of research on sciences and technologies of Agriculture-Forestry sectors. Agriculture Publishing House, Hanoi, Vietnam. pp. 259-264. Vietnamese.

Duyet, H. N. (2000). The ability of reproductive performance of Yorkshire sow have been kept in central Vietnam. In: The results of research on sciences and technologies of Agriculture-Forestry sectors. Agriculture Publishing House, Hanoi, Vietnam. pp. 227-231. Vietnamese

Duyet, H. N. and N. T. Loc. (2001). The effect of dietary protein level on the reproductive performance of Mong Cai sows. Livestock research for rural development 13 (4).

http://www.cipav.org.co/lrrd/lrrd13/4/duye134.htm

Duyet, H. N., Son, N. D., An, N. V. and Thuan, T. T. (2003). Effect of high dietary levels of sweet potato leaves on the reproductive performance of pure and crossbred Mong Cai sows. Livestock Research for Rural Development No. 15 (6). Retrieved September, 8, 2003 from:

http://www.cipav.org.co/lrrd/lrrd15/6/duye156.htm

Edwards, P. and Little, D. C. (1996). Integrated crop-fish-livestock improvements in South-East Asia. Philippines, IRRI. Pp.71-79.

Ellis, M. and Augspurger, N. (2001). Feed intake in growing-finishing pigs. In: Lewis A.J. and Lee Southern L. (Eds.). Swine nutrition. CPR Press , Boca Raton - Florida. pp. 717-724.

Eusebio, J. A. (1980). Pig Production in the Tropics. Longman, Harlow, Essex, UK.

Falvey, L. (1981). Research on native pigs in Thailand. World Animal Review 38:16-22.

Hai, L. T. and Nguyen, N. H. (1997). Outlines of pig production in Vietnam. Pig News and Information 18:91-94.

Hai, L. T. and Pryor, W. J. (1996). Social features and the development of swine production in Vietnam. In: Exploring approaches to research in the animal sciences in Vietnam. A workshop held in the city of Hue, Vietnam, 31 July - 3 August, 1995. ACIAR Proceedings No. 68; pp. 186-189.

Hai, L. T., Vien, N. T., Hang, T. T., Thao, N. H. and Giai, D. V. (1996). Study results on three-way crossing for high lean meat percentage. In: National seminar on animal sciences and development to year 2000. Agricultural Publishing house – Hanoi, Vietnam, pp. 147-150. Vietnamese.

Hai, N. M. (2002). Changing comparative advantage of rice production under transformation and trade liberalisation – A policy analysis matrix study of Vietnam' s rice sectorDoctor thesis. Department of development theory and policy in the tropics and subtropics - University of Hohenheim, Germany.

Hang, D. T. (2000). Study of use ensiled cassava leaves in pig ratio. In: The results of researches on Technology - Science in Agriculture - Forestry sector - Hue University of Agriculture – Forestry in 1999. Agricultural Publishing House. pp. 279-286. Vietnamese.

Hot, N. T., Thang, N. V. and Nong, D. T. (1999). The use of F1 crossbred (Large white x Mong Cai) sows in farmer households production in the Red River Delta. In: The results of science - technology researches in animal husbandry and veterinary department (1996 - 1998) - Hanoi Agriculture University. 1999. pp.14-18. Vietnamese.

http://www.FAO.org/ag

Huan, D. D., Binh, V. T., Anh, D.T. and Le Coq, J. F. (2002). Maize commodity chain in Northern area of Vietnam. In: Workshop: 2010 trends of animal production in Vietnam. October 24 to 25, 2002, Hanoi, Vietnam.

Huynh, D. and Diem, T. X. (1980). Determination of feeding requirement (feeding unit) for Mong Cai and I sows. Vietnam - Research results of animal husbandry from 1969 to 1979 - National Institute of Animal husbandry. Agricultural Publishing House- Hanoi, Vietnam. pp. 223-230. Vitnamese.

Huynh, D., P. D. Kinh, T. X. Diem, and H. T. Tuat. (1985). Determination of feeding standard for F1 - fattening crossbred between exotic breeds and local breeds. Research results of animal husbandry from 1969 to 1984 - National Institute of Animal husbandry, Vietnam. Agricultural publishing House, Hanoi. pp. 231-237. Vietnamese.

Jones, R. (2002). Priorities for pig research in Southeast Asia and the Pacific to 2010. In: Priorities for pig research in southeast and the Pacific to 2010. ACIAR working paper - March 2002. Centre for international agricultural research, Canberra, Australia. pp. 5-11.

Kaufmann, B. and Valle Zárate A. (2002). Efficiency of smallholder animal husbandry depending on intensity of management and genetic potential of livestock in mountainous regions of Northern Vietnam. Report of sub-project D2 submit to SFB 564, and to DFG. Institute for Animal Production in the Tropic and Subtropics. University of Hohenheim, Stuttgart, Germany.

Kinh, L. V., Hai, L. T., Quang, D.V, and Duc, N. V. (2002). Pig production in Vietnam. In: Priorities for pig research in southeast and the Pacific to 2010. ACIAR working paper No. 53 - March 2002. Centre for international agricultural research – Canberra – Australia, pp. 65-71.

Lai, N. V. (1998). On-farm comparison of Mong Cai and Large White pigs fed ensiled cassava root, rice bran and duck weed. Livestock research for rural development 10 (3). Retrieved September, 8, 2003 from: http://www.cipav.org.co/lrrd/lrrd10/3/lai103.htm

Lan, L. T. K. (2000). Epidemiology and economics of classical swine fever at smallholder level in Vietnam. Master thesis. The University of Reading, Department of Agriculture, Veterinary Epidemiology and Economics Research Unit.

Le, P. N. and Tuyen, T. Q. (1998). Building the models of rearing Landrace and Yorshire breeding sows at smallholder farms with the herd size of 8 - 10 sows. In: Scientific papers on animal production

from 1996 – 1997 – National Institute of Animal Husbandry. Agriculture Publishing House, Hanoi, Vietnam. pp. 23-26. Vietnamese.

Lehane, R. (2000). Vietnam' s pigs primed for peak performancePartners in Research for Development No. 13: 10-14.

Lemke, U., Thuy, L. T., Valle Zárate, A., B. Kaufmann, and E. Forster. (2000). Characterisation of a model for conservation of autochthonous pig breeds on smallholder farms in North Vietnam. Report of sub-project D2 submit to GTZ. Institute for Animal Production in the Tropic and Subtropics University of Hohenheim, Stuttgart, Germany.

Lemke, U., Thuy, L. T., Valle Zárate, A., Kaufmann, B., and Vang, N. D. (2002). Characterisation of smallholder pig production systems in mountainous areas of North Vietnam. in: Deutscher Tropentag 2002. October 9 to 11, 2002, Kassel-Witzenhausen, Germany.

Lewis, A. J. and Lee Southern, L. (2001). Swine nutrition. 2. ed. - Boca Raton: CRC Pr.,

Lich, L. B. (1996). Livestock production of Vietnam in the passing years and development orientation to year 2000. In: National seminar on the animal sciences and development to year 2000. Animal Husbandry Association, Hanoi, Vietnam. pp.13-30. Vietnamese.

Liem, D. T. (1996). Development of poultry production in Vietnam. Pryor, W. J (Ed.). In: Exploring approaches to researches in the animal sciences in Vietnam. A work shop held in the City of Hue. 31 July - 3 August, 1995. ACIAR Proceedings No.68, Australia, Canberra. pp.50-51.

Loc, N. T. (1996). Evaluation of protein supplementation of the traditional diets and cassava root silage for local crossbred pigs under village condition in Central Vietnam. Master thesis. Department of Animal nutrition and management - Swedish university of Agricultural sciences.

Loc, N. T. (1997). On-farm experiments in the use of local resources for pigs in Vietnam. In: Livestock feed resources within integrated farming systems. Second FAO Electronic Conference on Tropical Feeds. 9 September 1996. http://www.FAO.

Loc, N. T. (2000). Processing, preserving and using cassava leaf silage for pig. the results of research on sciences and technologies of Agriculture-Forestry sectors. Agriculture Publishing House, Hanoi, Vietnam. pp.316-322.

Loc, N. T., N. T. H. Ly, V. T. K. Thanh, and H. N. Duyet. (2000). Ensiling techniques and evaluation of cassava leaf silage for Mong Cai sows in Central Vietnam. In: Workshop: Making better use of local feed resources - Sarec-UAF, Hanoi, January, 2000.

Loc, N. T., Ngoan, L. D., Ly, N. T. H., Hang, D. T.,Thuan, T. T. and Phung L. D. (2003). Assessment of available pig feeds and adoption of recommended feeding practices by farmer households in central Vietnam. In: Preston T. R. and Ogle B. (Eds.). Proceedings of Final National Seminar-Workshop on Sustainable Livestock Production on Local Feed Resources HUAF-SAREC, Hue City, 25 - 28 March.

Loc, N. T., Ogle B., and Preston T.R. (1997). Protein supplementation of traditional diets for crossbred pigs under village conditions in Central Vietnam. Livestock Research for Rural Development Volume 9 No. 2:8-11.

Lukefahr, S. D. and Preston, T. R. (1999). Human development through livestock projects: alternative global approaches for the next millennium. World Animal Review No. 93: 24-35.

Ly, J., C. Ty, and P. Samkol. (2003). N balance studies in young Mong Cai and Large White pigs fed high fibre diets based on wheat bran. Livestock research for rural development Volume 15 (1). Retrieved September, 8, 2003 from: http://www.cipav.org.co/lrrd/lrrd15/1/ly151.htm

Ly, L. V., Giao, H. K., Sanh, M. V. Su, V. V. and L. M. Sat. (1999). Meo pig. The local domestic animal genetic resources and their conservation in Vietnam. Agricultural Publishing House - Hanoi. Vietnamese.

Ly, L. V. (1993). Note on the local animal genetic resources and their conservation in Vietnam. In: Animal genetic resources information. UNEP United Nations Environment Programme, Rom, Italian. pp. 23-27.

Ly, L. V. (1996). A review of animal science research in Vietnam. In: Pryor. W.J. Exploring Approaches to research in the animal Sciences in Vietnam. A work shop held in the city of Hue, Vietnam. 1995. ACIAR proceedings No. 68, Australia. pp.15-20.

Ly, L. V. (2000). The development of a sustainable animal production system based on the advantage of tropical agriculture. 2000. A workshop - seminar " Making better use of local feed resources", Hanoi, Vietnam. 2000.

Ly, L. V. (2001). Improved utilization of by products for animal feeding in Vietnam. Proceeding - Workshop on improved utilization of by-products for animal feeding in Vietnam. Held in Hanoi, Vietnam. 28-3-2001.

Ly, L. V. and B. V. Chinh. (1996). Development of animal production in sustainable agricultural systems. Agricultural Publishing House, Hanoi. Vietnamese.

Ly, N. T. H., Loc, N. T., Hang, D.T., and Thuan, T.T. (2003). Effect of dietary protein level on the performance of growing pigs under village conditions in Central Vietnam. In: Preston T. R. and Ogle B. (Eds.). Proceedings of Final National Seminar-Workshop on Sustainable Livestock Production on Local Feed Resources. HUAF-SAREC, Hue City, 25 – 28 March, 2003.

Manh, L. H., Binh, T. C., Dung, N. N. X. and Hang, B. P. T. (2000). Composition and nutritive value of rice distiller's by-product (hem) for small-holder pig production. A work-shop seminar "Making better use of local feed resources" Sarec-UAF, Hanoi, January, 2000.

National Statistical Yearbook. (2001). Agricultural Publishing House, Hanoi, Vietnam. Vietnamese

Nga, L. Q., Magnusson U., and B. Ogle. (2000). Evaluation of the reproductive performance of an indigenous pig breed in Vietnam (Mong Cai) and a cross-breed fed on local and conventional feeds. Workshop-seminar "Making better use of local feed resources" SAREC-UAF, Hanoi, January , 2000.

Nghi, N., Huynh, D., Mai, N. T., Huu, H. T., Goi, B. T. and Loi, P. V. (1985). Determination of feeding ratio for pigs. In: Research results of animal husbandry from 1969 to 1984 - National Institute of Animal husbandry. Agricultural Publishing House, Hanoi, Vietnam. pp. 150-158. Vietnamese.

Nghi, N., N. T. Mai, N. T. Huu, and B. T. Goi. (1980). The influence of different protein levels reproductive performance of local sows. In: Science researches in animal husbandry in Vietnam from 1969-1979 – National Institute of Animal Husbandry. Agricultural Publishing House, Hanoi, Vietnam. pp. 257-265. Vietnamese.

Ngoan L.D., Duong L.K, Loc N.T., and Hang D.T. (1996). Local feed resources in smallholder pig development in Central Vietnam. In: Pryor. W.J. Exploring Approaches to research in the animal Sciences in Vietnam. A work shop held in the city of Hue, Vietnam. 31 July - 3 August, 1995. ACIAR Proceedings No. 68; pp. 82-85.

Nha, N. T., Long, N. D. and Khoi, P. V. (1996). Study on livestock economics, processing and marketing in Vietnam. In: Strengthening of veterinary services in Vietnam – SVSV project. ALA/96/20.

Nind, L. and Tu, T. D. (1998). Traditional systems of duck farming and duck egg incubation in South Vietnam. World's Poultry Science Journal 54:375-384.

Ogle, B. and Phuc, B. H. N. (1997). Sustainable intensive livestock-based systems in Vietnam. IRD Currents No. 13-14, pp.16-22.

Paris, T. R. (2002). Crop-animal systems in Asia: Socio-economic benefits and impacts on rural livelihoods. Agriculture System 71: 147-168.

Payne, W. J. A. and Wilson, R. T. (1999). Pigs. In: An introduction to animal husbandry in the tropics. 5. ed. Oxford: Blackwell Science. pp. 576-615.

Pehu, J. (1999). Upland agriculture: Vietnam. Helsinki, Finland. Unpublished Work.

Perkins, J. (2002). What should I do? research for people, not pigs. In: Priorities for pig research in Southeast Asia and the Pacific to 2010. Centre for International Agricultural Research –ACIAR working paper No. 53 - March 2002, Australia, Canberra. pp.14-21.

Peters, D. (1998). Improving small-scale pig production in northern Viet Nam. World Animal Review No. 91: 2-12.

Pérez, R. (1997). Feeding pig in the tropics. FAO animal production and health paper/Food and Agriculture Organization; 132. Rome: Food and Agriculture Organization of the United Nation.

Phuc, B. N. H., Ogle, R. B., Lindberg, J. E. and Preston, T. R. (1997). The nutritive value of sun-dried and ensiled cassava leaves for growing pigs. Preston, T. R., Ly, L. V., Hieu, L. T.(Eds.). In: National Seminar –workshop "Sustainable livestock production on local feed resources" September 10-14, 1996. Agricultural Publishing House - Hochiminh city, Vietnam. pp. 95-102.

Pond, W. G., Church, D. C. and Pond, K. R. (1995). Basic animal nutrition and feeding. John Wiley and Sons. New York.

Quac, N. K., Vuong, N. V. and Tham, P. D. (2000). The suitability of three-crossbreds of Mong Cai, Yorkshire, Landrace in different agro-ecology regions in Thai Nguyen province. In: The results of science research and technology transferring in 2000 - Thai Nguyen Forest - Agriculture University. pp.189-194. Vietnamese.

Quan, H. M. (2000). Initial assessment on feed resource and feeding methods in cattle raising of household in Quang Binh province. In: The results of researches on Agriculture and Forestry sectors from 1998-1999. Agricultural publishing House, Hanoi, Vietnam. pp. 353-359. Vietnamese.

Quang, P. Q. (1997). The investigation on nutritional value of pig diets in smallholder in Nam Thanh village - Hai Hung province. Animal husbandry - Animal husbandry Association of Vietnam 5(15): 20-21.

Rake, C., Mayer, G., Tien, L. V., Long, N. Q., Quang, V. D., Tuc, N. V. and An, D. C. (1993). Markets of important products, non timber forest products and agricultural products in the provinces Hoa Binh, Son La and Lai Chau in the North West of Vietnam. Vietnamese - German Technical Cooperation Social Forestry Development Project (SFDP) Song Da Ministry of Forestry (MoF) – GTZ Forestry Inventory & Planning Institute (FIPI) - GFA.

Reh, I. (1993). Situation analysis of the current state of livestock development in developing countries. Richter, J., Peters, K. J., and Franzen, H. Feldafing. Deutsche Stiftung für Entwicklung DSE, Zentralstelle für Ernährung und Landwirtschaft ZEL. Germany. pp. 35-74

Robinson, J. W. (1996). Development of industrial feed and animal husbandry in Vietnam. National seminar on the animal sciences and development to year 2000. A workshop held in Hanoi, Vietnam. 1996. Animal Husbandry - Animal Husbandry Association, Hanoi, Vietnam. pp. 71-75. Vietnamese.

Rodríguez, J. L. and Preston, T. R. (1997). Local feed resources and indigenous breeds: fundamental issues in integrated farming systems. Livestock research for rural development 9: 20-26.

Rodríguez, J. L., Preston, T. R., Dolberg, F., Dolberg, F. and Petersen, P. H. (1997). Participatory rural development: Experiences in Binh Dien and Xuan Loc villages in Central Vietnam. Integrated Farming in Human Development, Denmark, 25-29, March, 1996. pp. 161-196;

Sanh, M. V., Thac, N. D. Nhi, D. L. and Petheram R. J. (1996). Buffaloes rearing in a Northern Mountainous Village, Vietnam. In: Exploring approaches to research in the animal sciences in Vietnam. A workshop held in city of Hue, Vietnam. 31 July - 3 August, 1995. ACIAR Proceeding No. 68, pp.163-166.

Serres, H. (1992). Manual of pig production in the tropics. C.A.B International.

Singh, D. N., Mc Phee, C. P. and Kopinski, J. S. (1996). Helping to improve pig production in Vietnam. Exploring approaches to research in the animal sciences in Vietnam. A workshop held in the city of Hue. 31 July - 3 August, 1995pp. 176-181.

Son La province Statistical Yearbook. (2001). Son La Publishing House. Vietnam. Vietnamese.

Steinfeld, H. and Mack. S. (1997). Livestock development strategies. World Animal Review 88:18-24.

Taveros, A. A. and More, S. J. (2002). A field trial of the effect of improved piglet management on smallholder sow productivity in the Philippines. Preventive Veterinary Medicine 53:235-247.

Thanh, V. T. K., Loc, N. T. Phuong, D. T. and Luu, P. T. (2000). Evaluation of ensilaged groundnut leaves for fattening pigs. 2002. A work-shop seminar "Making better use of local feed resources" Sarec-UAF - Hanoi, Vietnam, January- 2000.

Thien, N. (2002). The results of research and development of pig crossbreds with high performance and high quality in Vietnam. In: National Institute of Animal Husbandry –Over 50 years established and development. Agricultural Publishing House. Vietnamese.

Thong, T. T. (1996a). Present livestock development trend of the World application-opportunities for developing traditional and industrial livestock production in Vietnam. In: National seminar on the animal sciences and development to year 2000. A workshop held in Hanoi. November 26-28, 1996. pp. 35-50. Vietnamese.

Thong, T. T. (1996b). Animal husbandry advances which contributed to major livestock development in Vietnam. Pryor, W. J (Ed.). Exploring approaches to research in the animal sciences in Vietnam. A work shop held in the city of Hue, Vietnam. 31 July - 3 August, 1995. ACIAR Proceedings No. 68. Australia, Canberra. pp. 21-24.

Thong, T. T., Hai, L. T. and Quac, V. A. (1996) Research work on pig production in the Mekong Delta. Pryor, W. J. Exploring approaches to research in the animal sciences in Vietnam. A work shop held in the city of Hue, Vietnam. 31 July - 3 August, 1995. ACIAR Proceedings No. 68, Australia, Canberra. pp. 52-56.

Thong, T. T., Hien, N. X., Cuong, L. X and Thien, N. T. (1991). The goat production and research in Vietnam. In: J. M. Panandam, S. Sivaraj, T. K. Mukherjee, and P. Horst (Eds.). Goat husbandry and breeding in the tropics. Papers from an international seminar carried out by DSE. Deutsche Stiftung für Internationale Entwicklung DSE, Feldafing, Deutschland. pp. 336-341.

Thuan, N. T., Kai, S. and Yutaka, T. (2000). An overview on pig production and pork market in the Red River Delta in Vietnam. Journal of the Faculty of Agriculture, Kyushu University 45:325-334.

Thuong, N. V. (1996). Some results of study of beef and dairy cattle in Vietnam. In: Pryor, W. J (Ed.). Exploring approaches to research in the animal sciences in Vietnam. A work shop held in the city of Hue, Vietnam. 31 July - 3 August, 1995. ACIAR Proceedings No. 68. Australia, Canberra. pp. 46-49.

Thuong, N. V., Sumilin I.S., Nghi, N. Chinh, B. Huyen, D. V., Tuan, D. T. Thuy, D. T, Oanh, B. T. N. N. Ha, N. D. Giang, and T. Q. Viet. (1992). Composition and nutritive value of animal feeds in Vietnam. Agricultural Publishing House - Hanoi, Vietnam. pp 230-235.Vietnamese.

Thuong, N. V. and Vang. N. D. (1996). Achievements in animal science and technology to be applied in animal production in Vietnam from 1996 to 2000. MARD & VUSTA – National Seminar on Animal Sciences and Development to year 2000 A workshop held in Hanoi. November 26-28, 1996 - Animal Husbandry Association of Vietnam. Vietnamese.

Thuy, L. T., Lemke, U., Hau, N. V., Kaufmann, B., Vang, N. D., Ly, L. V., Giao, H. K. and Valle Zárate, A. (2002). Efficiency of smallholder husbandry in mountainous region of North Vietnam. Proceeding of the planning workshop for the 2nd phase, 2003-2006 Halong-Vietnam 29/7 - 1/8/2002. The Upland program - Research for sustainable land use and rural development in mountainous regions of Southeast Asia. pp. 27-29.

Thuy, N. T. (2001). Epidemiology and economics of Foot-and-Mouth Disease at smallholder level in Vietnam. Master thesis. University of Reading, Department of Agriculture, Veterinary Epidemiology and Economics Research Unit.

Tjallden, U. (1999). Indigenous breeds of domestic animals in northern Vietnam. Minor Field Studies International Office, Swedish University of Agricultural Sciences No. 89:26.

Tran, N. D., Xuan, T. C. and Hoa, N. T. N. (1985). The determination of the maize ratio in the compound feed for reproductive sows. Research results of animal husbandry from 1969 to 1979- National Institute of Animal Husbandry. Agricultural Publishing House, Hanoi, Vietnam. pp. 247-256.

Trottier, N. L. and Johnston, L. J. (2001). Feeding gilts during development and sows during gestation and lactation. In: Lewis A.J. and Lee Southern L. (Eds.) Swine nutrition. pp. 725-769. CPR Press, Boca Raton - Florida.

Truc, V. K. 2001. Pig production development in the year of renovation. Animal Husbandry, Hanoi Vietnam No. 7 (35):21-24. Vietnamese.

Tung, D. X. (1999). Roles of livestock on smallholder farming systems in northern provinces of Vietnam. Master thesis. Agricultural University of Norway; Centre for International Environment and Development Studies Noragric.

Tuyen, D. K., Lich, L. B. and Trivedi, K. R. (1998). Livestock production situation in Vietnam and development orientation. International workshop on animal recording for smallholders in developing countries India, 20-23 October, 1997. ICAR-Technical-Series. No. 1, 111-127:20-23.

Valle Zárate, A., Kaufmann, B. Lemke, U. Thuy, L. T. Ly, L. V. Giao, H. K. Vang, N. D. Hau, N. V. Tang, L. V., Chau, T. T. and Long, D. T. (2003). Efficiency of smallholder animal husbandry depending on intensity of management and genetic potential of livestock in mountainous regions of Northern Vietnam. Report submitted to Department of Agriculture and Rural Development Son La province. Institute for Animal Production in the Tropic and Subtropics. Hohenheim, Germany.

Van, P. T., Tra, H. T. H., Ngoc, L. T. K. and Dung, T. H. (2001). Crossbreds among Landrace, Yorkshire and Duroc under different management methods. In: Science papers on animal production - National Institute of Animal Husbandry from 1999-2000. pp. 56-63.

Vang, N. D. and Ly. L. V. (2000). A review on poultry production in Vietnam. Retrieved September 8, 2003, from http://www.vcn.vnn.vn/sp_pape/spec_00_9_1.htm

Vang, N. D. and N. T. Son. Chicken sector in Vietnam. 2000. Retrieved September 8, 2003, from

http://www.vcn.vnn.vn/sp_pape/spec_00_10_20_7.htm#_Toc496275026

Vercoe, J., Coffey, S. Farrel, D. J. Rutherford A., and Winter, W. H. (1997). An assessment of priorities for Asian livestock research and development. ILRI in Asia: Nairobi, Kenya.

Viet, T. Q. and N. T. Len. (2003). Determination of metabolizable energy and crude protein requirement for Mong Cai gilts, pregnancy and lactation sow. Scientific papers on animal production 2002 – 2003-National Institute of Animal husbandry. Agricultural Publishing House, Hanoi, Vietnam. In press. Vietnamese.

Viet, T. X., Giang, V. D. Binh, D. V. Chinh, D. V Son, V. N. Hung, N. V. Thuy, N. V. and Thuy, N. T. (1996). Performance of Landrace and Yorkshire fattening pig in smallholder households in Ha Tay province. Animal husbandry Association. National seminar on animal sciences and development to year 2000. 141-146. 1996. Hanoi, Vietnam, Vietnam

Vuu, N. V. (1996). Development strategy of animal production in rural areas. A National seminar on Animal sciences and development to year 2000. A workshop held in Hanoi. Animal husbandry association, Hanoi, Vietnam. pp.128-131

Waters, B. A. and Bayer, W. (1992). The role of livestock in the rural economy. Nomadic Peoples No. 31:3-18.

Xuan, V. T., L. T. Hai, and C. B. Loc. (1995). Research priorities for improving animal production by agro-ecological zone in Vietnam. Global Agenda for Livestock Research Proc. Consult. South-East Asia Region, 10 - 13 May 1995, IRRI, Philippines. pp.197-213.

9 Annex 1

Figure 12: Ban sow with her piglets (Thai farm in Song Ma) (Tra, 2003)

Figure 13: Mong Cai sow (Kinh farm in Son La) (Lemke, 2002)

Figure 14: Keeping pigs in Ban Keo – Song Ma. (Tra, 2003)

Figure 15: Poor hygienic conditions in Ban Keo – Song Ma. (Tra, 2003).

Annex 2: **Questionnaire for individual household interview**

I. Introduction of interviewer

II. Identification

Name of interviewed	Date
Name of head of household:	
Age of interviewed:	Ethnic group:
HH ID.:	Village:

II. Socio-economic situation of farmers

1. Labour force

How many people belong to your family including:

	Old persons (> 65)	Adult (16- 65)	Children (<16 years old)
No.			

2. External labour force

Do you hire labour? Yes ≤ No ≤

Season/month of hiring work?

Total days need to hire labour in 2002?

Payment of wage/person/day

Type of works need to hire labour?

Do you be hired by other farms? Yes ≤ No ≤

If yes, how many hours do you work per day?

How much time do you work in 2002?

How much do you get per day?

Which season/month in year do you often be hired?

Do your family have exchange labour with other families? Yes ≤ No ≤

If yes, how long do you need to exchange labour in 2002?

Which season do you need to exchange work with them?

Which kind of work do you need to exchange labour?

Farmers' opinion on labour iss ues:

Lack of family labour ≤ Hire labour is so expensive ≤

Not enough work to do ≤ No problems ≤

Other opinions:

3. Off-farm activities

Does you family have off-farm activities? Yes ≤ No ≤

If yes, which kinds of off-farm activities do your family have?

How many persons in your family attend off-farm activities?

How much time does each person work per day?

How much income does each person get from those activities in year 2002?

When did you do it in year? Outside crop seasons ≤ in crop season ≤ in all year round ≤

4. Land issue

How much total arable land (ha) do you have?

Upland area: Flat area:……..

House and garden land: Rented land:…… Others ….

Have you got enough land for crop production? Yes ≤ No ≤

5. Forest

How much forestry's land have you got? of which:

Since when have you got the natural and planned forestry?

Do you get pig feed from forestry? Yes ≤ No ≤

If yes, detail about feed resources, amount, in which time these feeds have in year, etc.

Name of feeds	Times get per month	Amount get per time	Time shortage	Replacement feeds
Wild taro				
Rau Duong				
Others				

6. Crop production

Total income from crop production in year 2002?

6.1 Kinds of plants,

	Area (ha)	Total yield 1st crop	Total yield 2nd crop	Harvesting times
Upland rice				
Paddy rice				
Maize				
Soybean				
Other beans				
Cassava				
Longan				
Apricot				
Plum				
Mango				
Tea				
Coffee				
Sugar cane				
Sweet potato vines				
Cabbage				
Water cress				
Water plan				

How much rice does you family use per year? How much does your family need to buy per year?

By-products from milling rice used by your family? (10 kg rice): Rice ban: …Broken rice: ….

6.2 Planting and harvesting time

	1st planting time	2nd planting	1st harvesting	2nd harvesting
Upland rice				
Paddy rice				
Maize				
Soybean/other beans				
Cassava				
Sugar cane				
Watercress				
Sweet potato vines				
Water plan				

6.3 Crops' and by -products' utilisation

Crops	Family consumption	Price/kg	Amount used for pigs	Used for other animals
Upland rice				
Paddy rice				
Rice bran				
Maize				
Soybean				
Black beans				
Green bean				
Fresh cassava				
Dry cassava				
Watercress				
Sweet potato vines				
Longan				
Apricot				
Plum				
Mango				
Tea				
Coffee				
Sugarcane				

6.4 Residues and by-products from crops used for livestock

	Amount used	Animal species	For how long?	Sold amount	Price/ton
Green maize stalk					
Rice straw					
Sugar cane top					
Other					

7. Livestock production

Total income in 2002 from livestock production?

7.1 Which animal species do you keep at the moment?

	Genotype	Male (No.)	Age	Female (No.)	Age
Buffalo					
Cattle					
Dairy cattle					
Horse					
Goat					
Dairy goat					
Rabbit					
Guinea pig					
Duck					
Muscovy duck					
Chicken					
Fish	Area:	Kilogram:			
Cat					
Dog					

7.2 Feed resources for ruminants: Name, amount used

Feedstuffs	Amount used/day	Purchased amount/day	Time shortage	Replacement feed

7.3 Feed resources for poultry

Feedstuffs	Total amount/year	Total purchased/year	Price/kg	Time of feed shortage
Maize				
Rice				
Broken rice				
Rice bran				
Fresh cassava				
Dry cassava				
Compound feed				
Concentrate feed				

7.4 Buying livestock in 2002 (except pigs)

Species & types	No	Breed	When bought			Month	Whom
			Age		Price		

7.5 Selling livestock in 2002 (except pigs)

Species & types	No	Breed	When sold			Where	Month
			Age		Price		

II. Pig production

1. Pig population

Type	No	Breed	Age	Notes
Sow				
Boar				
Gilt				
Fattening				
Piglets				
Post-weaning piglets				

2. Reproduction state of sow

	Sow 1	Sow 2	Sow 3	Sow 4
Genotype				
Age				
Total litters (up to now)				
Litter No. (present)				
Genotype of boar (present)				
Present farrowing time				
No. of new born piglets				
No. piglets died				
No. piglets killed				
No. of piglets at the moment				
No. weaned piglets				
Post-weaned oestrus time				
Last farrowing time				
No. of litters/year				

3. Buying of pigs in 2002

Type	No	Breed	When bought			Where*	Month
			Age	kg	Price		
Post-weaning							
Fattening							
Gilt							
Boar							

4. Selling pigs in 2002

Type	No	Breed	When sold			Where*	Month
			Age	kg			
Post-weaning							
Fattening							
Gilt							
Boar							

*1. Dealers 2. Neighbour 3. Market 4. Relatives 5. Extension services

How is the situation of selling the products: Easy ≤ Difficult ≤

Which product is difficult to sell? Why is selling products difficult/easy?

In which time of the year, this product is difficult to sell? ho decide the price of your products?

Do you slaughter pig for your family consumption? Yes ≤ No ≤

If yes, which type, weight and price, etc.

Type	No	Breed	Age	Weight	Price	Month

For what purposes do you need to slaughter?

Do you gif pig?

How many pigs do you give per year and how heavy are they?

5. Pig management in general

At which age do you wean piglets? When did you wean your piglets later or sooner than normal time?

Why did you wean them late or soon?

In which condition of piglets can you wean them sooner than normal time?

Which feeds do you give in the time you need to wean them sooner than normal?

What were the results of growing rate and their health?

Which age do you often sell post-weaning piglets?

Which criteria do you use to choose or buy breeding pig?

Which criteria do you use to choose fattening pigs?

Do you buy pig depend on their age? Yes ≤ No ≤

Do you buy pig depend on their weight? Yes ≤ No ≤

If yes, which weight/age of them do you want to buy?

Why do you want to buy at that weight/age?

When do you start mating for your gilt? In which age and in which weight of gilt?

How can you recognise the sow is in oestrus?

Which kind of mating do you used for your sow? Natural mating ≤ AI ≤

Which boars do you use for your sows:

- Your neighbour' boar ≤ - Your own boar: Offspring of sow ≤
- From other sows ≤ - Exotic boar ≤ Detail breeds used
- Crossbred boar ≤

How much money do you need to pay for one time mating?

How many times mating do you need for your sows to get pregnant?

If use your own boars from offspring of sow, why do you use that?

Do you know about inbreeding and its effecting to your pig production?

6. Stable and hygiene situation

Do you use straw or other materials for pigpen in winter and farrowing time: Yes ≤ No ≤

If yes, how often do you use it?

How often do you clean the stable (per month

Do you collect the manure from the stable? Yes ≤ No ≤

How do you use pigs' manure?
Do you sell pigs' manure? Yes≤ No ≤
If selling, how much manure do you sell per year? Price of manure per m^3/ton?
7. Diseases of pigs in 2002
Did your pigs got sick in 2002? Yes ≤ No ≤ if yes

Name/symptoms of disease	Time happen	No.	Type of pigs	Recover/ /Died/Sold	Medicine used	Total expense

When your pigs get sick: + Treated by veterinarian ≤ + Treated by yourself ≤
Did you also use traditional medicine? Yes ≤ No ≤
If yes, for which diseases?
Which kinds of traditional medicines do you use?
In which months/seasons do diseases happen more often?
Which kinds of diseases did happen often in 2002?
Which type of pigs do often get sick?
Do you use vaccines: Yes ≤ No ≤
If yes, for which type of pig?
Which kind of vaccines do you use?
How much do you pay for vaccination per pig/year?
VI. Pig feeding
1. What do you feed your pigs and how much used per day and for each kind of pigs?

Type of feeds	Amount used/day	Types of pig used	For how long does it used in year?	Replacemental feeds and amount
Rice bran				
Broken rice				
Rice				
Maize				
Fresh cassava				
Dry cassava				
Fish				
Sweet potato vines				
Soybean				
Water plant				
Wild taro				
Rau Duong				
Banana stem				
Water cress				
Cabbage				
Distiller's grain				
Concentrate feed				

2. How many (%) cooked feed weight do you give for?

	Stable 1	Stable 2	Stable 3	Stable 4
Sow				
Post-weaning				
Fattening pig				
Boar				
Gilt				

3. Feeding resources used in 2002

Type of feeds	Produced amount/year	Purchased amount/year	Price/kg	Frequency of purchase	Buying in season/time
Rice bran					
Broken rice					
Rice					
Maize					
Fresh cassava					
Dry cassava					
Soybean					
Fish					
Sweet potato vines					
Water plant					
Concentrate feed					
Salt					
Vitamins					

4. Buying price in different times in one year

Type of feeds	Highest price	Time	Lowest price	Time
Rice bran				
Broken rice				
Rice				
Maize				
Fresh cassava				
Dry cassava				
Fish				
Soybean				
Concentrate feeds				
Salt				
Sweet potato vines				
Water plant				
Cabbage				

Are feed resources for pig often lacking in your family? Yes ≤ No ≤

What are you doing when feed resources lacked?

Give less feed ≤ Find more vegetables ≤

Buy more feed ≤ Others ≤ detail

Which season/time do you lack of feeds for pigs?

What do you do at that time?

5. Feeding management

Do you mix different components of grains before using/cooking? Yes ≤ No ≤

If yes, how much each component do you mix with others?

Do you learn how to mix pig feed? Yes ≤ No ≤

If yes, from where/who?

Is there any different amount and components do you give among different kinds of pigs?

Yes ≤ No ≤ if yes

What do you do when the time pigs give birth

How do you give feed/look after different kinds of pigs in your family?

Early Pregnant sow	1 week before farrowing	After farrowing	Sow after weaning
Post-weaning	Fattening	Boar	Gilt

How many times per day do you feed to pigs?
At which time of day? Morning ≤ lunch ≤
Evening ≤ other times ≤
When do you give more times than normal (2 or 3 times)? How do you practise for pigs?
Where do you give feed to pig (trough, floor, etc.)
If use trough, do you clean it before give feed? Yes ≤ No ≤
If yes, how often do you clean it per week?
How do you make feed for pig (describe detail)?
Have remained feed after eating? Yes ≤ No ≤
When it happens?
In which stable?
How often it happen per month/year?
If remain feed more often due to: Give too much feed ≤ Low quality feed ≤
Pig sick ≤
Do you have any problem with pig feed (e.g. lack of feed, lack of money to buy feed, lack of processing techniques, lack of knowledge, etc.)? Yes ≤ No ≤
If yes, which problems do you face?
Where do you learn about feeding management (feed practices) for pig?
Have you ever learn feed practices from your neighbours?
Yes ≤ No ≤
How did you learn?
Do you want to attend training courses in feed practices and processing of by-products? Yes ≤ No ≤
Why do you want to attend? Why do not you want to attend?
Do you want to improve quality of feed for your pigs? Yes ≤ No ≤
If no, why don't you want to improve?
If yes, why you want to improve feed?
Will you improve feeding?
Using new techniques to processing, etc. ≤
increasing feed quality and quantity e.g. buying more feeds and good feed ≤
use more labours to collect more feed ≤
6. Water for pigs
Do you give: Extra-water for pig ≤ During clean stable ≤
No water ≤ Water in feed only ≤
If give extra water, how many times do you give water to pigs per day?
How much water do you give per time?
Do you give enough water to pigs? Yes ≤ No ≤ Why do you think that?
Do you think water is importance to your pig? Yes ≤ No ≤ Why do you think so?
Where do you get the water for family consumption and animals' drinking?
Where do you get water if you have not enough water?
V. Purpose of keeping pig breeds and plans in pig feeding in future
Why do you keep Ban/MC/others sow breeds?
Do you have any plan in pig feeding in next few years? Yes ≤ No ≤
If yes, which plan do you want to implement? How will you do?
Do you want to invest pig production by feeding? Yes ≤ No ≤
If yes, how will you invest e.g. buy more and good feed, apply new feeding processing, etc.?
Which kinds of pig do you want to invest? Which breeds do you want to invest?

Annex 3: Measurement of fattening pig weight

1. Name of family interviewed……
2. District /town……
3. Name of commune……
4. Name of village……..
5. Tribe……
6. Name of interviewer……
7. Date of measuring……
8. Household number……

Name of farmer	Weight of pigs	Age	Situation of pigs	Note
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				

*Notes:

.....

.....

Annex 4: Measurement of feed compositions

1. Name of family interviewed……
2. District (town)…… …..
3. Name of commune……..
4. Name of village……
5. Tribe……..
6. Name of interviewer……
7. Date of interview……
8. Householder number……

I. Measure feed components before cooking

Name of feeds	Weight	Status of feed	Note
Maize			
Rice brain			
Rice broken			
Rice			
Fresh cassava			
Dry cassava			
Soybean			
Other bean			
Fish			
Sweet potato vines			
Wild taro			
Duong			
Water plan			
Banana stem			
Other vegetables			
Concentrate feed			
Notes			

* Notes:

……

……

II. Measurement of quantity of cooked feed for very kind of pig

Sow	Piglet	Fattening pig	Boar	Gilt

*Notes:

……

……

Declaration

I do here by declare that this thesis is my own work. The sources used are indicated. In addition, I have not used any aid. This thesis has never been in part or whole submitted to other examining boards to get any academic degree.

Stuttgart, September 15th, 2003

Hoang Thi Huong Tra