R2036-3(S)

Root and tuber crops for livestock feeding in Vietnam.

3. Background notes.

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TABLE OF CONTENTS. **PAGE**

ABBREVIATIONS

AHRI	Animal Husbandry Research Institute, Hanoi.
AI	Artificial Insemination.
CIAT	Centre for Tropical Agriculture, Colombia
CIS	Commonealth Independent States.
CGPRT	Centre for Research and Development of Course Grains, Pulses, Roots and Tuber Crops in Humid Tropics of Asia and Pacific, Bogor, Indonesia.
DM	Dry matter.
FAO	Food and Agriculture Organisation of United Nations, Rome.
FAO/UNDP	Food and Agriculture Organisation / United Nations Development Programme, Regional Office, Bangkok.
F1	First cross generation.
HCM	Ho Chi Minh City.
HI	Harvesting Index.
HL	Hung Loc Centre, Dong Nai Province.
IAS	National Institute of Agricultural Sciences, Hanoi.
INSA	National Institute for Agricultural Sciences (South),
HCM	Ho ChiMinh City.
LR	Landrace Breed (pig).
LW	Large White Breed (pig).
LWT	Liveweight.
MC	Mon Cai Breed (pig).
RH	Relative humidity.
SAREC	Swedish Agency for Research Cooperation with Developing Countries.
TIA	Trypsin Inhibitor Activity
UA #2	University of Agriculture, Hue.
UA #3	University of Agriculture, Bac Thai.
UAF #4	University of Agriculture and Forestry, Ho Chi Minh City.

1. SUMMARY.

1. These notes were prepared in relation to a visit to Vietnam to identify the opportunities for improved resource utilisation within crop-livestock systems based on tuber crops.

2. The country can be divided into 8 recognised agro-ecological zones which feature different cropping patterns and resource availability. Agricultural production involves over 85% of the population (65% of the workforce) and is based within 9.4 million farmer households. These are organised at the village, commune and district level within each of the 56 provincial administrations.

3. The rice crop accounts for 57% of the total agricultural production; cassava and sweet potato account for 7.1% and 6.0 % of overall food production. Sweet potato is grown as a rotation crop with rice or on poorer soils; cassava is grown on more marginal drier soils. Cassava and sweet potato are primarily cash crops with more than 40% of their overall production being marketed fresh; both serve as subsistence and risk aversion food crops over both the dry or wet season.

4. The largest areas of cassava cultivation are found in Nghe An province in the North, and Dong Nai, Binh Dinh and Tay Ninh provinces in the South. Planting and harvesting times vary between provinces; yields of local varieties average 8-9T per ha over a ten month growing cycle. Manure and fertiliser applications are low, reflecting the low financial return on the crop. Local cultivars contain 1% true protein and less than 30% starch but have a low free cyanide content (<110 mg per kg wet tissue). Old cultivars have been superseded by improved or shorter period varieties in specific regions; higher yielding bitter varieties are under test at research institutions and their satellite farms.

5. Sweet potato cultivation is concentrated on the sandy soils of the northern and central coastal provinces. Planting times reflect its major use as a break crop between rice cultivations, although it is may also be grown in rotation with vegetables and groundnut. Yields average 6T per ha although crops on alluvial soil may return 14 T per ha; inputs of manure and fertiliser are low. New varieties for both foliage and tuber production are on trial at the research institutions.

6. Cassava use varies regionally, reflecting the differences in economic circumstances between agro-ecological zones and provinces. 15% of the overall crop is retained for household consumption, although this proportion may exceed 60% in poor areas during periods of crop failure.

58% of the overall crop is sold fresh, largely for industrial starch or alcohol production, the former operations being more prevalent in southern provinces. The balance of crop, amounting to 40% when byproducts and cassava leaves are taken into account, is fed to livestock.

7. Sweet potato tuber use varies regionally. Overall 40% of the crop is used as human food, although this may rise to 80% in some of the southern provinces. There are no processing operations and the balance of the stored tuber crop is used as pig feed. Important use is made of the foliage, either as fresh vegetable or as a protein and vitamin source for livestock.

8. Livestock are fully integrated with crop production. Cattle and buffalo are retained within households for draft purposes; pigs and chickens are the largest source of meat production. The cattle herd distribution is skewed, with 48% of the native cattle being produced in the central coastal regions. The national herd shows some improvement as the result of schemes for using crossed animals for milk and meat production. Draft animals are slaughtered for meat after 7 to 10 years work or may be exported to neighbouring countries.

9. Pig meat represents 73% of the total meat production and are more evenly distributed within households. Artificial insemination is in widespread use in order to introduce exotic blood onto the local breed of sows. Sow productivity is low despite a high rate of fertility; mortality is high in young stock due to poor nutrition and facilities. Growth rates are low, averaging 350 g per day; this appears to result from the poor growth potential of the local stock and the lack of appropriate feeds.

10. Poultry and egg production are largely small holder exercises although the production of duck in the South is semi-commercialised. Egg consumption averages 0.6 kg per capita per month in comparison to meat, which averages 0.8 kg per capita per month. Layer productivity can be increased through the release of new local breeds to farmers although this may be constrained by lack of feed.

11. Root and tuber crops (whole crop or byproduct residue) are used regionally as feeds in all classes of livestock. Livestock production systems are relatively inefficient, resulting in poor utilisation of the tuber crop resource. Productivity will be limited by lack of feed protein; there is little use of leguminous forage crops. Sources of available protein for monogastrics include fish meal, rice bran, and groundnut cake; the quality of these products is variable and they will need improving.

12. A number of opportunities exist for the increased utilisation of tuber crops in livestock feeding. The research Institutions have experience of the use of root and tuber crops in conventional animal feeds which can be integrated into a programme of farm based research developing small holder feeding systems. Programmes should operate within the crop to feed, feed to livestock and livestock to crop cycle.

13. The main areas for farmer participatory research are:

a) The use of the whole or partially processed tubers as supplements in small holder dairy enterprises.

b) The establishment of cattle fattening systems using supplements derived from cassava processing waste and other feed byproducts.

c) The contribution of livestock (manure and cash value) to yield and sustainability of improved crop cultivars on poorer soils - nutrient cycling.

d) Improvements in the production of dried tuber products for animal feeding; the production of dried composite meals using fresh and stored cassava.

e) The cost effective use of available protein supplements to low nutrient density cassava based ratios for crossbred LW x MC growing pigs, breeding sows and in young pigs.

f) The interaction of livestock on low nutrient density rations to varying level of anti-nutritonal factors in dried sweet potato and cassava based products.

14. Farmer extension services operate at the province and district level, and provide assistance to farmers in association with commune and village appointed agricultural officers. These would provide the local support to farmers participating in programmes of adaptive research.

15. Technical support and project staff can be provided through the Agricultural Universities, National Institutions and Provincial Technical Departments. It is important that these bodies and the programmes in (12) be co-ordinated under the National Tuber and Root Crops Programme in order to transfer the widest range of options to farmers.

2. INTRODUCTION.

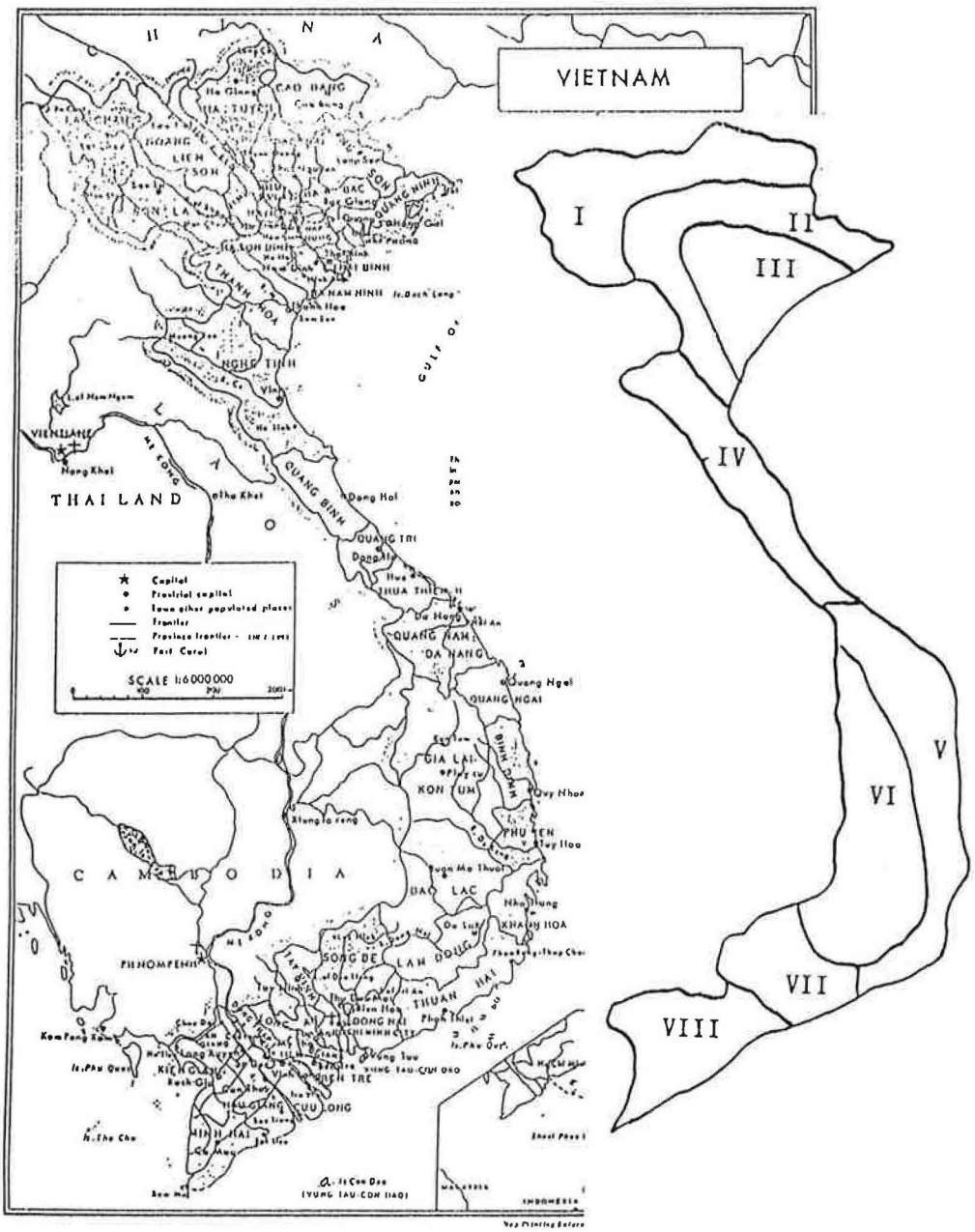
16. Vietnam stretches over 1600 km along the eastern coast of Indochina between latitudes 8.5° and 23.5° North. Three-quarters of the country's overall area of 331,000 km^2 is made up of mountains and hills. The Truong Son mountain range makes up much of the 2700 km westerly border with Laos and Cambodia. The sloping land to the largely east-facing 3,200 km long coastline is interrupted by the lateral extensions of the range, dividing the coastal plane into separate regions.

17. The climate is predominantly tropical, although the sub-tropical regions of the North can experience cool winters with daily average temperatures of <10°C. Annual rainfall over different regions ranges from 1600 to 3300 mm; monthly average rainfall varies with region but is highest (from 3.4 to 587 mm) on the northern, central and southern coastal plains. These areas are largely reliant for rain on the summer monsoon from September to November. Serious flooding and crop damage often occurs in these regions where a high proportion of the annual rainfall is also accompanied by typhoons.

18. The combination of topography and climate results in the division of the country into eight recognised agro-ecological zones shown in Figure 1. These are based on the two highly fertile rice growing deltas, two central coastal low elevation regions, two mid-elevation and two high elevation mountainous regions. The Northern Red River Delta region (zone I area 15,000 km^2) is an area of bunded fields and controlled irrigation works. The main crops are rice, maize, soya and vegetables and the region is the main source of produce for the major population centres of Greater Hanoi and Hai Phong. The Mekong River Delta in the South (zone VIII area 60,000 km^2) is more naturally drained; the main crop is rice, with small plantings of sugar-cane, maize, sweet potato, wheat and vegetables. The main market is Ho Chi Minh City.

19. The coastal central zones (IV and V) have fishing industries and produce rice, livestock, sugar-cane, cassava, sweet potato, cashew and coconut. Agricultural production in mountainous zones (III and VI) tends to be restricted to cassava, livestock, vegetables and specialist crops such as tea, fruit and flowers. Mid elevation zones (II and VII) tend to have fairly poor soils and limited rainfall; a wide variety of crops are grown in this region including rubber, cassava, forestry and mulberry. The mountainous and central coastal regions are relatively less developed.

Figure 1. Map indicating the location of the different agro-ecological zones of Vietnam.



Zones

I	North Highlands	II	North Midlands
III	Red River Delta	IV	North Central Coast
V	South Central Coast	VI	South Highlands
VII	South Midlands	VIII	Mekong River Delta

20. The current human population is 67 million and is expected to grow over the next ten years by 2% per annum. Twenty per cent of the population live in urban areas with over 50% of these living in Ho Chi Minh City (HCM) City and Hanoi. There are a further 10 cities which contain more than 100,000 people. Ethnic Vietnamese, who account for 87% of the population, live mainly in the Delta regions and coastal planes (lowlands). These regions comprise 30% of the land area in the South and <15% of the North, introducing a wide variation in population density. Minority groups (53 clans) are found in the mountain regions and within small enclaves in the coastal areas and deltas. The historical influences of conquest and trade, which introduced varied mechanisms of food production between the zones, have been moderated by re-unification and state control.

21. Agriculture currently employs 65% of the national workforce, giving about 22 million agricultural workers (men and women). This figure does not include the work done by children, whose labour is used extensively within households. The large state farms, which were a major feature of agricultural production from the 1970s to early 1980's, have been disbanded; 5% of these remain as specialist units or regional experimental stations. Agricultural production is now concentrated within 9.4 million farmer households; these are grouped at the commune, district and province level. Most households in the North remain within autonomous commune structures, although these represent an evolving and more liberal adaptation within the role of the district, commune and village committees. Communes were less widely adopted in the South, with the result that there are significantly more individual businesses and entrepreneurs, particularly in the region of HCM city.

22. Vietnam has been undergoing a change to a more market driven economy since the late 1980's, although the extent of this change is different within each of the 56 provinces that represent primary local government. This is partially a reflection of the potential of economic growth to act as a vehicle for change, which undoubtedly influences the ability of individuals to adapt to new approaches. There remain considerable social and economic differences between the North and South. This is reflected in average incomes between the provinces of the economically depressed North and those in the South (Appendix 4.). This holds for both 'workers and officials incomes' and farmer incomes; average worker income is 57% higher in the South although the differential in farmer income is lower at 9%. Data for expenditure (from the National Statistics Office) is consistently higher than income; this can be explained by the general inaccuracy of Government data, unofficial

earnings or the extent of remuneration from relatives overseas. Purchasing power will remain relatively higher in the South; this may promote a shift to more intensive meat production systems in the broiler and beef sectors. These factors will add to an already heterogeneous picture regarding the potential for improvements in root crop and livestock production.

23. Two studies have been completed recently on the production and utilisation of root crops in Vietnam under control of the National Tuber and Root Crop Programme (NTRCP). Aspects of sweet potato production and marketing were reported in 1991 through the Regional Centre for Research and Development of Course Grains, Pulses, Roots and Tuber Crops in Bogor, Indonesia (CGPRT Report No. 24). Cassava production and utilisation was discussed in a Centre for Tropical Agriculture, Columbia (CIAT) workshop held in Hanoi in 1992. A review of the livestock sector in relation to animal feeding was completed under FAO/UNDP funding in 1993. The three studies, which were not linked, share a common theme in suggesting the need for improvements in the efficiencies of production of root and tuber crops and of their utilisation in animal feeds. No recommendations were made on what would be the most appropriate course of action to achieve this.

24. The Ministry of Agriculture and Food Industry (MAFI) endorses the proposal that better use should be made of the root crop resource within current householder livestock production systems. They would be fully supportive of an appropriate programme in relation to the increased or more efficient production of root crops and their use in animal feeding. MAFI would hope that NRI would take a lead in the inception and operation of co-ordinated programmes within the NTRCP. This was also emphasised at meetings with Provincial Agricultural Development Authorities.

3. GENERAL AGRICULTURAL PRODUCTION.

25. In 1991 Government Statistics indicated that the gross production of agriculture amounted to 2,500 million US dollars (in actual prices). This represented 36% of the country's total output value, 47% of the total National Income and 40% of the export income. Food and agricultural crops made up 76% of the gross value of agriculture exports in 1990; cassava and sweet potato are not export crops. The 24% balance of agricultural exports came from livestock and livestock products.

26. There are currently 9.2 million ha of land (out of the total 33 million ha) in cultivation. Food production currently accounts for 88% of the annual crop area, approximately 7.4 million ha - (Table 1. from Appendix 1.). This is dominated by rice cultivation with an area of 6.30 million ha and an annual production of 19.4 million metric tonnes (MT). Vietnam became a net exporter of rice in 1989 and has increased this year on year to the export of 1.9 million MT in 1992. This has been achieved by an enlargement of the planting area, the increased use of irrigation, and the introduction of higher-yielding and shorter-season varieties. The 1.1% annual increase in rice yield is likely to be maintained over the next five years. Rice straw and rice bran would appear to be in excess of the current economic demand for animal feeds.

27. The attention shown to the increase in rice productivity has not been matched in other crops; the root crop sector in particular has suffered neglect. In 1991 the residual 1.1 million ha of land devoted to food crops produced 14.1 million MT of cassava, sweet potatoes and maize, and 3.5 million MT of vegetables. Production of cassava and sweet potato was 7.2 and 6.3 million MT, respectively; the crop yield has declined steadily over the 1980 production level of 10.0 and 7.3 million MT for each crop. Production over the last two years has stabilised, with increased planting of cassava on more marginal land and sweet potato being retained as a rotation crop with rice. A limited quantity of other root crops, such as canna and taro, are grown specifically for local regional consumption or noodle manufacture. The majority of vegetable and fruit production is within general householder cultivation systems; specialist vegetable producers tend to supply the larger urban markets.

Table 1. Sown area, crop yield and production of main food and industrial crops, Vietnam. 1980 -1991.

		Year			Average yearly increase (%)
		1980	1989	1991	1988 - 1991
Food crops.					
Paddy	Area 000ha	5600.2	5895.8	6295.0	3.5
	Yield T/ha	2.1	3.2	3.1	-3.1
	Production 000T	11647.4	18996.3	19427.6	1.1
Maize	Area 000ha	389.6	509.4	432.9	-7.5
	Yield T/ha	1.1	1.6	1.5	-3.1
	Production 000T	428.8	837.9	651.6	-11.1
Cassava	Area 000ha	442.9	284.6	267.2	-3.1
	Yield T/ha	7.5	9.1	8.9	1.1
	Production 000T	3323.0	2585.4	2389.9	-3.8
Sweet Potato	Area 000ha	450.0	327.3	348.8	3.3
	Yield T/ha	5.4	5.8	6.0	1.7
	Production 000T	2417.6	1909.2	2104.5	5.1
Vegetables	Area 000ha	189.8	252.0	279.3	5.4
	Yield T/ha	11.4	12.4	12.2	-0.8
	Production 000T	2164.8	3135.4	3416.8	4.5
Industrial Crops					
Sugar cane	Area 000ha	125.2	131.2	141.1	3.7
	Yield T/ha	39.6	40.7	42.1	1.7
	Production 000T	4964.6	5344.6	5939.8	5.6
Groundnut	Area 000ha	224.5	208.6	196.2	- 3.0
	Yield T/ha	0.79	0.81	0.85	2.5
	Production 000T	211.1	205.8	211.7	1.4
Soya bean	Area 000ha	106.5	100.2	115.4	7.6
	Yield T/ha	0.81	0.81	0.85	2.5
	Production 000T	84.7	82.0	97.5	9.5

Source: **Statistical Data of The Socialist Republic of Vietnam Statistical Publishing House, 1992**

28. Production of other crops, particularly maize and soya-beans has shown a marginal increase over the last 5 years. Current production of maize is 650,000 MT; the majority of this is consumed as fresh corn. Current production of soya-beans (115,000 MT) has risen by 8.4% over the 1986 production figure; this product is primarily used for human food. Sugar cane production (5.9 million MT) has increased by 6.2% over the 1986 total although planting area has apparently fallen by 13%. Sugar is processed by both artisanal and industrial processors; molasses, in wholesale and retail quantities, is available in most provinces. Groundnut production has risen by 15% over the 1986 figure

and is currently 211,000 MT; 76% of the crop is exported as premium hand-sorted grade nuts whilst second grade materials are processed artisanally for oil. All non-rice crops, including cassava and sweet potato, have shown a reduction in planting area over that recorded in 1986-1988. This corresponds to the increase in area for the cultivation of rice.

29. The national livestock population consists of 12.1 million pigs, 3.2 million cattle, 2.9 million buffalo, 0.4 million goats and sheep, and 108 million poultry (Table 2.). Livestock make an important contribution to householder cash incomes; according to government statistics they generate about 50% of cash funds in the South and 25% in the North. The bulk of cattle and buffalo are held in small (average <3 head) numbers within householder farms, although there is some larger scale ownership varying widely between provinces (see Appendix 3.). Pigs are more evenly distributed, and with the exception of some large units in the South, are retained by the majority of households. Livestock are fully integrated within agricultural systems; cattle and buffalo provide the bulk of draught power on householder farms and their manure is important in the maintenance of soil fertility and structure.

Table 2. Sumary of livestock population data for Vietnam - 1991.

Regions (agro-ecological zones)		Pigs '000	Cattle '000	Buffalo '000	Poultry '000
North Mountains	(I)	2,019.6	326.5	1,042.2	13,936.2
North Midlands	(II)	1,009.3	205.0	262.1	9,075.9
Red River Delta	(III)	2,816.0	283.0	354.4	23,979.5
Central Coast (N)	(IV)	2,079.8	655.0	583.7	14,687.8
Central Coast (S)	(V)	1,378.5	865.1	155.6	8,775.0
Central Highlands	(VI)	602.5	375.8	63.6	2,388.4
East of Southland	(VII)	501.2	209.8	138.6	7,947.8
Mekong River Delta	(VIII)	1,729.5	229.6	254.6	27,194.5
Whole country		12,140.4	3,151.0	2,885.6	108,152.4

Source: Statistical Data of the Socialist Republic of Vietnam. Statistical Publishing House

30. Livestock productivity has been marginally improved over the last twenty years; breed improvement programmes have not been widely introduced in farming systems owing to poor management, low potential recognition, poor feeding systems and very low genetic selection pressures. An

efficient pig artificial insemination (AI) programme exists in the North and Central areas and has been been useful for producing exotic F1 crosses with local breeds of sow. Disease is a major factor in some livestock production systems; epizootic outbreaks have increased, particularly in stock in highland regions. FAO/UNDP (1993) indicate that vaccination rates are as low as 30% as a result of poor organisation and lack of resources.

31. Feed concentrates for the livestock sector are derived largely from rice by-products; these are available in sufficient quantity to meet demand within existing animal production systems (FAO/UNDP, 1993). The Government has plans to increase the intensity of production in the pig and poultry sectors, but this will be restricted by the availability of feed concentrates, and in particular the lack of dry season protein. It may be equally appropriate to increase livestock productivity within existing householder production systems by improving the efficiency of use of the existing feed resource base. FAO/UNDP (1993) report that little attempt has been made to exploit forage production, although this probably reflect the difficulty that farmers have in assimilating its value in the overall benefit of increased livestock production.

32. Crops and byproducts, such as legumes, fish-meal, oil-seed cakes and sugar byproducts offer a high potential for supplementing existing small-holder livestock feeds. Considerable work has been carried out in the agricultural research institutions utilising feed byproducts in trials but little, if any, of the work has been applied within current farming systems. Increased production efficiency and an improvement in the quality of byproduct and primary animal feed crops, notably fish-meal, is needed for these products to be economically useful to farmers. In the meantime, feeding systems have to be developed that utilise lower quality protein products without compromise to the feed value of the energy component of the ration.

4. CASSAVA PRODUCTION AND UTILISATION

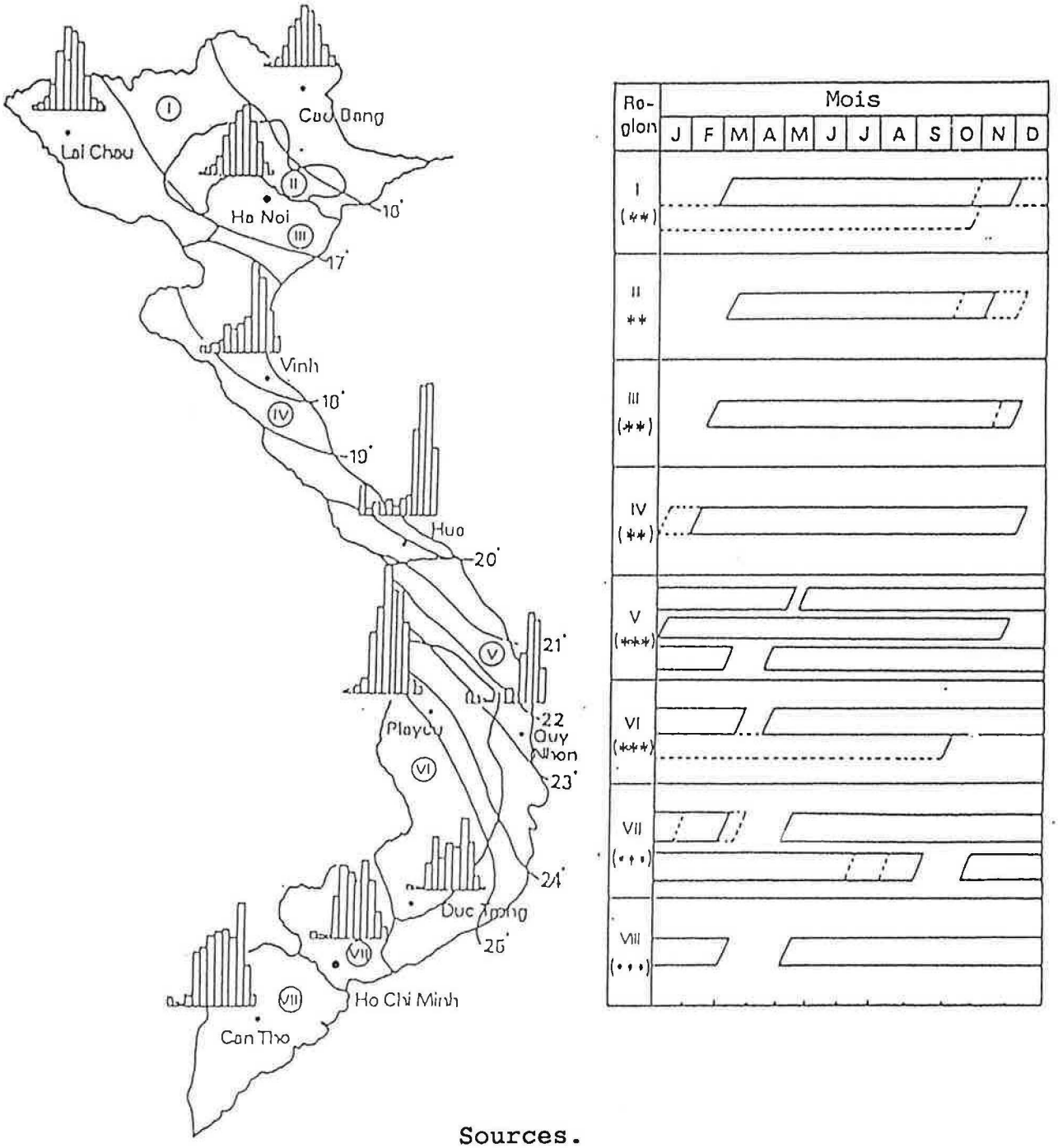
Cassava Production

33. Vietnam has an annual production of 2.5 million tonnes fresh cassava representing 1.6% of the global output (neighbouring Thailand produces 13.2% of the world crop). Cassava is grown on 260,000 ha of predominantly low quality or marginal land. Production is concentrated in five agro-ecological zones, in the Northern Mountains and Midlands (Figure 1 - zones I and II), Coastal Central North (zone IV), Coastal Central South (zone V) and the Eastern South (zone VII). These regions account for 72% of the planted area and 71% of the production tonnage (Appendix 2). The provinces of Nghe Tinh [now split into Nghe An and Ha Tinh] (zone IV), Binh Dinh (zone V), and Dong Nai (zone VII) contain the largest individual planted areas, with approximately 20,000 ha in each. A smaller area (10,000 ha) is planted in Tay Ninh province (zone VII). The average size of cassava farms in the Eastern South region is 0.85 ha, as compared to 0.42 ha in the North; the average farm area planted to cassava is 0.27 ha (Binh *et al.*, 1992).

34. Cassava is planted and harvested over different time intervals within the regions relating to climate or in the less changeable climatic zones, in response to the demand for raw material for starch processing (Figure 2.). In the North stakes are planted over the January-February period in order that the crop is well established prior to the increase in rainfall in April and May. The 10-month cultivars are lifted in November and December prior to the rice harvest. A large proportion of cassava in the North Mountains (zone I) is left in the ground for over a year, some undergoing a complete second growth cycle (with some intervening tuber removal) similar to the Chinese two-year production system.

35. Two planting times are followed in the Central Coast South (zone V), either January or May to June. This gives a harvested crop from October to December or March to May. Farmers in the Central Highlands (zone VI) plant from April to May and can harvest in March or through an extended growing cycle from September. Planting in the Eastern South Zone (zone VII) is in May or November giving a 10-12 month harvest from March or September. Farmers in Tay Ninh province prefer to plant after the end of the rainy season in November. However, province officials hope to introduce more rapid growing cultivars and irrigation in order to develop a three crop in two year cycle. The relatively small amount of cassava in region (zone VIII) is planted in May and harvested in the following March. Harvest times in much of the South appear to be co-ordinated, thus giving the artisanal or industrial starch processors access to the

Figure 2. Rainfall and cassava planting cycle in the agro-ecological zones of Vietnam.



Sources.

1. R.H. Howeler and Kim, H (1978).
2. Ho, T.V. et al, 1991.
3. Kim, H. et al., 1991.

fresh root for at least ten out of their twelve months operational cycle.

36. Cassava tends to be on grey podzolic soils in the south but on a wider range of poor soil types in the North and Highlands. Cassava is normally a rain-fed crop; podzolic and sandy alluvial soils have very poor moisture retention characteristics in periods of restricted rainfall but are not subject to water-logging in the monsoon. The yield of cultivars averages 9T per ha and ranges from 6.7T per ha (in Gia Lia - Kon Tum provinces (Central Highlands - zone VI) to over 20T per ha in Bac Thai (Northern Mountains (zone I). Very few provinces are harvesting over 10T per ha although many demonstration plots in Ha Bac, Hoa Binh, Vinh Phu (all zone II) and Dong Nai (zone VII) provinces consistently yield over 30T per ha (Thang, 1992). Low yields result from the use of old cultivars, low inputs in terms of fertiliser and labour, and low soil fertility, including serious problems associated with soil erosion. Cassava is very much less effective than grasses in the control of erosion by contour planting (Howeler, 1992).

37. Cassava producing soils have a low agricultural value, with rapid leaching of nitrogen and potassium and fixation of phosphorus. There is no firm evidence of yield reduction through soil exhaustion due to potassium extraction (unlike Thailand). This may become apparent with attempts to increase yield through the introduction of new cultivars without higher inputs of manure and fertiliser. Manure from livestock is used preferentially on rice or sold to other farmer householders for this purpose. Nitrogen and manure application rates are dependent on the farmers financial circumstances and crop area. Where fertiliser is used, application rates range from 40 to 200 kg NPK/ha (Henry *et al*, 1992); the highest rates on marginally better soils are equivalent to < 40 kg/N per ha and, thus, there is lower production of foliage. Some of the benefit of higher fertiliser application would be lost in low humus sandy soils.

38. Some manure is applied to the crop prior to planting (by hand-digging or animal-ploughing), but the majority appears to be applied to the plant base at intervals after planting. Overall application rates (according to farmer survey) average 4-5T per ha and are often accompanied by a small application of urea. Manure would provide nitrogen and trace elements, but the method of application and its amount may have little effect on long term soil fertility. The incorporation of a higher level of composted material (cattle manure and chopped rice straw) might improve soil fertility but would require more labour (draught power and time).

39. The rate and method of manure application for cassava trials on experimental stations is different; inputs range from 10 to 20T per ha and this is turned into the soil surface by tractor prior to ridge formation. This system is further augmented by the use of fertiliser and may explain why yields on these stations are consistently higher than on neighbouring farms. Workers at the University of Agriculture #2 (Bac Thai) are examining the performance of new cultivars in highland regions; they propose to address this inconsistency by examining the effects of manure application (rate and method) on-station and on-farms.

40. The harvest index (HI - the biomass ratio of tuber to foliage) of many of the local varieties is below 0.2; the improved local cultivars grown at Hung Loc Centre in Dong Nai province (zone VII) may achieve an HI of 0.50 (e.g. HL 20) although on-farm performance is significantly lower, i.e. a farm average HI of 0.29 for HL20 in Dong Nai province. Hung Loc (HL) Centre has a number of Thai and CIAT varieties under evaluation in a controlled field trial to select superior lines for general release. The most promising varieties are Kasetsart 50, Rayong 60, CM 6125-125 and MKUC 28-71-66 (Tran The Thong, 1992); these have HIs of between 0.62 and 0.55 at Hung Loc; on-farm performance is certain to be lower.

41. There are few high yielding cultivars in use outside the experimental stations; these are not evenly distributed and remain confined to specific regions. A selected variety such as Mi Trang (HL20) represents >90% of the cultivars grown in the Red River Delta, but only 28% of cassava grown in the North Central Coast (Ngoan *et al*, 1992). Newer varieties have had a more widespread introduction in the South. In the eastern south (VII) region e.g. Tay Ninh province, HL 20 represents 33.6% of grown cultivars alongside other improved cultivars (HL 24 - 30.9%, HL 23 - 8.2% and HL 34 - 6.8%).

42. All varieties in common use are 'sweet' varieties, which have been selected in the past for human food, and have low cyanide contents. Old local cultivars have free (not freed) cyanide contents of 2.2 to 54 mg per kg wet tissue; the improved HL varieties have slightly higher cyanide contents, i.e. HL 20 has a cyanide content of 106 mg per kg wet tissue. All cultivars have less than 0.5% nitrogen content on a wet weight basis (Thong *et al.*, 1992); over 50% of this is non-protein nitrogen and for practical purposes cassava can be considered as having a zero protein content. The new improved HL cultivars have a higher starch content, offering in excess of 25% on a wet weight basis. The dedication of an increased part of the resource to animal feed would suggest a change in part to the use of the high cyanogenic-glucoside containing 'bitter' varieties, e.g. Rayong 1. These have the double advantage of higher

crop yield and >30% starch content but require the introduction of a simple processing step to reduce the freed cyanide content. The short and longer term sustainability of yields in these varieties in relation to inputs of manure, fertiliser and trace minerals (and rotation) needs to be determined on the farm.

43. Cultivation practices are simple; ridging is extensively practised in the North where the disease stake rot is more prevalent. The total labour requirement for the crop varies considerably; Binh *et al.*, (1992) reported an average of 322 man days per ha in the North compared to 175 man days per ha in the South. These and other averages represent wide variation and whilst the data have yet to be corrected to farm (field) size, they relate to the more extensive use of draught power in the South. The majority of labour is provided by the family; between 17 and 25% of labour is hired, this relating to specific tasks of stake storage, land preparation and harvesting on the larger cassava farms. The crop should get up to six weedings over the growing cycle; in most provinces low yield appears related to the limited weeding practised when labour is required for the rice crop. Shortage of labour and competition from weeds tends to limit the use of intercropping; weed control by mulching or cover-cropping is not practised on farms.

44. Cassava has been intercropped on farms with better soils with soya-bean, canna, hot pepper and groundnut. On poorer soils projected data from the institutions indicate that crops like groundnut need heavy (>100kg NPK/ha) fertiliser application in order not to reduce significantly the yield of the cassava crop. This use of intercrops may account for the very wide differences in fertiliser application (0-36% of input costs) in different areas noted by Binh *et al.*, (1992). Green manuring, cover cropping or more importantly (in the context of animal feed) legume forage crops have been examined by a number of research institutions. The low uptake of these systems may be the result of poor technology transfer. However, it is more likely to be due to the additional requirement for labour, the increased costs of seed and fertiliser, and the relatively low on-farm performance of these systems reported to date (Howeler, 1992).

45. Cassava has been replaced on less marginal soils by groundnut, cashew nut or trees including rubber. Producers on poorer soils who have limited alternative crops have been reluctant to plant or harvest cassava because of the low returns on the fresh material. The current 1992 price varied between 1.5 and 3.0 cents per kg; industrial loads made as little as US$ 10 per tonne. The dried material returned between 4 and 6 cents per kg. The level of income generation from cassava is traditionally low, with the

result that resources, notably labour, tend to be invested in other crops first.

46. Farmers also argue that the lack of marketing systems acts unfairly against them, lowering price or increasing price variability from year to year. Binh *et al.* (1992) reported that the average profit from cassava per ha in 1991 was about $US200 per ha at 1992 prices; profit was extremely erratic in the North. The lack of a marketing strategy (or structure) was identified at a CIAT workshop (Henry *et al.*, 1992) as a major restraining influence on crop potential. Ways are being sought to improve market stability, which would include the increased diversion of the crop to animal feed and chemical feedstock. Farmers identified poor soil condition, lack of improved cultivars, and the lack of funds for fertiliser as their major constraints to increased production (Henry *et al.*, 1992). The alleviation of each and all of these constraints depends on an increase in the cash return for the crop; higher unit yields have to be accompanied by better crop utilisation.

Cassava Utilisation

47. Cassava is grown primarily as a cash crop, either for direct sale in local markets or to middlemen, although an average of 15% of the crop is retained within the household for human food. According to the CIAT 1992 benchmark survey (Henry *et al.*, 1992) household use is largest (26%) in the Central Coastal North region (zone IV). Data presented by Kim *et al.*, (1991) indicated annual per capita food consumption in this region averaged 220-230 kg rice, 60-70 kg sweet potato and 70-80 kg fresh cassava. Discussions with members of University of Hue and provincial officials indicate that in some districts of zones IV and V over 60% of the crop is used as human food; furthermore 40% of the population in these areas are dependent on cassava for some of their nutrient requirements. The dependency has a seasonal aspect, where the high cassava consumption co-incides with a below subsistence diet in 30% of households prior to the harvest of spring rice.

48. According to the CIAT 1992 benchmark survey (Henry *et al.*, 1992), approximately 40% of the crop is sold as the fresh root, although this varies between 29 and 66% over the different agro-ecological zones (Table 3). Fresh cassava has a limited shelf life; farmers quote a maximum of 5 days shelf life of the fresh root from harvest to consumption. Cassava is not stored as clamps; the effort of stack preparation and the indifferent performance of this system has not endeared the procedure to farmers. Curing *in situ* to extend retail fresh shelf life has not been adopted since fresh root sale is somewhat limited; in some areas, particularly the mountains, the crop is left for more than 12 months in the ground effectively introducing a fallow

cycle. In the central coastal regions (zones IV and V), dried cassava chips act as a major food security resource within the household. Some of the fresh product sale is purchased by non-cassava producing households for sun-drying as a human or animal food reserve.

Table 3. Cassava utilisation in farmer householder units in different agro-ecological zones in Vietnam, 1991.

Regions (zone)		Household consumption (%)	Direct fresh sale (%)	Processing (%)	Animal feed (%)
North Mountains	(I)	11.9	34.7	11.3	42.2
North Midlands	(II)	21.2	29.2	9.6	40.1
Red River Delta	(III)	18.0	45.3	15.4	21.3
North Central Coast	(IV)	26.4	32.2	13.1	28.3
South Central Coast	(V)	8.7	31.1	40.3	20.0
Central Highlands	(VI)	0.9	65.9	20.2	12.9
Mekong River Delta	(VIII)	-	-	-	-
Overall average		14.5	39.7	18.3	27.4

Source. CIAT Benchmark survey 1992

49. A major market for fresh cassava is direct sale to middlemen (field collection agents) who deliver the fresh root to artisanal starch extraction businesses (mainly in the South) or to industrial processors as the starting feedstock for maltose, glucose, starch and alcohol production (mainly in the North). The variation in planting and harvesting schedules within provinces enables middlemen to supply the processors with fresh material over an extended season. Field collection agents organise bulk collection, (contract harvesting occasionally) and delivery. These operations are targeted at the larger producers or at co-operatives where harvesting can be co-ordinated.

50. The main processed products at the house-holder level are wet and dry starch, dried chips, alcohol, and in the South the production of noodles (cassava starch mixed with rice flour or canna starch). Less than 20% of the overall crop is processed within households although there are significant regional differences. Artisanal starch processors are mainly found in the South, particularly regions V, VI, and VII. These are either farmers with cassava holdings, who have specialised in processing, or are smallholder business men who import raw material from

collection agents and have or supply livestock enterprises based on the starch processing byproducts. The type of operation can be distinguished by level of throughput; farmer processors operate at 100-500 kg per day over a four to six month season whilst businesses can be operating at 5-15T per day over a ten month season. Artisanal scale processors are most numerous in a number of areas surrounding HCM city, e.g. Thuc Duc, Tay Ninh and Thong Nhat. Starch processing has not been widely adopted in the North where the whole dried product predominates. A limited number of householders there operate alcohol and starch extraction processes from dried peeled cassava chips.

51. Starch is extracted from ground fresh cassava using water; a higher level of mechanisation tends to be found in house-holder businesses. Processors in the South receive roots from farmers or middlemen on a daily basis; this assists in limiting the storage of raw material. Roots are cleaned of surplus and hand peeled by the family or relatives; this is followed by a brief soaking in water although this period can be extended for up to 18 hours. The wet roots are ground using a mechanical rasper; additional carrier water is used to maximise starch release when grinding the more fibrous cassava from extended underground storage or from the two year cycle crop. In three of the five large-scale extraction plants visited, ground material was routinely held for 24 hours in polythene enclosed stacks prior to starch recovery. All processors claimed that tightly packed material was stable for 7 days; the light fermentation which it undergoes appears to have no effect on starch recovery and starch quality. In the North starch may be extracted from dried whole or peeled cassava chips or from ground fresh unpeeled cassava as part of a simpler starch feedstock process.

52. Starch is extracted by repeated cold water filtration and settlement. Mechanically assisted filtration has been widely adopted in high throughput units; besides increasing throughput it saves on water-usage and reduces pollution. Starch sedimentation is carried out in concrete lined flat tanks and is completed within 48 hours. There is a small (<5%) loss in quality through oxidation; this product is sold as second grade starch. Wet starch is largely sold onto middlemen (cash sale) or large industrial processors for noodle manufacture.

53. Approximately 30% of the extracted starch is sun-dryed; this is carried out on elevated trays which can be quickly moved to shelter in showers. Dried starch is sold for culinary purposes in markets or to middlemen for use as food additives, e.g. bread. Wet starch in the South is sold for the equivalent of 8.5 US cents per kg delivered; dried extracted starch is sold for 15-20 US cents per kg. Dried

starch is available at most markets in the North at 10-20 US cents per kg.

54. The wet residue after extraction can be fed to livestock or sun-dried for sale. Many of the larger starch processors in HCM city have semi-intensive dairy and/or livestock rearing facilities. Hereford Friesian cows are typically fed 3-4 kg cassava waste dry matter per day. However, most of the wet residue is fed to growing pigs at up to 50% of the total ration from 30 kg liveweight (lwt); purchased pig grower-ration and occasionally soya-bean meal is used as a balancer ration. HCM city, 250 kg loads of the wet cassava residue may be distributed by vespa tricycles (taxis) to pig enterprises sited as far as 50 km from the processor.

55. Smaller starch processors sun-dry excess residue in shaped pyramids or half-spheres; this allows for an intermediate rate of moisture loss but gives a 250g dried product unit that is easily transportable and marketable. A wet residue from starch extraction of the whole ground washed (unpeeled) root is available in the North; the residue contains up to 4 times the fibre content (17% of dry matter (DM) in the dried product) of the residue from peeled cassava extraction. The optimum use of both residues in dairy and smaller pig growing facilities needs further examination. A portion of this 'on-farm' programme would involve the transfer of experience and technology from South to North; 'self-help experience' can be identified in other aspects of root crop and livestock production.

56. Root peelings from the starch extraction process are also sun-dried as a dairy feed; in HCM city peelings are collected from the processor by intermediaries for sun-drying or (as I was told) direct feeding. There appears to be no problem relating to the cyanogenic glucoside content in the dried peelings. Dairy producers feed 1-2 kg dried peelings daily in combination with grasses and molasses blocks; there appears to be little data relating to efficiency of milk production. Dried peelings are not included in pig rations.

57. In addition to starch residue, 27% of the overall cassava crop is fed in the whole root form to livestock. The highest direct use is in regions I, II and IV, which corresponds to greatest producers of sun-dried chips. Farmers in the North sequentially harvest over a two-month period in order to provide material for sun-drying operations. Whole cassava is sun-dried as 5mm thick chips; these are normally prepared with a fixed blade slicer at 50-60 kg per hour. Sun-drying is carried out on the roadside, on concrete areas in front of the house or on woven mats. The high relative humidity (> 85% RH) experienced on drying days slows the drying process, taking 3-4 days to produce a

partially stable (20% moisture) product. This must be dried to < 14% moisture for sale in the market or storage for human or animal feed.

58. The chips are spread in a 50-60 mm layer during drying and the bottom layers always show signs of mould. The drying product is seldom turned over during the day since families are fully occupied in the preparation and planting of rice beds. Drying cassava is often re-wetted by rain because of the extended drying cycle, which encourages fungal rot, leading to complete spoilage. High quality chips are often ground and sold as cassava flour, for use as a food ingredient or for alcohol production. Lower quality chips for animal feed are stored in covered stacks or ground and stored, as cassava meal, in sacks. The ground-meal is dusty and the ungelatinised starch imparts a sticky texture to rations. These properties seriously reduce the palatability of rations and limits its rate of inclusion into dry or wet composite rations. Industrially prepared cassava meal is pelleted to reduce dustiness. Small-holder farmers occasionally cook the rehydrated meal (or chips) prior to feeding.

59. The increasing use of cassava to animal feed should encourage new approaches to drying and ration preparation. The claimed stability of tightly packed ground cassava root implies that all cultivars, particularly bitter varieties, could be held in this form for 24 hours or longer to allow for cyanide development in order to accelerate its rate of loss during rapid sun-drying. Mechanisms for increasing starch digestability (other than heat) in low cyanogenic glucoside cultivars could be introduced during this holding step. A preliminary evaluation of the positive effects of fungal amylase on ground cassava is to be initiated at the University of Agriculture and Forestry (UAF #4) in HCM city; Van Mien (1992 - personal communication) has suggested that mixing with sprouted rice may provide a low technology application of this method if the action of amylase proves to be of benefit.

60. The Animal Husbandry Research Institute (AHRI) are carrying out an initial laboratory study on the production of dried composite cassava meals from ground cassava and rice bran. This work was suggested by NRI experience in producing sun-dried hydrolysate rations, and has the objective of introducing an accelerated drying cycle using technology commonly used in the starch extraction process in the South. Molasses was added to some treatments with the intention of decreasing meal dustiness; this may also be useful in increasing solar absorption and lowering the water activity in the semi-dried product. Other treatments in this pathfinder exercise are examining similar treatments with the starch residue and the effect of adding molasses and rice bran within an ensiled cassava product. These

approaches somewhat commit the dried products to animal feed use, which may decrease short term food security, although this could be alleviated if the product were, as anticipated, to find a ready market. An on-farm evaluation of composite production is needed to quantify the factors affecting product quality and flexibility.

61. Dried cassava leaves are used extensively for animal feed providing a useful protein source for pigs and chickens. Over 1000 T of sun-dried cassava leaf meal are produced annually for sale in Dong Nai province (zone VII), finding its way to feed compounders and pig producers in HCM city. Some leaves are removed during growth but the majority are collected at the time of tuber harvest. Workers in Vietnam (e.g. Chinh *et al.*, 1992) have shown that the sun-dried product can be incorporated into poultry rations to provide 5% of protein intake; Nghi and Hai (1992) report that there may be problems of higher inclusion relating to loss in performance due to the presence of cyanogenic glucosides. They reported levels of >250 mg HCN per kg dry leaf, which seem high compared to values of 170 to 90 mg HCN for non-bitter cultivars reported by Ravindran *et al.*, (1987). Dried leaf meal is prepared from general cassava cultivars; it would be appropriate to examine the financial return on the use of cultivars that were grown more specifically for foliage production. Ravindran (1993) has identified similar research needs in relation to leaf meal quality.

62. Cassava acts as a high security crop because of rapid leaf replacement after typhoons. Under good growing conditions up to 50% of the leaves can be removed without undue loss in tuber yield (Preston, 1992 - personal communication). A small programme at the University of Hue funded by the Swedish Agency for Research Cooperation with Developing Countries (SAREC) is examining the effect of intermittent leaf harvest (up to 50% of the total leaf cover) during the growth cycle of cassava planted at different densities. It is perhaps unfortunate that the fertile soil of the trial grounds and the levels of manure (10T per ha) and other inputs (urea 200kg/ha; lime 400 kg/ha and P_2O_5 400 kg/ha) do not represent the conditions under which the majority of the crop is grown.

63. There may be doubt regarding the economic effectiveness of leaf removal from cassava grown on marginal soils, both in relation to short term effects and long term sustainability. It is somewhat antagonistic to the plant breeder's attempts to increase the root HI; foliar cultivars may be appropriate. The plant may respond to leaf loss by increased production of anti-nutritive factors. It is known that drought or shading increases the level of cyanogenic glucosides (Ravindran, 1993). It is interesting to note that high levels of manure are reported to decrease

cyanogenic glucoside levels. There may be other responses involving the production of condensed tannins which would reduce leaf meal quality. Farm production data for leaf dry matter yield related to sustained tuber yield is not available. Cassava grown in Kerela State, India, with a tuber yield of 17.6T per ha, produces 4T per ha leaf dry matter; 75% of this is ploughed back into the soil as leaf fall with the remaining 25% removed at harvest (Mohan Kumar, 1993). Extrapolation is difficult; the removal of 25% additional biomass may threaten the longer term fertility of low input low humus soils. The extent of this interaction with higher yielding root varieties (or foliar cultivars), and its alleviation by manure and compost addition, could be examined with farmers in Dong Nai province.

64. Other technologies for the preservation of cassava have been evaluated by a number of scientific institutions. The Institute of Agricultural Sciences (IAS) have developed a separation system to remove the protein component from extracted wet starch (Nghiem, 1992); it is claimed that the alkali stabilised starch rich product can be stored anaerobically for up to six months. Anaerobic storage of partially de-watered wet starch is in minority use in the North where sun-drying is difficult; there is some initial fermentation but starch quality (for alcohol production) is claimed to be unimpaired.

65. The ground whole root can be ensiled in a simple clamp; cassava root silage is somewhat prone to oxidation and will become unstable after about six months storage. Whole plant silage does not appear to be successful owing to an inability to fully exclude air. Cassava root silage represents a low cost intermediary product, which could be stabilised later by sun-drying (when drying conditions improve) to provide a longer term feed ingredient. Losses in subsequent nutritional value may be related to speed of drying and could be investigated under practical on-farm conditions.

66. Various fermentation processes to increase the nitrogen content of ground cassava have been evaluated up to pilot-scale level at a number of research institutions. The most promising product in terms of being a usable monogastric feed ingredient has been produced at the University of Cantho using inoculation with *Cephalosporium eichhorniae* 512 (Mikami *et al.*, 1982). The economics of the process would naturally be reflected in its performance as an animal feed; the process (substrate - cassava 50g/l; submerged fermentation 20 hours; pH 3.8; 45^{o}C) would need adaptation if it is to be used at the farm. The process or its derivative may become appropriate as second generation technology for animal feed or human food. The pelleted fermented product needs assessing in pigs under conditions which fully test its nutritional value in association with

other lower quality food by-products. Fruit cannery waste for such an exercise is available near Cantho.

4. SWEET POTATO PRODUCTION AND UTILISATION

Production

67. Vietnam is the worlds second largest producer of sweet potato, with an annual production of 2.1 million tonnes, which is 17% of the global total. Sweet potato is grown on 350,000 ha of mixed-quality land, with over 60% of the total yield originating in the Northern provinces. Survey data indicate that over 50% of production is concentrated in the Central Coastal region from Thanh Hoa (zone IV) to Thua Than Hue (zone V) provinces. Within these zones, 51,000 ha is planted in Nghe An province, equivalent to 15% of the national output. Sweet potato is grown in association with a number of other crops; the sizes of small-holder farms growing the crop vary from 0.16 to 0.9 ha and the planted area varies from 0.05 to 0.25 ha (Binh *et al.*, 1992).

68. Sweet potato is a bi-seasonal crop, and often features as part of a rotation with rice (sweet potato, winter rice), groundnut (groundnut, sweet potato) and vegetables (sweet potato, vegetables, sweet potato). In the Northern provinces it is planted in January and September and harvested after a five month growing cycle. In the Mekong delta, where it acts as a dry season break crop between rice cycles, planting is in March for an August harvest prior to land preparation for the next rice crop.

69. The crop is grown on alluvial soils in the Delta regions, and on sandy alluvial or podzolic soils elsewhere. The average national yield is currently 6 T per ha. Detailed studies in both the North and South regions give considerably higher average yields, ranging from 10-14 T/ha (Bottema *et al.*, 1992). Sweet potato yields in the Mekong Delta are in excess of 15 T per ha; this crop is partly irrigated and receives significant rainfall during the March to July growing cycle. The current yield of an irrigated local variety (Long Hai) in a collaborative on-farm trial at UAF #4 (HCM) is 19 T per ha. Much lower yields are reported for Nghe An province, where they average 4.7T per ha. This reflects low soil fertility, poor local cultivars and a growing cycle from January to May that is within a fairly dry period.

70. Sweet potato is planted with varying quantities of manure and fertiliser, depending on resource availability and the rotation cycle. Farmers surveyed in Northern provinces reported the use of 8-12 T manure per ha, when planting within a rice rotation cycle (Hoanh *et al.*, 1991). Inputs of fertiliser are low; the highest application rates of urea and NPK varied between 100-150 kg per ha. The position regarding inputs in other rotation cycles is not clear; manure and fertiliser application may be nil since the primary call for them is for the rice crop. Binh *et al.*

(1991) reported a equally varied position in the South; in one area manure was applied at 3.7 T per ha whilst nil inputs were reported in others. Average inputs of urea (250 kg per ha) and fertiliser (50 kg per ha) were relatively higher than those in the North.

71. The labour requirement for the crop varies widely; Binh *et al.* (1991) reported values between 135 and 289 days per ha in different areas of the South. Hoanh *et al.*, (1991) reported a similar range of 167 to 293 days per ha in regions of the North. Labour calendars indicate that the majority of effort is related to land preparation and vine planting, although this always relates to the type of rotation. Very efficient utilisation of labour was observed in the Mekong delta, where sweet potato is grown in a rice rotation. Overlapping cuttings are planted immediately into the ridges cut by hand in the stubble burnt paddy fields. Manure is incorporated for the previous rice crop; fertilisers are applied to the crop in small amounts over the season. This planting regime gives the crop a beneficial start with minimal land cultivation and a high level of early weed repression. Land preparation on non-irrigated land requires the use of draught power or human labour to raise dry ridges in the soil; manure is incorporated before vine planting. Planting and cultivation is more labour intensive since ridge ploughing offers a lower level of initial weed control.

72. According to 1989 survey data, sweet potato production was limited by the lack of high-yielding varieties, inadequate irrigation, lack of fertilisers, the lack of processing technology and pests. New cultivars in the research institutions are expected to give irrigated yields in excess of 25 T per ha; the various cultivars under on-farm trial at UAF #4 (HCM) are approaching this level. There is some difficulty in transferring new cultivars between regions since attributes of colour and cooked texture are particularly important in the South. Cultivars released from Hung Loc, which have been selected for tuber or foliage yield, are also under test at UAF #4 in trials examining the effect of potassium addition, since its depletion may be a serious longer term problem affecting the sustainability of production. Immediate crop yields are seriously reduced by the sweet potato weevil (up to 30% losses), which damages the tuber and allows fungal rot in storage.

Sweet potato utilisation

73. Sweet potato is grown primarily as a cash crop although in the North it acts as a high security crop since it can withstand some flooding. The lifted tuber is reasonably shelf-stable and can be held in a cool dark place for at least 4-5 months. In the Northern Highlands and Midland

regions (zones I, and II), 68% of households did not carry out any processing, i.e. drying (Bottema *et al.*, 1991; this pattern tends to be consistent between provinces (Table 4.). Differences are observed in the proportion of sweet potato tuber fed to livestock between provinces in the North and South; in the South, well over 80% of the product is marketed off the farm and is primarily for human consumption. Tubers are graded and low graded products go to pig feed. In the North, 30% of the total crop in the North is retained on-farm for human food; up to 25% of the crop is sold directly. The balance of the crop (up to 60%) is fed to livestock, either in the form of the harvested fresh tuber or as the chipped and dried product. The dried product is also marketed.

Table 4. Sweet potato utilisation in different areas in Vietnam.

Sweet potato (Note 1)	North Central Coast (IV)		South Central Coast (V)
	Tu Loc	Hiep Hoa	Thang Binh
	%	%	%
Home consumption	30	30	40
Animal feed	40	60	20
Direct sale (market)	24	10	20
Processing	5	0	20

Note 1. Source: Kin *et al.* (1991); (Hoanh *et al.* (1991) in CGPRT Study No 24.

74. Sweet potato is not used as the basis for the large-scale production of starch, owing to its inferior technological properties. Some householders extract starch for direct incorporation into rice wafers, which are produced artisanally. There are a number of proposals under consideration at the research institutions to investigate methods for improving the usefulness of the dried starch or utilising its potential as a feedstock for the fermentation industry.

75. Vine tips and leaves are removed prior to harvest and are sold for consumption as a vegetable, either fried or boiled. Vine tips and vines are also by many farmers for use in pig and cattle rations. The removal of vine tips does not appear to reduce the yield of tubers, although it may have an effect in marginal soils; it is said to stimulate vine growth in foliar varieties. Vine tips and new foliage may represent a significant source of vitamins and protein to sows and growing pigs. At harvest, the early course growth may be separated for ruminants, with the more

succulent later growth going to pigs. Sweet potato vines that are not sold are dried for incorporation into pig and poultry 'rations'.

76. Local sweet potato cultivars contain between one and 3% protein on a wet weight basis (Thuong and Sumilin, 1991). Sweet potato tubers are normally cooked before being given to pigs. Extension workers have noted that feeding the raw tubers depresses growth; the improvement after heating probably relates to an increase in starch availability rather than a reduction in anti-nutritional factors. No data are available on the overall presence of trypsin-inhibitor in local cultivars and how this might vary within dry matter yield. Trypsin inhibitor activity (TIA) increases in proportion to tuber protein content (Yeh and Bouwkamp, 1985) and is partially heat stable. Trypsin-inhibitors (or other anti-nutritional factors) may express a more significant growth repression effect in diets which are somewhat deficient in one or all of the nutritional components anticipated in a balanced diet.

77. The current low rates of growth in livestock suggest below optimum levels of nutrients in their rations. There has been little analysis of the component interactions of stock quality, animal husbandry, feed inputs and value on livestock productivity in existing small-holder enterprises. TIA levels and starch status are one possible limitation of sweet potato in feeds and should be assessed (under the control of the AHRI) within an 'on-farm' feeding programme. Their effect might be expected to be greater in feeds developed using the sun-dryed tuber. The requirement for heat, for TIA inactivation or starch gelatinisation, could be satisfied from biogas if it is shown to be necessary.

78. Raw tubers at the end of their shelf-life are fed to cattle. There is limited experience of the ensilage of roots, vines and whole plants and none relating to its 'on - farm' performance. The literature would suggest that there may be problems with product stability relating to the rate of fermentation process (Yeh and Bouwkamp, 1985). There would be some doubt as to the margin over feed cost of using sweet potato as cattle feed. There would be an opportunity for some development work as a student project within village trials on tuber performance in monogastrics.

6. THE LIVESTOCK SECTOR

Cattle

79. Cattle are primarily raised for draught purposes and at the small- holder level are fully integrated with crop production. Cattle numbers have increased by 12% over the five-year period from 1986 to 1991 to give a population of 3.2 million head (Appendix 3.); 1.8 million of the total are classified as draught animals (FAO, 1992a). The population consists in the main of native cattle (known colloquially as 'yellow' cattle) which are unimproved; there are also some non-descript zebu stock introduced from a number of local crossbreeding programmes. The herd distribution is heavily skewed, with 48% present in the central coastal regions (zones IV and V); these zones contain much of the 360,000 ha of native pastures. Animals in these regions are raised in herd sizes ranging from 20 to 300. Draught cattle in other provinces are kept singly or up to three pairs per household.

80. Draught animals are usually purchased by the householder farmers and retained through their working lives. A limited number of replacement animals may be raised where the farmer has more than two working cattle. Yellow cattle have a small body weight (250-280 kg), grow slowly, mature late and are poor. They are efficient draught animals and are particularly well-suited to the working of small areas of light silts and loams used for dryland rice production. Red Sindhi cattle were introduced in a crossbreeding programme to increase milk yield when trying to establish rural milk production schemes. The dairy programme was not successful, although the crossbred has found favour in some provinces e.g. 25% of the cattle in Binh Dinh and Tay Ninh province have Sindhi blood.

81. In 1991, 585,000 head of cattle were slaughtered producing 110,000 tonnes of beef; over 17,000 tonnes went for export to the Commonwealth Independent States (CIS), France and Japan earning in excess of $US20 million. Draught animals are slaughtered for meat at 7-10 years of age. Carcases from culled yellow cattle are small, averaging 140-160 kg; the Red Sindhi influence increases liveweight by 30% giving an average carcase weight of 190 kg. FAO (1991) quote an <u>average</u> carcase weight of 220 kg, but these data may refer to selective heavier export-grade animals or those from limited fattening programmes. The meat quality would appear to be extremely poor, but the boneless, frozen export product has found a market as manufacturing meat in the CIS. Meat of higher quality might attract a comparative premium within the catering (hotel) trade in HCM city. It would be easier to establish this premium for fattened younger animals. The major meat slaughtering company in HCM city foresees a substantial

market for quality beef in view of the anticipated influx of foreign workers and visitors.

82. Various breeds of cattle have been introduced through bilateral aid programmes. White Brahman, Sahiwal, Charolais and other species were introduced from Cuba or Europe from the 1970's onwards. Santa Gertrudis, Droughtmaster and Brahman semen was brought in from Australia between 1987 and 1991, but the value of this genetic potential appears to have been lost within the general herd pool. The white Brahman has proved to be a highly nervous strain and white cattle were reluctantly accepted by farmers even when they received considerable financial assistance for their purchase. A number of crossbred animals are held by AHRI and province husbandry units for future use in local herd improvement.

83. The 1992 livestock sector study (FAO/UNDP, 1993) concluded that 'breed improvement programmes were characterised by inadequate or inappropriate resources, poor management and livestock productivity in elite groups and very low genetic selection pressures.' There is an efficient AI network set up in the North to provide and distribute exotic pig breed semen; a regional system is being introduced for the supply and distribution of cattle semen. The current status of a number of provincial breeding stations further supports the FAO observation. Units appear to have a lack of purpose and limited resources which may even extend to a shortage of feedstuffs. The cattle and pasture breeding station in Binh Dinh province will have a pasture allocation of 25 ha in support of 50 breeding stock which were acquired locally.

84. The MAFI cattle unit at Duc My, Khoah Hoa province is another example of a poorly utilised resource. The unit is currently evaluating the acceptability of cross bred Sahiwal Brahman cattle, which retain the farmers preferred brown colour over the white Brahman. Approximately 24 one year old Sahiwal Brahman male calves will be available per annum for crossing onto native yellow cattle. These animals are released to farmers at a price equivalent to twice the market price of local draught cattle (when discounts are counted). The lack of a specific cattle fattening programme integrated to a market results in animals being released and lost within the general population. The contract purchase of improved animals by provinces on behalf of communes intending to finish cattle would encourage the more commercial development of this and similar provincial cattle units and retain the herd nucleus.

85. Draught animals are fed from the grass verges, bunds between paddy fields and are given rice straw, cut grasses and some forages, such as sweet potato vines. Herded feeding is carried out by the younger members of the family.

Feeding of cut forage crops is also carried out where the animals are confined within stalls. The great majority of draught animals observed in various provinces were in good nutritional condition and farmers did not offer evidence that work rate over the year was restricted by periods of low feed availability. Cattle manure is a valuable by-product of stall feeding and is used on crops or sold to other householder-farmers. Manure is often crudely stacked within the stall area and no further composting operations are carried out. There is little local expertise on the production and value of composts in relation to poorer, sandy soils. More intensive soil treatment systems are practised in the central highland region; these including the use of compost, manure and fish sauce waste as a major nitrogen and mineral soil conditioners.

86. Growing cattle grazed on natural pastures are herded regularly to fresh pastures or onto crop residues in the dry season. Grazing pressures are increasing and the Government has set aside more marginal land for cattle and small-ruminant production. The animals will experience some weight-loss during the two month period of restricted forage availability at the height of the dry season. There are a number of small, individual production systems within many provinces which use improved pastures or, more typically, some by-products. One interesting system in Phu Yen province is based on grasses (*Brachiaria dystachia; Panicum maximum*) planted into the river bed after the autumn flood. Sindhi x yellow cattle, housed on the river bank, are moved onto the pasture after it has made 2 to 3 months growth. Cattle are housed in temporary shelters and fed off the pasture on a cut and carry basis for up to 8 months of the year; these animals achieve a 350 kg body weight in 3 years. Manure is collected and dried for sale for the gardens of small, non-livestock-owning, householder-farmers. The growth of these cross-breeds indicates that an improved local animal offers a good, cost effective response to a high plane of nutrition. The 'extensive feedlot' system is highly appropriate where labour is available for feed collection. Similar cut and carry systems, based on king grass or sugar cane, are under evaluation on AHRI or provincial agricultural stations.

87. An intensive cattle fattening system in HCM city for the production of export beef has been discontinued; this was based on imported feed resulting in insufficient margins on the exported product (to the CIS). A number of small enterprises near HCM city operate as short-term fattening operations using draught cattle (aged >7 years). Animals are given a low level of finish prior to shipment to Cambodia and Laos; some animals may go to local slaughter. The operations are primarily conditioning exercises, designed to minimise liveweight loss on transport. Rations are based on cassava starch processing waste or sugar cane

tops. Their experience could be useful in the assessment of the performance of cassava starch by-products for finishing cattle. UAF #4 (HCM) have a small 'in-house' project fattening male calves on rations containing cassava starch processing waste and molasses under SAREC funding.

Dairy cattle.

88. The dairy cattle population in 1990 was 15,000 animals, with 7000 milkers and a production of 12,000T of milk. Vietnam currently imports dairy products worth $US 6.7 million, in the form of dried milk powder, for the manufacture of canned condensed milk and butter. A government objective is to promote the production of local milk in order to completely replace imported dried milk by the year 2000. This would require an unrealistic seven-fold increase in the dairy herd. 75% of the national herd is Holstein-Friesian (HF) stock, imported in the late 1970's, the remainder being cross-bred animals e.g. Red Sindhi x HF or yellow cattle. Small-holder dairy enterprises are concentrated near Hanoi or HCM city; these have been encouraged by the selective disbursement of the state dairy farms.

89. Milk producers near Hanoi typically hold up to 4 cows in stalls adjacent to their living areas. Animals are fed grasses cut from the river or from grass-producing areas collected by intermediaries for sale to the small-holder. AI is used extensively, with female calves being sold at six months and male calves being sold earlier for meat. Daily milk yields are 8-9 litres for Holstein-Friesian and 4-5 litres for Red Sindhi cross-breds. All stock are fed locally mixed supplements which appear to be similar to a pig grower (16% crude protein: energy 12.5 MJ/kg) ration and a general vitamin premix. AHRI have introduced molasses blocks to Hanoi milk producers under an FAO programme for forage supplementation (for rice straw) in the winter period when grasses are in short supply. The response by farmers has been mixed since the advantages of blocks in the maintenance of milk yield were somewhat oversold. The use of blocks does appear to reduce the loss in cow condition prior to increased grass availability. AHRI have produced nutrient blocks from industrial cassava waste which may have a use within small holder systems, although they may be more suitable for milking goats.

90. Milk producers in HCM city tend to be larger; one held 31 stall fed cows and 60 growing pigs in a 200m^2 area adjacent to the family dwelling. Many producers feed a combination of grasses cut from garden plots and cassava processing waste. Each lactating cow consumes 8-10 kg of cassava waste per day. Cows are given feed and vitamin supplements which appear to be originally intended for pigs (although containing no copper); milk yields of 12-15 litres

have been achieved using this system. A similar programme of molasses block supplementation was undertaken by UAF #4 (HCM) and the National Institute for Agricultural Sciences - south (INSA). This has met with more success since most dairy producers are operating fully supplemented production systems on higher yielding cows.

91. In both cities milk is taken to middle-men, who sell the product fresh or consolidate the supply of a number of producers to provide bulk milk for condensed milk manufacture. The lack of infrastructure will continue to limit milk production to peri-urban enterprises. The larger urban dairy units have considerable environmental effect, particularly in terms of slurry generation. Building pressures often result in units being surrounded by housing, limiting expansion in the business to a search for new premises. New sites tend to be sought as a means of setting up family members in a similar business; it is seldom commercially attractive to relocate the existing unit. The facility is inevitably overstretched to provide family capital. The fish pond and cultivated grasses area, which is central to the Vietnamese agricultural VAC [Vuon - garden or crop science; Ao - fish pond; Chung - livestock] system is often not able to absorb both the slurry and cassava processing waste of the present operation. The 31 cow unit was to have a second biogas unit installed in an attempt to reduce the dischargeable biological oxidation demand. Some breakdown in disease control within this and adjoining units would seem to be inevitable.

Buffalo.

92. The majority of buffaloes are draught animals which are better suited to working rice paddies. The buffalo population currently stands at 2.85 million head, of which 1.84 million are animals in work. The majority of the population are native swamp buffaloes, which are particularly suited to work in paddy cultivation. Current slaughterings amount to 415,000 head, producing 89,000 T of meat. Slaughter stock is made up of translocated animals, injured animals or those too old for work. A significant number of swamp buffaloes are exported for subsequent slaughter in Cambodia.

93. The herd distribution is skewed with 77% of the National herd being located in North Vietnam; 45% of the herd is located in the Northern mountains province. Some improved breeds have been introduced for milk production; some Indian Nili buffalo were imported for dairies around HCM city in the early 1970's. The National Buffalo and Pasture Research Station at Song Be has Murrah animals; these are not adapting to the local environment.

94. Buffaloes kept on householder-farms as draught animals are often rented and provide a valuable source of income. Animals are fed on grasses verges at the edges of paddy fields or at the roadside. Draught animals observed in all regions appeared in good condition; the longer term work status was not determined although province agricultural officials did not recognise seasonal loss in work ability as a major problem. Stall-feeding with grasses is practised widely; the collected manure is more valuable than that from cattle. Animals tend to receive rice bran as a supplement. There are a small number of small operations providing a conditioning-staging service to export buffaloes; there are no specialist feedlot fattening operations. The National Centre has carried out some studies relating to the growth response of local buffaloes to a higher plane of nutrition. There is no information relating to the value of root crop feeding in Vietnamese production systems.

Sheep and goats

95. The National Herd consists of 40,000 head of sheep and 370,000 headof goats which are concentrated in the Central Coast South region (zone VI). The herd of non-wool (non-specific Indonesian Donggala plus Indian blood) sheep is confined to a small area of Ninh Thuan province. Individual small-holder flock sizes range from 20 to 300 animals. Currently <20,000 sheep are slaughtered per annum; over 190,000 goats are slaughtered yielding 3,000 T of meat. Sheep and goats for slaughter are raised to a carcase weight of between 18 and 25 kg over a nine month period. Live animals are bought on regular visits by middlemen and are shipped to HCM city.

96. Sheep are grazed on common-land pasture during the day and are enclosed at night near water; ewes may be given rice bran as a supplement during pregnancy. The pasture is of low nutritive value during the December - March period, these being the months of minimal rainfall. These grasslands are found on light sandy soils. Farmers using this pasture also retain fields for the production of crops near their main dwelling, which may be 20 km from the pasture and, as such, employ herdsmen assistants from the local villages.

97. A project team from Hue University (UA #2) are examining the use of a ewe supplement produced from ingredients which are collected locally without cost (rice straw (40%); whole soya (10%); cactus (40%)) and 10% by weight purchased molasses. This trial has been operational with one farmer (flock size 260 head) for two months. A 3 kg difference in body weight has been retained over the non-supplemented group. Lambing performance is now being assessed (30% lamb drop Jan-March; 50% June-August) and the successive fertility in ewes will be followed. Farmers are

assisted by graduate students on their six month mandatory farm placement; the programme shows a high level of commitment, application and adaptation to local conditions.

98. The majority of goats in the national herd are milking goats originating from India (Malabar and Jamnapari breeds) although the main product is meat. Goats are allowed to graze freely on thorn-scrub and may be given some rice straw in the evening on return to the kraal. There is some evidence of overgrazing during the dry season which may progressively increase; many herd owners have moved onto larger areas of more marginal grazing land as the herd size (ranging from 110 to 400 head) increased. Goats are sold to middlemen from HCM city at 25 to 30 kg liveweight which is achieved after six months growth; some animals achieve 40 kg in this period.

99. Many goats owners also own herds (>20 head) of cattle; cattle dung is dried and sold locally. Goat droppings are not collected. Children are used to move herds to new grazing areas; they work for half a day and attend school during the other half. Cattle and goats looked in good condition considering that it was the dry season; these farmers are evidently good stockmen (they appear to be settled pastoralists), but the environment is under pressure. Farmers assume that children will take on newly released marginal land as they have done; they do not see the finality in this.

100. AHRI are currently examining the use of cassava and sweet potato as supplements for milking goats at the Ba Veterinary Institute (BAVI - Ha Tay province) under SAREC funding. This programme is linked to the introduction of milk-goats into other rural communities. The knowledge gained at BAVI could be combined with the local experience of UA #2 (Hue) to evaluate the advantage of supplementation in meat-producing animals on farms. This may be particularly relevant in view of the longer term environmental impact that low productivity livestock systems may have in the Central Coast South Region.

Pigs

101. The national pig herd currently stands at 12.3 million head; it predominates in terms of the animal population but has shown the lowest rate of growth (3.9%) over the most recent five year (1986-91) period. Currently 11.3 million head are slaughtered per year, yielding 34 million tonnes of meat. This is 73% of the total meat production of Vietnam (meat consumption averages 0.77 kg per capita per month). Pig numbers are more evenly distributed over the country and within individual provinces, averaging 0.92 animals per household. There are a small number of units where large groups (>40) of pigs are raised, e.g. some cassava starch-

extraction enterprises around HCM may keep in excess of 50 growing pigs. The majority of pigs live in small, dark, confined facilities in covered areas adjacent to the householder's main living accommodation.

102. There are 1.58 million sows in the herd; the majority of these are local breeds. FAO data indicate that productivity per sow is very low, amounting to 460 kg liveweight of growing pig per year. Farmers, except those in the HCM area, persist in the use of local Mon Cai (North) or Ba Xuyen or Thuoc Nhieu (South) sows. These breeds are prolific, giving litter sizes of 10 piglets or more. Piglet survival to weaning averages less than 60%, although individual producers may get 80% survival. Mortality is due to diarrhoea and lack of iron. A much higher mortality rate is shown by exotic sows raised on householder farms; this may approach 60% in the Landrace breed. Most young pigs have to endure poor conditions of environment, hygiene and diet. The combination of environmental and nutritional conditions prevents the useful introduction of any exotic stock to some parts of the country, e.g. the far south of the Mekong delta. Local sows are also retained within communities in view of the cost of purchasing and feeding exotic stock.

103. Farmers make use of AI to introduce exotic blood into local sows. The donor semen comes from Large White (LW) or Landrace (LR) boars held in provincial centres. These animals were imported from Cuba, Japan and Belgium and may need the introduction of new exotic lines. The AI units are not being used to their full potential since conception rates are well below two inseminations per year. Insemination is carried out by a trained operator in the commune; the cost is between 50 cents and $US1.5. The AI units have little direct participation in pig improvement programmes in the villages.

104. The pure-bred MC pig can expect to reach a liveweight of 70 kg after one year under a low intensity feeding system. Piglets are weaned at 60 days; the F1 (LW x MC) crossbred will typically achieve a 90-100 kg liveweight over a 10-12 months feed cycle. These animals tend to have a high tendency to lay down excessive fat as they approach the slaughter weight. Growing pigs in the North are fed on a variety of foodstuffs, the ration being based on kitchen waste, rice bran, and vegetables; cassava and sweet potato make up the 'balance' of the diet. Average liveweight gain is 300g per day, and appears to be restricted by the level of protein offered (possibly compounded by trypsin-inhibitor in sweet potato). The low weight gain is particularly wasteful of the energy component of the ration where its price should offer a distinct advantage in production costs.

105. Historically consumers from the North favoured high fat carcases, where the fat was used for culinary purposes. Pig fat is still used as the basis of *banh chung*, a dish eaten (as are the highest proportion of pigs) during the new year *Tet* festival. The introduction of more oil-bearing vegetable crops has made this general culinary use less important. There is now a tendency, particularly in urban consumers, to show greater preference for less fat meat although succulence remains an important subjective attribute. This trend has yet to fully establish itself but evidence from retailers suggests that negative price differentials are now considered in relation to shoulder backfat levels over 35 mm in depth.

106. More intensive pig producers in HCM have better facilities and access to feed and are able to capitalise on the increased genetic potential in the pure bred pig. These farmers tend use a LR(B) x LW(S) derived growing piglet, and three way crosses including Duroc are occasionally observed. Farmers report daily liveweight gains in excess of 500 g; these seem appropriate due to the low nutrient density of the overall rations. Some producers purchase pig grower ration from the local feed mill as a balancer for rice bran and cassava starch byproduct feeds. A minority are able to mix a formulated ration from purchased soya, fish meal, rice bran, cassava starch byproduct and vitamin premix. There appears to be a wide range of efficiency in producers using cassava by-product waste; this may be related to the strong tendency of producers to dilute purchased pig grower concentrate meals.

107. The combination of cassava waste, pig-grower and other balancing ingredients and the use of exotic breeds gives a high grade pig carcase albeit at a lower growth rate. Carcase quality is reduced where LR x LR crossed growers are used, where the poor effect (pale, soft, exudate muscle) of the Belgian LR is evident (Nguyen Ngoc Tuan 1992 - personal communication). Consumers in the South show a distinct preference for a lower fat carcase.

108. Production systems in the South incorporate many of the principles of good pig production but their size and reliance on concentrated feeds makes them <u>currently</u> inappropriate in the North. Programmes for the improvement of pig production in the North should include funds to enable extension officers and farmers to travel to the south to observe production methods which may be their longer-term targets. The correct formulation of diets containing root crops or root crop residues would be of benefit to both systems. Better facilities and improved pig performance on small householder farms in the North should be given the more immediate priority.

Poultry

109. National census data indicate a population of 109.6 million head, comprising 84 million head of chicken and 23 million head of ducks. The sector produces 168,000 T of meat or 18% of total meat production. Poultry production has increased by 10.7% over the last five years, although this growth has been proportionally higher in the duck production sector. Most poultry production is still at the farmer small-holder level using local dual purpose poultry; some producers have tended to specialise in chicken production although these are very small with sales of less than 20 birds per week. There are a number of small broiler enterprises although the exact number and size was unquantifiable. AHRI maintain the single Ross broiler grandparent flock of 1800 birds at Thuy Phuong from which they distribute parent chicks nationally. The low availability of feed-grade maize and soya will continue to restrict the growth of the broiler sector.

110. The majority of the duck production in the North is undertaken by small producers who effectively herd their flocks in order that they may scavenge irrigation canals and paddy fields. Flock sizes range from 100-200 birds; these are enclosed at night where they may receive supplementary feed such as rice bran, broken rice, small fish. The productivity is reasonably low; for instance they achieve slaughter body weight at 2.8 kg after 75-80 days including 4 kg of supplemental byproduct feed. Cassava meal or sweet potato tubers are not fed to ducks.

111. Duck production in the South has both traditional systems of low productivity cultivation and the increasing introduction of a more commercial rearing systems which represents a good example of a diversified stratified industry. Most of growth is the commercial sector has been encouraged by the introduction of the Super M meat duck from Cherry Valley (UK) in 1988. The AHRI VIGOVA programme in HCM city introduced the parent stock (FAO UNDP programme 86.007) and is still responsible for the maintenance of the grandparent stock for new producers. This unit is currently undertaking trials with VAC duck and fish pond systems. The super M duck will attain a 3.1 kg slaughterweight in 63 days on a semi-commercial ration.

112. The biggest producer of day old chicks has 4000 parent laying ducks; each pen contains 140 females and 17 males and has access to a fenced area of water. The producer has no fattening facilities and therefore confines his risk and expertise within one single enterprise. Ducks are fed with rice bran and shrimp head waste; some problems have been experienced regarding aflatoxiosis in rice bran although this derives from the purchase of cheap, wetted rice. This producer would be very interested in evaluating a rice bran

cassava composite meal since it would not impose any additional handling practice.

113. The current production of hens and ducks eggs is estimated at 100,000 and 760,000 T per annum (FAO, 1992b), although data for the former are probably an underestimate. Approximately 500 T of eggs (mainly duck) were exported in 1991 to neighbouring countries. The local laying hen was derived from improvement of the local hens with Rhode Island Red which was imported from Cuba more than 20 years ago; this has developed into a stable ubiquitous strain. Egg production rates are low, varying between 90 and 110 eggs per year, and the eggs are small (50g). However the strain is a good converter of poor quality (or more likely scavenged feed) and is therefore popular with farmers. AHRI have imported a brown-line strain from Poland (Hybro parent stock) which produces 180 eggs per year although this requires additional feed.

114. Many farmers already feed small quantities of cassava and sweet potato to laying hens and would therefore be in a favourable position to implement feed trials. Egg production would be influenced by protein provision but represents an opportunity for improving the return on root crops. This and poultry production using whole root crops should be re-examined in more detail when the NRI field trials are complete in The Cameroon. A small programme could usefully examine egg production related to energy and protein level (allowing free protein scavenging) in diets based on a composite cassava rice bran ration.

Rabbits

115. There are currently 130,000 head in Vietnam, located in the North in the vicinity of experimental farms. The animal represents a useful source of protein, particularly to the smaller householders. A rabbit unit is operational at BAVI although it is not operating with any degree of efficiency. It may be useful to assess the feed value of a moulded rice bran cassava pellet as part of support to small scale sustainable agriculture to low altitude cassava farmers.

116. AHRI sites also maintain small parent flocks of Rheinland geese for evaluation within VAC and other integrated livestock systems. These and milk goats for cheese production would appear to represent more suitable small stock operations than rabbits for the highland regions.

7. SUPPORT FOR AGRICULTURE.

117. The National Tuber and Root Crop Programme (NTRCP) provides a co-ordination mechanism for the Institutions, e.g. AHRI, INSA, IAS, and the Agricultural Universities, UA #3 (Bac Thai), UA #2 (Hue) and UAF #4 (HCM), and Cantho. The four Universities of Agriculture are organised on a regional basis, taking graduates from catchment areas within local agro-ecological zones. All offer a similar graduate 4.5 year course; the course contains a high proportion of direct teaching as library facilities are limited in each. Each student is required to prepare a dissertation based on a six months attachment to a farmer during which time they are expected to carry out simple evaluation and monitoring exercises. Their attachment and work programme is supervised by course lecturers by monthly or more frequent visits to the student in post. These students would form a pool of labour which can be used in an 'on-farm' research programme. UA # 2 (Hue) currently supervises student placement in Nghe An province; UAF # 4 (HCM) would provide placements in Tay Ninh province. Work with NRI personnel would attract the highest calibre of student.

118. Much work has been carried out within the Research Institutions on the use of root crops in animal feeding although noticeably this has not extended to feeding systems research. The Institutions have tended to lose focus on the need to disseminate results and ideas. This has to be addressed by the more active participation of research scientists in the field, working in co-operation with the provincial extension services. Briefings on tuber, root crop and livestock production and wider discussions were held with senior agricultural representatives in five provinces. Poor access to demonstrations of new techniques and appropriate technology were given as the main reasons for lack of technology transfer. Progress in this area is seen as a learning exercise in which farmers are participative agents.

119. Villages continue to rely on the district and provincial agricultural support services, for which they pay. These include services such as irrigation, pest control, artificial insemination and veterinary services. Extension services are managed at the province level, and are co-ordinated through links to the district, (commune) and village committees. This structure enables existing extension services, particularly in the North, to co-ordinate the inputs of a number of governmental, universities and non-governmental agencies. This type of organisation can assist in 'on-farm' research, whilst allowing farmers to set their own agenda in terms of evaluating new ideas. Extension work in the South is augmented more directly by the Institutions; these ha

number of programmes of farmer co-operation and information dissemination.

120. Each villager is required to give 13-20 days labour to district self-help schemes, such as the digging of irrigation ditches. As such communes are used to organising labour to a common purpose and would be able to offer a pool of labour for the improvement of facilities for 'on-farm' research.

121. Women and children play a major role in the provision of agricultural labour within households. Women and children feed animals as as extension to the preparation of family meals or help with guided grazing on common land. Children are required to attend full time education until the age of 12. All communes have primary schools and secondary schools which are based within districts; schools should be able to participate at a general level in supporting district based research. Visits to farmers and projects would help to increase the awareness of the village and the non-participants on progress.

122. Non-governmental agencies, such as the Peasant's Union and the Women's Union, have direct relationships with extension departments in certain provinces through links that are well established. The Women's Union have been used successfully under SAREC funding to administer rolling funds allocated for farmer projects feeding cane sugar byproducts and disseminate the techniques demonstrated on 'model farms'.

123. All the support structures that were required under the state control of agriculture remain in place but now operate in a co-ordinating and enabling role. Farmers have access to credit through the Agricultural Bank. There are mechanisms within communes and districts for payment for livestock and support feeds, although funds for this operation are limited. Programmes that are initially donor funded can be taken up by forms of revolving funds, by credit unions or by access to the Agricultural Credit Bank. Practical advice and experience for the establishment of revolving funds and credit unions in different regions in Vietnam is available through the FAO/UNDP office in Hanoi.

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Appendix 1. Change in sown area and average yield of the major rice and industrial crops in Vietnam, 1

Crop	Sown areas and average yields		1980	1986	1989	1990	1991	Average % increase 1986-1991	Average % increase 1989-1991
1. RICE									
a) Spring paddy	Area	000ha	1707.00	1828.50	1992.30	2073.60	2159.70	3.62	1.36
	Production	000T	3874.00	6118.20	7539.30	7845.80	6788.30	2.19	1.36
	Yield	T/ha	2.27	3.35	3.78	3.78	3.14	-1.21	.00
b) Autumn paddy	Area	000ha	681.30	914.60	1140.30	1215.60	1370.50	9.97	2.20
	Production	000T	1593.80	3008.60	4063.20	4110.40	4767.70	11.69	0.39
	Yield	T/ha	2.34	3.29	3.56	3.38	3.48	1.15	-1.70
c) Winter paddy	Area	000ha	3211.90	2945.50	2763.20	2738.50	2764.80	-1.23	-0.30
	Production	000T	6179.60	6876.10	7393.80	7268.90	7871.60	2.90	-0.56
	Yield	T/ha	1.92	2.33	2.68	2.65	2.85	4.39	-0.27
d) Total paddy	Area	000ha	5600.20	5688.60	5895.80	6027.70	6295.00	2.13	0.75
	Production	000T	11647.40	16002.90	18996.30	19225.10	19427.60	4.28	0.40
	Yield	T/ha	2.08	2.81	3.22	3.19	3.09	1.94	-0.34
2. OTHER CEREALS									
a) Maize	Area	000ha	389.60	400.90	509.40	431.80	432.90	1.60	-5.08
	Production	000T	428.80	569.90	837.90	671.00	651.60	2.87	-6.64
	Yield	T/ha	1.10	1.42	1.64	1.55	1.51	1.18	-1.84
b) Sweet potato	Area	000ha	450.00	329.00	327.30	321.10	348.80	1.20	-0.63
	Production	000T	2417.60	1958.70	1909.20	1929.00	2104.50	1.49	0.35
	Yield	T/ha	5.37	5.95	5.83	6.01	6.03	0.27	1.00
c) Cassava	Area	000ha	442.90	314.70	284.60	256.80	267.20	-3.02	-3.26
	Production	000T	3323.00	2882.30	2585.40	2275.80	2389.90	-3.42	-3.99
	Yield	T/ha	7.50	9.16	9.08	8.86	8.94	-0.47	-0.82
d) Total cereals	Area	000ha	1448.80	1123.70	1193.80	1083.20	1097.80	-0.46	-3.09
	Production	000T	2759.00	2376.20	2519.30	2263.50	2290.00	-0.73	-3.38
3. TOTAL RICE & CEREALS	Area	000ha	7049.00	6812.30	7089.60	7110.90	7392.80	1.70	0.10
	Production	000T	14406.40	18379.10	21515.60	21488.60	21717.60	3.63	-0.04
	Yield	T/ha	2.04	2.70	3.03	3.02	2.94	1.78	-0.14

Crop	Sown areas and average yields		1980	1986	1989	1990	1991	Average % increase 1986-1991	Average % increase 1989-1991
4. FOODSTUFFS									
a) Vegetables	Area	000ha	189.80	239.10	252.00	261.10	279.30	3.36	1.20
	Production	000T	2164.80	2938.10	3135.40	3225.00	3416.80	3.26	0.95
	Yield	T/ha	11.41	12.29	12.44	12.35	12.23	-0.09	-0.24
b) Beans	Area	000ha	109.80	161.40	167.40	165.00	169.60	1.02	-0.48
	Production	000T	54.10	95.30	102.10	94.20	109.40	2.96	-2.58
	Yield	T/ha	0.49	0.59	0.61	0.57	0.65	1.85	-2.13
5. INDUSTRIAL CROPS									
a) Sugar cane	Area	000ha	109.80	125.20	131.30	130.60	141.10	2.54	-0.18
	Production	000T	4358.90	4964.60	5344.60	5397.70	5939.80	3.93	0.33
	Yield	T/ha	39.70	39.65	40.71	41.33	42.10	1.23	0.51
b). Peanut	Area	000ha	85.50	198.43	201.68	225.89	228.64	3.04	4.00
	Production	000T	95.00	211.10	205.80	213.10	211.70	0.06	1.18
	Yield	T/ha	0.90	0.94	0.98	1.06	1.08	2.98	2.72
6. TOTAL ANNUAL CROPS									
a) Annual crops	Area	000ha	7772.80	7846.00	8052.80	8101.50	8391.80	1.39	0.20

Source: Statistical Data of the Socialist Republic of Vietnam.

Statistical Publishing House.

Appendix 2. Distribution of paddy and other 'cereal' crop equivalent production by province.

Province	Popln	Food	Paddy		Cereal		Food Crop Total		Crop area per capita	Crop product per capita	Crop product per area	Cereal as % total
	'000	kg/capita	Area	Prodtn	Area	Prodtn.	Area	Prodtn.				
			000ha	000T	000ha	000T	000ha	000T	ha/cap	T/cap	T/ha	
North Mountain	11542.8	226.8	748.9	1702.0	338.9	647.8	1087.8	2349.8	0.094	0.204	2.160	27.6
Ha Tuyen	1087.1	229.7	69.3	154.9	58.1	88.3	127.4	243.2	0.117	0.224	1.909	36.3
a) Ha Giang	489.9											
b) Tuyen Giang	597.2											
Cao Bang	591.5	232.5	36.9	78.5	37.5	56.6	74.4	135.1	0.126	0.228	1.816	41.9
Lang Son	643.6	233.9	46.0	120.1	15.8	25.9	61.8	146.0	0.096	0.227	2.362	17.7
Lai Chau	467.6	62.1	48.0	69.1	33.6	49.7	81.6	118.8	0.175	0.254	1.456	41.8
Hoang Lien Son	1101.9	223.0	70.8	153.5	40.2	85.5	111.0	239.0	0.101	0.217	2.153	35.8
a) Loa Cai	491.5											
b) Yen Ba	610.4											
Bac Thai	1082.6	99.1	76.6	170.2	21.3	40.9	97.9	211.1	0.090	0.195	2.156	19.4
Son La	726.8	206.3	49.8	72.8	30.0	72.3	79.8	145.1	0.110	0.200	1.818	49.8
Quang Ninh	848.2	169.1	44.9	110.9	15.5	29.6	60.4	140.5	0.071	0.166	2.326	21.1
Vinh Phu	2097.7	200.0	128.5	289.3	40.9	81.7	169.4	371.0	0.081	0.177	2.190	22.0
Ha Bac	2172.9	282.7	178.1	482.7	46.0	117.3	224.1	600.0	0.103	0.276	2.677	19.6
Hoi Binh	722.9											
Red River Delta	13275.6	294.5	1057.6	3618.1	189.4	482.6	1247.0	4100.7	0.094	0.309	3.288	11.8
Ha Noi	2095.0	163.7	123.5	397.6	44.7	118.5	168.2	516.1	0.080	0.246	3.068	23.0
Hai Phong	1516.9	196.6	92.2	277.1	5.6	14.4	97.8	291.5	0.064	0.192	3.981	4.9
Ha Son Binh (Ha Tay)	2130.0	291.2	157.6	470.7	40.4	78.7	198.0	549.4	0.093	0.258	2.775	14.3
Hai Hung	2554.5	357.2	230.6	783.2	36.8	110.9	267.4	894.1	0.105	0.350	3.344	12.4
Thai Binh	1705.4	470.3	164.3	710.2	29.1	76.7	193.4	786.9	0.113	0.461	4.069	9.7
Ha Nam Ninh	3273.8	329.6	289.4	979.1	32.8	83.4	322.2	1062.5	0.098	0.325	3.298	7.8
a) Nam Ha	2473.7											
b) Ninh Binh	800.1											

Province	Popln	Food	Paddy		Cereal		Food Crop Total		Crop area per capita	Crop product per capita	Crop product per area	Cereal as % total
	'000	kg/capita	Area 000ha	Prodtn 000T	Area 000ha	Prodtn. 000T	Area 000ha	Prodtn. 000T	ha/cap	T/cap	T/ha	
Central coast - Northland	9054.2	226.0	677.0	1642.3	212.0	355.7	889.0	1998.0	0.098	0.221	2.247	17.8
Thanh Hoa	3152.9	266.2	243.8	684.4	70.8	135.8	314.6	820.2	0.100	0.260	2.607	16.6
Nghe Tinh	3796.4	218.8	296.2	659.0	94.5	150.6	390.7	809.6	0.103	0.213	2.072	18.6
a) Nghe An	2561.9											
b) Ha Tinh	1234.5											
Quang Binh	693.2	146.7	46.8	89.2	18.6	22.9	65.4	112.1	0.094	0.162	1.714	20.4
Quan Tri	490.8	173.2	41.4	82.2	11.3	17.5	52.7	99.7	0.107	0.203	1.892	17.6
Thua Thien Hue	920.9	208.2	48.8	127.5	16.8	28.9	65.6	156.4	0.071	0.170	2.384	18.5
Central coast - Southland	6995.6	274.0	494.9	1607.0	132.8	268.6	627.7	1875.6	0.090	0.268	2.988	14.3
Quan Nam - Danang	1832.3	247.6	118.3	351.8	40.1	92.2	158.4	444.0	0.086	0.242	2.803	20.8
Quang Ngai	1090.4	269.9	87.6	241.2	24.6	48.2	112.2	289.4	0.103	0.265	2.579	16.7
Binh Dinh	1295.0	307.6	116.0	360.2	16.0	30.4	132.0	390.6	0.102	0.302	3.959	7.8
Phu Yen	670.5	408.1	56.7	254.2	9.1	16.5	65.8	270.7	0.098	0.404	4.114	6.1
Khanh Hoa	871.7	211.7	36.0	139.9	16.6	38.9	52.6	178.8	0.060	0.205	3.399	21.8
Thuan Hai	1235.6	251.1	80.3	259.7	26.4	42.4	106.7	302.1	0.086	0.244	2.831	14.0
a) Ninh Thuan	412.0											
b) Binh Thuan	823.6											
Central Highlands	2688.9	223.7	165.3	386.0	81.5	195.0	246.8	581.0	0.092	0.216	2.354	33.6
Gia Lai (+ Kon Tum)	923.6	242.0	73.6	143.9	34.5	74.4	108.1	218.3	0.117	0.236	2.019	34.1
a) Gia Lai	773.8											
b) Kon Tum	149.8											
Da Lac	1072.3	244.9	62.7	171.2	29.3	80.2	92.0	251.4	0.086	0.234	2.733	31.9
Lam Dong	693.0	166.2	29.0	70.9	17.7	40.4	46.7	111.3	0.067	0.161	2.383	36.3
East Of Southland	8194.2	121.6	304.0	789.4	83.6	186.3	387.6	975.7	0.047	0.119	2.517	19.1

Province	Popln	Food	Paddy		Cereal		Food Crop Total		Crop area per capita	Crop product per capita	Crop product per area	Cereal as % total
	'000	kg/capita	Area	Prodtn	Area	Prodtn.	Area	Prodtn.				
			000ha	000T	000ha	000T	000ha	000T	ha/cap	T/cap	T/ha	
Ho Chi Minh	4075.7	60.6	79.3	237.2	2.2	5.6	81.5	242.8	0.020	0.060	2.979	2.3
Song Be	1017.0	134.4	53.3	108.5	10.1	23.0	63.4	131.5	0.062	0.129	2.074	17.5
Tay Ninh	827.0	283.9	93.2	217.0	4.5	13.3	97.7	230.3	0.118	0.278	2.357	5.8
Dong Nai	1742.4	176.4	77.3	225.0	66.4	144.0	143.7	369.0	0.082	0.212	2.568	39.0
Vung Tau	532.1	15.7	0.9	1.7	0.4	0.4	1.3	2.1	0.002	0.004	1.615	19.0
Mekong	14882.6	658.2	2580.0	9480.3	45.0	127.5	2625.0	9607.8	0.176	0.646	3.660	1.3
Long An	1177.1	731.0	290.7	833.9	3.8	7.7	294.5	841.6	0.250	0.715	2.858	0.9
Dong Thap	1401.6	916.4	274.5	1249.9	3.0	8.2	277.5	1258.1	0.198	0.898	4.534	0.7
An Giang	1849.7	811.4	324.9	1477.0	5.9	21.4	330.8	1498.4	0.179	0.810	4.530	1.4
Tien Giang	1557.4	663.2	248.3	1004.9	3.0	5.5	251.3	1010.4	0.161	0.649	4.021	0.5
Ben Tre	1264.3	253.3	93.5	308.8	2.4	5.7	95.9	314.5	0.076	0.249	3.279	1.8
Cuu Long	1905.0	621.2	302.4	1117.4	11.2	40.2	13.6	1157.6	0.165	0.608	3.691	3.5
a) Vinh Long	1003.9											
b) Tra Vinh	901.1											
Hau Giang	2818.9	631.5	493.9	1726.1	5.0	15.5	498.9	1741.6	0.177	0.618	3.491	0.9
a) Can Tho	1695.0											
b) Soc Trang	1123.9											
Kien Giang	1266.0	712.0	270.8	861.6	7.4	17.5	278.2	879.1	0.220	0.694	3.160	2.0
Minh Hai	1642.6	564.8	281.0	900.7	2.8	5.8	283.8	906.5	0.173	0.552	3.194	0.6
Totals	66633.9	324.4	6027.7	19225.1	1083.2	263.5	27110.9	21488.6	0.107	0.322	3.022	10.5

Notes

1. Cereal is defined in Vietnamese statistic are non-rice food crop, i.e. maize, sweet potato, cassava.
2. Cereal production given in paddy equivalent (1T cassava or sweet potato = 0.33T rice).
3. Cereal as % of total in paddy equivalents.
4. (a) and (b) reflects current split of above province; no indidual data is available.
5. Source: Statistical Data of the Socialist Republic of Vietnam.
   Statistical Publishing House.

Appendix 3. Distribution and change of livestock holdings by province over 1986 to 1990 period.

Province	Popltn 000	Buffalo 1986 '000	Buffalo 1990 '000	% incr.	1990 hd/ hshld	Cattle 1986 '000	Cattle 1990 '000	% incr.	1990 hd/ hshld	Pigs 1986 '000	Pigs 1990 '000	% incr	1990 hd/ hshld
North Mountain	11542.8	1134.5	1286.1	13.4	0.56	450.5	523.9	16.3	0.23	2798.6	3087.1	10.3	1.34
Ha Tuyen	1087.1	178.2	193.5	8.6	0.89	48.7	39.2	-19.5	0.18	323.7	338.0	4.4	1.55
a) Ha Giang	489.9												
b) Tuyen Giang	597.2												
Cao Bang	591.5	108.8	124.6	14.5	1.05	75.3	93.7	24.4	0.79	233.2	254.7	9.2	2.15
Lang Son	643.6	160.6	179.8	12.0	1.40	23.8	29.1	22.3	0.23	176.7	194.2	9.9	1.51
Lai Chau	467.6	80.5	88.7	10.2	0.95	15.1	14.6	-3.3	0.16	133.0	142.4	7.1	1.52
Hoang Lien Son	1101.9	125.5	146.2	16.5	0.66	34.9	36.5	4.6	0.17	335.6	352.3	5.0	1.60
a) Loa Cai	491.5												
b) Yen Bai	610.4												
Bac Thai	1082.6	139.2	160.2	15.1	0.74	12.2	17.5	43.4	0.08	274.2	307.0	12.0	1.42
Son La	726.8	79.3	86.0	8.4	0.59	80.8	84.3	4.3	0.58	237.6	277.4	16.8	1.91
Quang Ninh	848.2	44.2	50.2	13.6	0.30	8.8	9.5	8.0	0.06	185.6	198.7	7.1	1.17
Vinh Phu	2097.7	91.2	96.6	5.9	0.23	110.9	130.4	17.6	0.31	390.2	420.6	7.8	1.00
Ha Bac	2172.9	127.0	160.2	26.1	0.37	40.0	69.1	72.7	0.16	508.8	601.8	18.3	1.38
Hoi Binh	722.9												
Red River Delta	13275.6	327.6	355.9	8.6	0.13	191.3	288.2	50.7	0.11	2662.0	2879.2	8.2	1.08
Ha Noi	2095.0	49.7	51.6	3.8	0.12	63.5	90.2	42.0	0.22	467.9	480.1	2.6	1.15
Hai Phong	1516.9	28.7	29.3	2.1	0.10	3.1	3.9	25.8	0.01	274.6	254.9	-7.2	0.84
Ha Son Binh (Ha Tay)	2130.0	94.7	108.2	14.3	0.25	47.5	63.6	33.9	0.15	395.0	446.1	12.9	1.05
Hai Hung	2554.5	59.5	65.5	10.1	0.13	22.9	41.0	79.0	0.08	509.9	581.0	13.9	1.14
Thai Binh	1705.4	33.5	33.9	1.2	0.10	15.3	29.2	90.8	0.09	372.7	402.2	7.9	1.18
Ha Nam Ninh	3273.8	61.5	67.4	9.6	0.10	39.0	60.4	54.9	0.09	641.9	714.9	11.4	1.09
a) Nam Ha	2473.7												
b) Ninh Binh	800.1												

Province	Popltn 000	Buffalo 1986 '000	Buffalo 1990 '000	% incr.	1990 hd/ hshld	Cattle 1986 '000	Cattle 1990 '000	% incr.	1990 hd/ hshld	Pigs 1986 '000	Pigs 1990 '000	% incr	1990 hd/ hshld
Central coast - Northland	9054.2	524.2	568.7	8.5	0.31	538.3	642.0	19.3	0.35	2019.8	2052.4	1.6	1.13
Thanh Hoa	3152.9	186.7	199.5	6.9	0.32	109.3	147.2	34.7	0.23	658.5	659.7	0.2	1.05
Nghe Tinh	3796.4	261.0	288.9	10.7	0.38	285.1	328.8	15.3	0.43	849.1	883.6	4.1	1.16
a) Nghe An	2561.9												
b) Ha Tinh	1234.5												
Quang Binh	693.2		23.1		0.17		96.1		0.69		193.3		1.39
Quan Tri	490.8	76.5	26.9	5.0	0.27	143.9	53.1	15.4	0.54	512.2	146.4	-0.6	1.49
Thua Thien Hue	920.9		30.3		0.16		16.8		0.09		169.4		0.92
Central coast - Southland	6995.6	137.8	151.8	10.2	0.11	806.6	845.6	4.8	0.60	1347.6	1343.5	-0.3	0.96
Quan Nam - Danang	1832.3	39.4	44.7	13.5	0.12	165.8	178.0	7.4	0.49	505.4	484.3	-4.2	1.32
Quang Ngai	1090.4	53.5	42.5	12.7	0.19	327.3	149.1	3.6	0.68	538.2	262.9	-4.3	1.21
Binh Dinh	1295.0		17.8		0.07		190.1		0.73		252.2		0.97
Phu Yen	670.5	18.8	3.9	0.5	0.03	195.3	147.1	5.6	1.10	211.9	145.3	12.7	1.08
Khanh Hoa	871.7		15.0	0.09		59.2		0.34		93.5		0.54	
Thuan Hai	1235.6	26.1	27.9	6.9	0.11	118.2	122.1	3.3	0.49	92.1	105.2	14.2	0.43
a) Ninh Thuan	412.0												
b) Binh Thuan	823.6												
Central Highlands	2688.9	53.7	61.8	15.1	0.11	287.5	342.0	19.0	0.64	510.2	577.6	13.2	1.07
Gia Lai (+ Kon Tum)	923.6	20.4	22.3	9.3	0.12	166.6	197.5	18.5	1.07	228.0	249.3	9.3	1.35
Gia Lai	773.8												
Kon Tum	149.8												
Dac Lac	1072.3	16.4	19.1	16.5	0.09	85.0	105.3	23.9	0.49	194.6	227.4	16.9	1.06
Lam Dong	693.0	16.9	20.4	20.7	0.15	35.9	39.2	9.2	0.28	87.6	100.9	15.2	0.73
East Of Southland	8194.2	147.9	138.5	-6.4	0.08	225.5	215.3	-4.5	0.13	565.2	515.4	-8.8	0.31

Province	Popltn 000	Buffalo 1986 '000	Buffalo 1990 '000	% incr.	1990 hd/ hshld	Cattle 1986 '000	Cattle 1990 '000	% incr.	1990 hd/ hshld	Pigs 1986 '000	Pigs 1990 '000	% incr	1990 hd/ hshld
Ho Chi Minh	4075.7	32.9	32.5	-1.2	.04	48.8	45.0	-7.8	0.06	227.1	157.5	-30.6	0.19
Song Be	1017.0	38.8	32.3	-16.8	0.16	53.0	53.4	0.8	0.26	80.4	103.6	28.9	0.51
Tay Ninh	827.0	60.1	55.3	-8.0	0.33	52.1	48.6	-6.7	0.29	65.8	58.3	-11.4	0.35
Dong Nai	1742.4	15.6	17.9	14.7	0.05	70.1	66.6	-5.0	0.19	185.3	191.1	3.1	0.55
Vung Tau	532.1	0.5	0.5	0.0	0.00	1.5	1.7	13.3	0.02	6.6	4.9	-25.8	0.05
Mekong	14882.6		331.9	291.3	-12.2	0.10	283.8	259.7	-8.5	0.09	1892.5	1805.4	-4.6
Long An	1177.1	63.2	51.0	-19.3	0.22	37.5	26.2	-30.1	0.11	129.8	137.9	6.2	0.59
Dong Thap	1401.6	19.2	15.3	-20.3	0.05	18.2	13.5	-25.8	0.05	129.5	152.1	17.5	0.54
An Giang	1849.7	2.7	5.7	111.1	0.02	66.4	79.6	19.9	0.22	124.7	97.4	-21.9	0.26
Tien Giang	1557.4	24.8	13.1	-47.2	0.04	35.0	15.7	-55.1	0.05	218.2	209.1	-4.2	0.67
Ben Tre	1264.3	23.8	18.8	-21.0	0.07	39.0	32.0	-17.9	0.13	151.6	159.5	5.2	0.63
Cuu Long	1905.0	62.5	60.8	-2.7	0.16	64.0	64.8	1.2	0.17	260.1	265.0	1.9	0.70
a) Vinh Lon	1003.9												
b) Tra Vinh	901.1												
Hau Giang	2818.9	51.0	43.9	-13.9	0.08	11.4	10.1	-11.4	0.02	393.5	313.1	-20.4	0.56
a) Can Tho	1695.0												
b) Soc Trang	1123.9												
Kien Giang	1266.0	32.6	34.4	5.5	0.14	12.0	17.6	46.7	0.07	187.1	177.1	-5.3	0.70
Minh Hai	1642.6	52.1	48.3	-7.3	0.15	0.3	0.2	-33.3	0.0	298.0	294.2	-1.3	0.90
Totals	66633.9	2657.6	2854.1	7.4	0.21	2783.5	3116.7	12.0	0.23	11795.9	12260.6	3.9	0.92

Notes
1. (a) and (b) indicates current split of above province; no individual data available
2. Source: Statistical Data of the Socialist Republic of Vietnam.
Statistical Publishing House.

Appendix 4. Annual income and expenditure for workers and farmers in North and South Vietnam and in selected provinces in North Vietnam, 1991.

a) North and South Vietnam.

Area	Workers and officials		Farmer household	
	Income VND/cap	Expenditure VND/cap	Income VND/cap	Expenditure VND/cap
Overall	48,084	47,835	32,248	35,107
North	37,639	37,325	27,900	29,565
South	58,467	58,467	36,596	40,649

b) Provinces in North Vietnam.

Provinces	Workers and officials		Farmer household	
	Income VND/cap	Expenditure VND/cap	Income VND/cap	Expenditure VND/cap
Hanoi	48,907	49,419	33,689	39,108
Hai Phong	47,686	50,467	35,706	39,708
Vinh Phu	34,357	32,770	31,843	34,347
Nghe Tinh	30,329	29,625	25,893	28,745

Notes 1. $US 1.0 = 10,000 VND (April 1993)

2 Source: Statistical Data of the Socialist Republic of V. Statistical Publishing House, 1992.