Country Pasture/Forage Resource Profiles

VIET NAM

by

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1. INTRODUCTION

Viet Nam stretches 1 600 km from China to the Gulf of Thailand, encompassing virgin forests, rugged mountains and fertile valleys. Shaped like an elongated **S**, or to the more imaginative a "descending dragon", Viet Nam covers the length of the Indochinese peninsula, bordering the China Sea in the East, Laos and China in the north, and Cambodia in the west (see Figure 1). Viet Nam's territory includes a vast sea area including a large continental shelf and various islands. Viet Nam is endowed with considerable diversity and is located between 8^0 33' and 23^0 20' North and 102^0 and 109^0 27' East. At either end of the country are two alluvial plains, the Red River Delta in the north and the Mekong Delta in the south.

Viet Nam has a history of 9 000 years. The capital is Hanoi and there are big cities such as Haiphong and Halong in the North and Ho Chi Minh, Danang, Hue, Nhatrang, and Cantho in the South. Although Viet Nam has 60 different ethnic groups and languages, Vietnamese is used throughout the country. According to the World Factbook the July 2006 population was 84 402 966 with a growth rate of 1.02%. There are a number of administrative units at province, district, city, town and commune level. Table 1 shows the extent of various land-cover types. Specific classes like marsh and mangrove are mainly in the Mekong Delta; forest is categorized as evergreen or deciduous; other groups like scrubland, agricultural area and water bodies are also noted.

At constant 1994 prices, Gross Domestic Production (GDP) increased by 8.71% in 1995. In comparison with the index of 1995 (1995=100), GDP increased 40% in 2000. From 1995 all sectors of the economy continued to grow. Agriculture, forestry and fishing were 24.3% of GDP in 2000 (General Statistics, 2000). Gross output of agriculture in 2000 was 125 384.3 billion dong (1 US$ =15 000 Dong); crops had the highest share with 77%, livestock was 20% and services 3%.

The two major classifications of land are alienable (tenured land and farm land) and forest lands, both of which are lands of the public domain. Forest land covers 9 280 230 hectares of which 1 471 400 ha are planted. There are types of forest classified as public forest, permanent forest or forest reserves, timber land, grazing lands and others and which are not alienated.

Figure 1. Map of Viet Nam
[Source: World Factbook]

Total area of crops was 12,470,700 ha in 2000 including cereals, annual industrial crops, perennial industrial crops and fruit. About 83% of farm land is used for annual crops and only 17% for permanent crops. Planted area and gross output of cereals (paddy and maize) in 2000 were 8 368 900 ha and 34 483 500 tonnes, respectively. Data show a total area of 7 540 900 ha of paddy and an output of 32 554 000 tonnes. All paddy is based on smallholders and is irrigated. Gross output of cereals per capita was:

363.1 kg in 1995
392.6 kg in 1997
407.6 kg in 1998
432.7 kg in 1999
443.9 kg in 2000

(Source: General Statistics, 2000)

Table 1. Land cover types and extent of Viet Nam

Land cover category	Area km²	%
Evergreen Forest	80 303.3	24.7
Deciduous Forest	11 348.6	3.5
Mangrove Forest	1 150.4	0.4
Marshes	6 039.2	1.9
Scrubland	162 841.0	50.1
Agriculture	60 886.5	18.7
Water	1 393.3	0.4
No data available	1 278.4	0.4

i) Evergreen Forest is multi-level with an undergrowth of shrubs and natural regeneration. Trees of Dipterocarpaceae often dominate the upper storey, sometimes reaching considerable heights. Other families represented in the upper storey are Ebenaceae, Leguminosae, Guttiferae and Meliaceae.
ii) Deciduous Forests are dominated by species of Lagerstroemia and constitute a transition between closed evergreen forest and woodlands. Bamboos are the undergrowth of deciduous formations and also invade abandoned farmland.
iii) Mangrove occupies large areas in the extreme south near Ho Chi Minh City and small patches in the Red River delta. Species of the genera Rhizophora and Bruguiera account for three quarters of well-developed-stands.
iv) Marshes are in areas more or less permanently covered by fresh water. The following species occur: Eugenia elaeocarpus, Sterculia, Adina cordifolia, Calophyllum inophyllum as well as numerous species of palm. Homogeneous stands of Melaleuca leucadendron form behind the mangroves in areas not reached by brackish water.
v) Scrubland normally follows forest destruction, an open shrubby vegetation develops with sporadic distribution of trees with grasses on the ground.
vi) Agriculture is cultivated land and consist mainly of paddy fields, either irrigated or rainfed. It includes abandoned fields and exposed soil during the dry period.
vii) Water is lakes, rivers and water-filled depressions on the alluvial plains.
viii) No Data Available designates those covered by clouds and some topographic effects such as mountain shadow (as the information was derived from satellite imagery).

Average farm area was 0.82 ha, with close to 50% of farms below 0.50 ha. Land areas and yield of crops and crop categories are shown in Tables 2 and 3.

Table 2. Total land area cultivated for the period 1994-2000 ('000 ha)

Item	1994	1995	1996	1997	1998	1999	2000
Annual crops							
Cereals	7 133.2	7 322.4	7 619.0	7 762.6	8 012.4	8 345.4	8 368.9
Industrial	655.8	716.7	694.3	728.2	808.2	889.4	808.7
Perennial crops							
Industrial	809.9	902.3	1 015.3	1 153.4	1 202.7	1 257.8	1 397.4
Fruit	320.1	346.4	375.5	426.1	447.0	512.8	541.0

Source: General Statistics, 2000

Table 3. Yield of main crops (quintal/ha)

Item	1995	1997	1998	1999	2000
Paddy	36.9	38.8	39.6	41.0	42.5
Maize	21.1	24.9	24.8	25.3	27.0
Sweet potatoes	55.3	63.3	60.2	64.6	64.3
Cassava	79.7	94.5	75.3	79.9	86.7
Groundnut	12.9	13.9	14.3	12.8	14.5
Soybean	10.4	10.6	11.3	11.4	11.6
Sugar cane	476.5	463.8	489.2	516.0	503.3
Jute	19.7	19.2	21.8	22.9	19.3
Cotton	7.3	9.2	9.2	10.5	10.1
Rush	72.7	72.9	71.3	66.5	67.2
Tobacco	9.9	10.3	10.3	11.0	11.1

Source: General Statistics, 2000

Farm work is done by the farmers themselves with some help from their families or between families. In larger enterprises in the Mekong River Delta, farmers may hire other persons for field preparation, planting and harvest. Management of farms is in the hands of the family members. Payments to labourers are in cash or in kind depending on the prevailing rate in the locality. The labour required for different agricultural activities or for certain crops varies with location and cropping systems; the use of animals, tractors or machines facilitate work.

For the livestock sector, from 1994 to 2000, the average increase in cattle numbers was 2.1%, 6% for goats and sheep, 4.4% for pigs and 6.6% for poultry. The ruminant population has been increasing for the last six years, except for buffaloes which recorded a 0.43% reduction and although there was no change in the horse population between 1994 and 2000 there was a decline thereafter. Viet Namese statistics on animal numbers are given in Table 4.

Of the country's land area, forest has the highest share with 28.6%. Agricultural land has about 18.7% while land for special use (hospitals, schools and universities, industry, mining and quarrying) and homesteads (fisheries, settlements and open land) account for 4.7 and 1.3%, respectively. At present, grazing areas are on community forest lands.

Table 4. Livestock numbers, production and imports 1995–2005

Item	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Cattle nos.(,000)	3 638.9	3 800.0	3 904.8	3 987.3	4 063.7	4 127.9	3 900	4 063	4 394.4	4 907.9	5 250.0
Buffalo nos. (,000)	2 962.8	2 953.9	2 943.6	2 951.4	2 955.7	2 897.2	2 807.9	2 814.5	2 834.9	2 869.8	2 950.0
Goat & sheep nos. (,000)	550.5	512.8	515.0	514.3	470.8	543.9	572.5	621.9	780.4	1022.8	1200.0
Horses nos.(,000)	126.8	125.8	119.8	122.8	149.6	126.5	113.4	110.9	112.5	110.8	111.0
Poultry nos. (mill.)	142.1	151.4	160.6	166.4	179.3	196.1	218.1	233	247	218.2	245.0
Pig nos. (mill)	16.3	16.9	17.6	18.1	18.9	20.2	21.8	23.2	24.9	26.1	27.0
Beef & veal production (,000 mt)	83	83	72	79	88.5	92.3	97.8	102.5	107.5	119.8	121.0
Buffalo meat prod.(,000 mt)	96.8	92.5	92.2	84.3	90.3	92.5	96.8	96.9	99.6	101.1	103.2
Sheep & goat meat (,000 mt)	4.1	4.6	4.6	4.7	4.7	4.8	4.9	5.4	6.0	7.8	9.2
Poultry meat (,000 mt)	175.8	196.7	284.7	299.4	325.5	365.3	385.4	420	455.5	404.6	388.2
Pig meat (,000,000 mt.)	1.0	1.1	1.2	1.2	1.3	1.4	1.5	1.7	1.8	2.0	2.1
Cow & buffalo milk prod. (,000 mt)	65.8	68.4	59.3	62.9	69.7	84.5	94.7	109.5	157.7	182.3	196.0
Poultry bird imports nos (,000,000)	0.7	0.5	0.5	0.5	0.7	0.8	0.7	1.5	1.1	0.5	n.r.
Milk equivalent imports (,000 mt)	233.7	247.1	175.8	276.6	397	558.5	800.6	513.1	647.5	644.2	n.r.

Source: General Statistics, 2000 and FAOSTAT, 2006
n.r.=no record

In terms of value of production at current prices cattle, buffaloes and small ruminants contributed 11 919.7 billion dong or around 65% of the total animal production in 2000. Poultry contributed 3 295.7 billion (18%), while non-meat production contributed just over 15% (2,802 billion dong). Livestock is a major source of income for smallholders. Production data are given in Table 4. Due to shortage of local milk, 90% of the country's milk requirement is imported, largely in dry form (see Table 4).

2. SOILS AND TOPOGRAPHY

Viet Nam can be divided into four physiographic regions: the Annamese extending from north to south through west-central Viet Nam, the Red River delta in the north, the Mekong River delta in the south, and the coastal plain in the east. The extremely rugged and densely forested Cordillera, a southward extension of the Yunnan Plateau, covers about two-thirds of the country. Parallel northwest-southeast ranges with several peaks rising to more than 1 800 m dominate the northern half, and a series of heavily eroded longitudinal plateaus average elevation 750 to 1 500 m extend into the southern half.

Viet Nam has fourteen soil groups and 31 soil units (a simplified soil map is shown in Figure 2), however, for easier evaluation these soils can be grouped into 2 big combinations:

Mountainous and hilly soils: most are Acrisoils, Ferralsols, or Alisols. Under annual cropping, without reasonable improving measures, the soil is rapidly degraded. The mountainous and hilly soils should be reserved for afforestation, cultivation of perennial crops, and fruit crops with appropriate protection measures.

Delta soils. The centres of food production are mainly the deltas of the Red River, the Mekong River and other rivers. These are regions with high levels of intensive cultivation

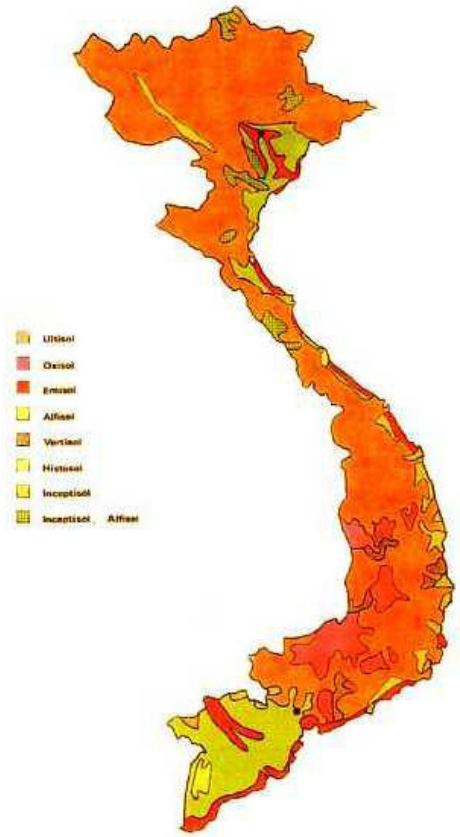

Figure 2. Soil map of Viet Nam
Adopted from FAO World Soil Map by R.H. Howeler

and crop intensity. With irrigation, moisture is sufficient, the rate of soil degradation is low; alluvial deposits bring fertility annually; this is often augmented by organic and mineral fertilizers.

The soil and vegetation characteristics of the main agro-ecological regions are described below:

North-eastern Region

The topography slopes from Northwest to Southeast with an average altitude from 400–500 m. In coastal regions bordering upon the deltas, there are sloping hills and land with an altitude above 200 m. Soil developed on calcareous low hilly and mountainous regions belongs to the yellow and red group. Alluvial soils are found in the valleys, along rivers and deltas. Two thirds of the forest has been removed and bare hills remain, or a thin secondary forest cover which can regrow in areas of high rainfall. Highland soils are easily lost through erosion.

Northeast Hoang Lien Son Region

This region and the Northeast are bordered by a range running from Nag Son and Coc Xo to Tam Dao. The border with the Northwest is the Hoang Lien Son range. Bare hills, and mountains cover 3 300 000 ha. The main geomorphological units are

- High mountains (above 2 000 m) are strongly dissected; deforestation has brought about increasingly serious erosion.
- Low hills and mountains (under 1 000 m).
- Highlands and calcareous mountains remain in Dong Van (1 600), and Quan Ba (1 100 m- 1 200 m).
- Valleys and swamps are found mainly in the south of the area. Although their area is not very large, they play an important role in agriculture.

The soil developed on low calcareous hills belongs to the yellow and red group. Alluvial soils are found in the valleys along rivers and deltas. Two thirds of the forest has been removed and bare hills remain; a thin secondary forest cover can regrow in areas of high rainfall. On highland areas soils are easily lost through erosion.

The North-west (Tay Bac Region)

The land slopes from northwest-east south, bounded by the Hoang Lien Son range and Pulasan-Pudendinh and Panamas ranges along the Viet-Lao border. Mountain ranges and highlands are divided by valleys, large rivers and streams running North West-Southeast. This region can be divided into geomorphic forms as follows:

- High mountains (over 2 000 m) in the northwest are strongly eroded, ending in the Hoang Lien Son range and Puxilung block.
- Average mountains (1 000–2 000 m), these are also strongly eroded.
- Low mountains (<1 000 m) are strongly eroded, their average altitudes are from 400 m to 800 m.

The soils of the region are: yellow-red, yellow-red humus group on the mountains and humus soil on high mountains. The soils on the level land are alluvial, black, deposited soil, brown soil on neutral and volcanic rocks, and red-brown soil on calcareous rocks. In general, soils are acid and poor, and very shallow. On the calcareous highlands and Dien Bien and Pudendinh regions, the soils are relatively deep.

Northern Central Region

Average mountain height is 1 000–2 000 m: these mountains form a narrow range along the Viet-Lao border, including some with altitudes above 1 000 m and some are above 2 000 m. However, hills under 1 000 m account for much of the region.

The main soil groups in the mountains are yellow-red, with humus soil. The main soil group of low hills is yellow-red soil on sedimentary rocks. In the delta the soils are alluvial coastal soil and coastal sand soil.

Central Southern Coastal Region

The Central southern coastal region consists of Bach Ma and the South-eastern Nam Truong Son ranges, which account for a large area. Deltas cover small areas. The arc-shaped mountains make up adjoining ranges with their branches stretching to the sea.

Above 1 000 m the main groups of soil are: yellow-red humus and humus soil while below 1 000 m the main soil belongs to the yellow-red group. Nam Ngai delta has the highest amount of alluvium in Quang Nam and Quang Ngai provinces.

Northwest Delta Region

Except on mountains, most soil is alluvial from the Red and Peace rivers. Alluvial land on river banks is extended by about 13 000 ha by annual silt deposits, of which 74% is from the Red river and of light mechanical composition, fertile, suitable for industrial trees, food crops and food trees. Alluvial soil covers the highest areas within dykes. On lower minor areas, swampy soil covers about 46 000 ha. In coastal regions there is alkaline soil. Around the margin of the delta, there is infertile, eroded grey soil which has been cultivated for a long time.

Tay Nguyen Region

Tay Nguyen, at average altitudes of 500 to 600 m, is mainly on Bazan red soil, calcareous rocks and granite hills. Dac Lac highland is lower than Gia Lai highland, and average altitudes are 400 m to 500 m.

In the South, on the Di Linh and Bao Loc highlands, the main soils are brown ferralitic red soil generated from Bazan rock, with 10–12 m thick, black, colour faded grey soil, yellow-red ferallitic soil on the sediment rocks and alluvial soil deposited by rivers and streams.

The South-eastern Region

There are two main soil groups. Grey soil covers 34.26% of the region. Yellow red soil covers 44%. The yellow-red soil group of red-basalt soil generated on basalt rocks, is heavy with a, high silt and humus content.

Mekong delta Region

The Mekong delta, a major area of food production, is alluvial and of low relief.

3. CLIMATE AND AGRO-ECOLOGICAL ZONES

Its latitude range means that Viet Nam has a tropical monsoonal climate with hot winters in the south and cool winters in the north. The main climatic zones and number of wet and dry months are shown in the agro-climatic map in Figure 3. Nine agro-ecological zones are recognized which are described briefly below (and see Figure 4):

North-eastern Region

The Northeast suffers most from the effects of the Northeast monsoon. The cold season comes earlier than in other provinces. Winter temperatures are from 1 to 10 ^{o}C lower than other regions. Average January temperature in Cao Bang is 11.5 ^{o}C and in July 26–27.7 ^{o}C; in Quang Ninh in January is 15 to 16 ^{o}C and in July 47 – 28.8 ^{o}C. The rainy season starts between May and September and its duration can vary from 4 to 10 months with the yearly rainfall more than 1 276 mm, except for coastal regions. The number of rainy days reaches 120–160. This supplies enough moisture for 7 to 9 months.

At altitudes of 500–600 m, trees remain of walnut, Pines such as *Pinus caribaea, Pinus khasya, Pinus dalatensis*, green ironwood *Cephalotaxus mannii, Cephalotaxus oliveri, Amentotaxus argotaenia, Manglietia chevalierii, Manglietia conifera, Manglietia insigni, Vatica cinerea, Vatica mangachapoi, Parashorea chinensis* which can grow in the cold and dry climate. These trees also remain in minor forests.

Northeast Hoang Lien Son Region

In the mountains, the monthly average temperature is over 20 ^{o}C from March to November. The highest monthly temperature is hardly above 28 ^{o}C, but night temperature in some places falls to below 1 ^{o}C. In high mountains, the winter is cold and it can freeze with snow and hoar-frost; average temperature

exceeds 20 °C from July onwards. Winter lasts from 70–100 days. The average day temperature is 15 °C. The average number of days below 10 °C is 50.

This region is moist throughout the year, with much heavy rain, and the highest rainfall in the country. Rainfall in the less rainy season is 30-40 mm to 60–70 mm/month. By the end of winter, drizzling rains increase strongly. The number of drizzle days exceeds 50-70. The highest rainfall reaches 3,000 mm. In heavy rain centres the amount of rainfall reaches 1,500 mm/month but in drier years, does not exceed 1,500 mm/year. In the mountains rainfall is over 200 mm/month, lasting for 5 months constantly. In low hills and mountains the growing season is under 8 months and rainfall is from 1000-1100 mm/year.

Cattle and buffaloes have a long tradition. There are many precious forest trees such as *Hopea recopei, Shorea henryana*, and *Vatica cinerea*.

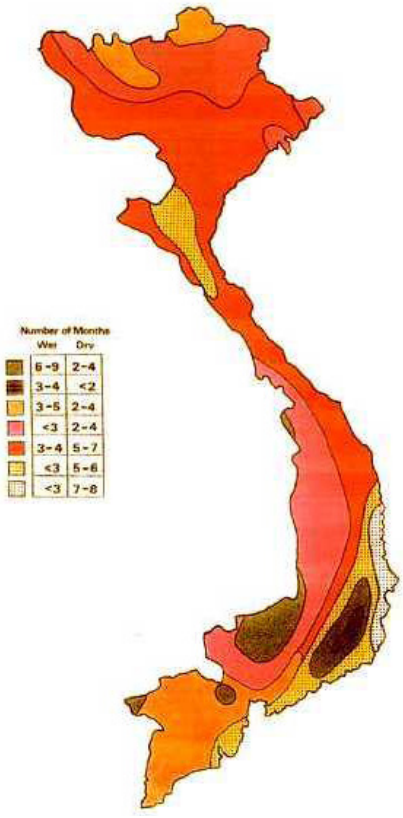

Figure 3. Viet Nam: main agro-climatic zones
Adopted from Agro-climatic map of S.E. Asia. Source: Huke, 1982

The North-west (Tay Bac Region)

Due to the geographical structure, the winter is cold, with hoarfrost on high belts. In the summer there is hot wind. During winter the diurnal temperature range is 12 °C to 14 °C. Summer comes sooner than to other regions, from March night temperatures are over 30 °C, and the weather in April is really hot. The month with the highest average temperature is June, but in Lai Chau it is August, in Moc Chau, it is July. The maximum temperature measured is from 41.1 to 42.5 °C. The minimum temperature is from - 0.8 °C to 3.9 °C. The valleys are sheltered from wind, so the dry seasons are longer, and the yearly amount of rainfall decreases. Dry seasons last from 4 to 5 months. The rainfall is usually under 1 500 mm.

The varied climate and terrain has created a variety of forest forms. In the North and South East, there is evergreen, tropical-humid forest. The main families are Lauraceae, Fagaceae, Magnoliaceae, Araliaceae and Euphorbiaceae. These forests are characteristic of the ecology of the North-western region and cover a large area; they are also found in Hoang Lien Son on a much smaller area.

The East and Southeast of the region have a sparse tropical forest. On high belts, under 700 m, forests are evergreen-wet and tropical. Trees include *Dipterocarpus costatus*, *Dipterocarpus intricatus, Dipterocarpus kerrii*, *Vatica fleuryana*, *Vatica astrotricha*, *Hopea chinensis*, *Neohouzeaua.* On low lands there is a type of deciduous forest, able to withstand wet and dry climate; broad leaved trees grow among conifers such as *Keteleeria davidiana*, *Pinus khasya*, *Pinus mercusia* and *Podocarpus fleurgi*. Under 700 m trees are mainly Dipterocarpaceae*, Vatica fleuryana, Vatica astrotricha.*

Northern Central Region

Winters are cold, the average temperature in December to February is below 20 °C (about 16 °C to 19 °C). Average temperatures in July are from 28 °C to 29 °C. In January average temperatures of the North are from 16.5 °C to 17.5 °C and of the South from 17 °C to 20 °C.

There is much rain, distributed unevenly. This region suffers from violent storms, hot winds and a winter monsoon. The number of

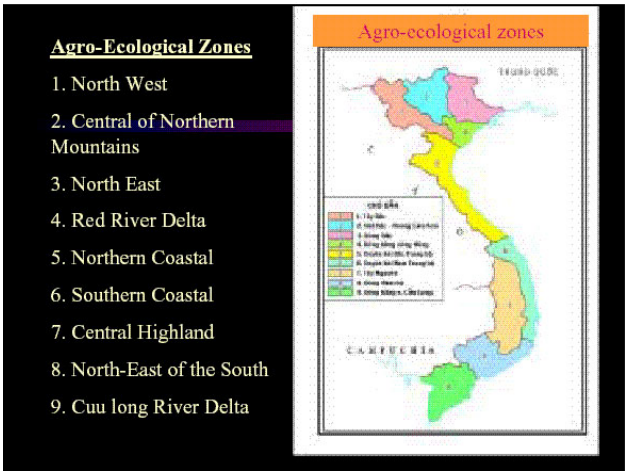

Figure 4. Viet Nam: the nine agro-ecological zones

sunshine hours is from 1 500 to 1 700/year. Calculated radiation is from 105 kacl to 130 kacl/cm^2/ year. The yearly average rainfall of Tay Hieu is 1 268 mm, of the North it is 2 399 mm, and of the South is 1 300 mm.

In the North and Northwest the flora is partially isolated, deciduous, wet forests with: Combretaceae, Lythraceae, Meliaceae, Sapindaceae, Sterculiaceae and Leguminoseae. In the West above 700 m, the flora is evergreen and isolated rain forests with *Dipterocarpus costatus*, *Dipterocarpus intricatus, Dipterocarpus kerrii, Symplocos olivacea.* On low land along the coast, uncultivated land accounts for approximately 1 400 000 ha in which there are 85 000 ha of planted forests and 300 000 ha of bamboo.

Central Southern Coastal Region

The yearly average temperature is above 25 °C. There is no cold winter. The rainy season lasts from September to December or January. Above Quy Nhon, the average temperature is above 23 °C; the yearly temperature range of the North is about 5 °C, of the South from Nha Trang it is about 3 °C. In the North (Quang Nam, Quang Ngai), there is heavy rain with 1 600–4 000 mm/year. In the South (from Binh Dinh to Ninh Thuan) rainfall only reaches 1 300 to 1 400 mm/year. Phan Rang is a dry area, the yearly rainfall is from 700–800 mm.

The flora of this region belongs to the hot and dry climate of the low mountain belt. Because the dry season lasts for 3-6 months it has a special flora with large isolated bushes and hard leaves. In the East, along central coastal regions, there are also plantations; the main trees are *Pinus patula, Pinus caribaea* and *Eucalyptus*. Coastal deltas are used for crop production. Main limitations: violent storms, hot wind, droughts and floods damage the region.

Northwest Delta Region

Every year there are about 60 to 80 days below 15 °C and there is hot wind during 38 days. Rainfalls of over 50 mm occur 7–12 times. The amount of moisture is enough for over 10 months every year. Radiation is abundant, 105l-120 kcal/cm^2/year. Photosynthetic radiation is also high, 56- kcal/cm^2/year. Rainfall is 1 600-2 200 mm/year. Sunlight is from 1 600 to 1 800 hours/year.

Tay Nguyen Region

Annual average temperatures are from 21 °C to 23 °C. The hottest months are March and April, the coldest is January. Minimum night temperature are from 5 °C to 8 °C in Da Lat and some time it can be below 0 °C. The diurnal temperature ranges are from 8 °C to 10 °C.

Moisture is insufficient from December to March. In many places it rains continuously for five months with more than 200 mm/month (from May to September). Cheo Reo has rainfall of more than 200 mm for two months but yearly amounts are from 1 200 to 1 800 mm and in Buon Ma Thuat it is no more than 1 400 mm.

The flora belongs to the isolated and sub-tropical forests of the highland and mountainous region and consists, according to the altitude, of the following floristic types. Above 1 000 m there is a highland climate, so there are isolated sub-tropical forests with *Pinus patula* and *Pinus dalatensis*. Main planted trees are pines, *Pinus massoniana*, *Pinus khasya*, *Pinus dalatensis*, *Amentotaxus argotaenia*, *Amentotaxus poilanei,* and tea. Below 1 000 m, there is tropical, dry broadleaf forest with bushes and tall tropical grass. Main plants are: *Cephalotaxus mannii, Amentotaxus yunnanensis, Manglietia chevalierii, Shorea guiso, Parashorea chinensis, Madhuca alpina, Madhuca firma Keteleeria davidiana*, *Pinus khasya*, *Pinus mercusia*, *Podocarpus fleurgi,* and other families such as Lauraceae, Fagaceae, Magnoliaceae, Araliaceae and Euphorbiaceae.

The South-eastern Region

The yearly average temperature in the mountains is 21 °C. The winter diurnal temperature range (from November to April) is 10–14 °C and of the other months from 7 °C to 9 °C. In high and average mountains there is not enough moisture for the whole year; in low mountains and deltas, moisture is just enough for nine months – usually 7–8 months have above 100 mm/month and there is more than 200 mm for six consecutive months. The months, with the highest rainfall are July and August. Rainfall in the mountain is 1 100 to 1 200 mm/year and in the delta from 1 400 to 1 600 mm. The driest months

are November and December. Yearly sunlight hours exceed 2000. January, February and March all have more than 200 hours/ month. September has the lowest sunlight time, 100-120 hours.

Mekong delta Region

Annual average temperatures are from 26-27 °C. In Can Tho, the maximum night temperature is 40 °C and the minimum night temperature is 14.8 °C. The amount of rainfall in the west is very variable with eight months receiving more than 100 mm among which there are six, consecutive months with 200 mm/month. In Ca Mau it rains continuously for five months with 300 mm/month. In the East and the Northeast of the deltas rainfall gradually decreases from more than 2 000 mm to 1 400–1 600 mm. In some places, during seven months, it rains continuously and for two months receives over 200 mm/ month, such as in Chau Doc, Cao Lanh, My Tho, Ba Tri and Moc Hoa; the yearly rainfall is more than 1 500 mm. Sunlight hours are more than 2 700 in the Northeast and 2 300 hours in the west. April has more than 200 hours of sunlight.

The Mekong delta has violent floods in September and November. River levels rise at the end of September and the beginning of October and fall in November – then comes a dry season. In the floods, water covers a third of the delta; some places are flooded to 3–4 m. In some places, salt water encroaches into the delta for 50 km. Salty lands (744 000 ha) cover 18.9% of the region with high alluvium levels.

4. RUMINANT LIVESTOCK PRODUCTION SYSTEMS

In Viet Nam ruminant production is based on small households; there are few dairy cattle in large commercial units. About 90% of farm households keep three to five cattle, mainly for draught, which can be sold when they need cash. There is some 10% of semi-commercial ruminant production units with 50 to 100 head in the North East, North West and North Central Coast; specialized cattle fattening is a source of main or additional income where crop production is not remunerative. Ruminant production is classified into dairy cattle, buffaloes and small ruminants.

Dairy cattle

See Table 5 for numbers.

Since 1958–1960 the Government has been developing milk production for improved human nutrition. The Roan White Black breed was imported from China and bulls of this breed were used for crossing with the Lai Sind in Bavi creating an F_1 herd. This F_1 herd could produce 1 800 kg/300 days of lactation. In 1970 to 1978, 1,500 Holstein Friesian were imported and raised in Mocchau, Sonla and Lamdong – milk production was 3,800–4 000 kg per 300 days.

From 1990-2001 dairy cattle numbers increased 3.8 times, and from 1999 to 2000 numbers rose from 30 000 to 40 000 and 42 000 in 2001, in which milking cows are around 18 000. At present 99% of dairy cattle are F_1 and F_2 Holstein Friesian (HF) in the structure of breeding (89% F_1 HF and 10% HF) and a few crossbred of F_1 Sindhi (1%). From 1994 to 2001, milk yield per lactation of F_1, F_2 HF increased from 2 330 to 3 300 kg. For pure breed HF, milk yield increased from 3 300 to 3 850 kg per lactation.

Dairy cattle are kept in three regions: (i) Ho Chi Minh City and peri-urban areas (some 85% of dairy animals); (ii) Provinces in the North (13-14%), and (iii) Provinces in the Central region (about 1%). About

Table 5. Population of dairy cows[1] and milk yield per lactation by years

Years	Total cows	Cross breed		Pure breed	
		Number	Milk yield/lact.	Number	Milk yield/lact.
1990	11 000	9 000	2 100	2 000	2 800
1991	12 100	9 300	2 200	1 800	3 000
1992	13 100	11 500	2 200	1 600	3 200
1993	15 100	13 500	2 250	1 500	3 200
1994	16 500	15 000	2 300	1 500	3 300
1995	18 700	16 200	2 330	1 500	3 300
1996	22 000	20 650	2 500	1 450	3 400
1997	24 500	23 050	2 700	1 450	3 500
1998	27 000	25 300	2 800	1 700	3 600
1999	28 500	27 750	3 000	1 750	3 700
2000	35 000	33 000	3 600	2 000	3 850

Source: Vu Van Noi et al. *(2002)*

1 FAOSTAT data for numbers of cows are nearly double these figures.

94.5% of dairy cattle are kept by small households with 3–5 head, there are some 0.5% of large farms with 50–100 head and another 5% are kept in large units to supply breeding stock for developing dairy cattle nationally. The total population is around 35 000 dairy cattle, mainly in peri-urban areas. Milk production was 45 000 tonnes in 1999, accounting for 10% of the country's demand (7 litre/person/year), thus the bulk of the country's milk requirement is imported (Vang, 2000). According to FAOSTAT (2005) milk production from cows tripled between 2000 and 2004 to nearly 150,000 tonnes

Table 6. Net income from dairy cattle on small scale farms

Parameter	Unit	Number of cows per farm		
		1–5 head	6–10 head	>10 head
No. of milking.herd	%	33.33	58.94	7.70
Milk yield/day	kg/cow	12.1	13.7	15
Expenditure/farm/year	VN Dong*	32 131 900	76 897 891	122 223 565
Net income/farm/year	VN Dong	2 117 850	17 675 201	35 283 100
Rate of net income/ expen.	%	9.15	22.98	28.85
Rate of income/expen.	%	40.28	54.06	56.53
Average of milking cow	head	1	4.6	7.6
Dairy cattle capital	VN Dong	8 500 000	41 400 000	76 000 000

(: 1 $ = 15,000 VN Dong)*
Source: Vu Van Noi, 2002

Table 7. Population of cattle including dairy cattle ('000 head)

Regions	1995	1997	1998	1999	2000
Whole country	3 639	3 965	3 987	4 064	4 128
Red River Delta	441	453	457	470	488
North East	419	453	476	500	507
North West	129	141	150	153	158
North Central Coast	831	871	872	869	890
South Central Coast	855	905	925	935	937
Central Highlands	437	498	521	534	525
North East South	376	423	421	418	424
Mekong River Delta	150	160	164	184	197

Source: General Statistics, 2000

In Viet Nam dairy cattle production is part and parcel of a crop-animal system; an important feature is its rapid expansion in smallholder areas, driven essentially by urban demand, and the opportunity to generate income. Ownership of 2–15 animals and a small area with crops or pasture, leads to a situation in which milk production is a major component of farm income. This model is very common in peri-urban areas, where good markets and production services are found. The major constraints to production in these systems are availability of suitable animals, feed resources and improved feeding systems, improved breeding, reproduction and animal health care, management of animal manure, and organized marketing and marketing outlets. In spite of being mainly on small farms production has provided good income compared to other jobs. With stable milk price from year to year, a high net income from 5-20% in dairy cattle production is obtained by the farms (Table 6).

Fattening cattle

The main source of fattening cattle is the local Vang breed which is small, average live weight about 140–160 kg/head for female and 250–280 kg for male, with a killing out percentage of about 42-44%. Pure Sindhi was imported in 1923; bulls of this breed crossed with Vang improve body weight of the F_1 female up to 35-40% and the carcase-weight by 44 to 49%. With the use of F_1 Sindhi female crossed with Charolais bull, F_1 can be 300 kg and carcase percentage of meat can be increased from 53 to 54%. Using F_1 Sindhi female could improve the beef herd not only by improving body weight but also to use as the source for continuing to cross with the male Holstein Friesian to improving body size. Cattle are mainly raised in hilly or mountainous areas. Beef cattle are raised on small farms with 2-5 head although there are some farms with 50–100 head. Some areas such as peri-urban Hanoi, Bienhoa, Ho Chi Minh City and large farms with many F_1 Sindhi females, cooperate with other regions to increase the size of beef cattle. The population of cattle by region from 1995 to 2000 were as shown in Table 7.

Buffaloes

Buffaloes are considered as a long-term investment by farmers and occupy a very high position as a source of inheritance from one generation to the next; Viet Namese farmers call buffaloes "the beginning of inheritance". In general, village farmers do not use the banks since they live in remote areas and, after all, do not have excess cash to deposit. What they earn in cash is barely sufficient for subsistence. Livestock is generally a means of saving: poultry and pigs are short term savings while buffalo and cattle are long term ones. In case of crop failure buffaloes or cattle will be sold to obtain cash. For traditional

ceremonies such as marriage or some religious rites, farmers sell buffaloes or slaughter them for meat. Buffaloes are stronger than cattle and, in the deltas, can be used on both high and low land. Their value is measured in terms of draught power, amount of manure and partly meat. Draught power is not as critical as formerly, and since agricultural mechanization is developed in some regions the role of buffaloes is sometimes neglected. Even if soil preparation could be mechanized, the buffalo remains important for rural transport and meat. Buffalo meat accounts for half of all beef. Despite this the buffalo herd remains static; numbers fell by 0.43% from 1995 to 2000 (General Statistics, 2000) and have remained the same from 2000 to 2004.

Table 8. Population of buffaloes in Viet Nam by region ('000 head)

Regions	1995	1997	1998	1999	2000
Whole country	2 962	2 943	2 951	2 955	2 897
Red River Delta	287	252	236	229	213
North East	1 210	1 244	1 269	1 290	1 252
North West	320	342	356	365	375
North Central Coast	661	669	670	668	679
South Central Coast	135	125	125	127	128
Central Highlands	69	72	72	72	68
North East South	155	141	131	127	118
Mekong River Delta	125	99	90	76	64

Swamp buffalo rearing is a backyard activity with 99% in the hands of smallholders, mainly the rice farmers, for draught power. Each farmer keeps one or two buffaloes and maintains them by grazing on roadsides or common land. Only two state farms keep a few dozen to a hundred dairy buffaloes. In semi-intensive systems dairy buffaloes are raised mainly for milk and are stall fed; forage or grass are cut and carried. Rice straw and crop residues are supplementary feeds. Crop by-products are mixed with the concentrate. Occasionally buffaloes are given urea molasses blocks or urea treated rice straw. A very few herds larger than a dozen are kept in mountainous areas, where grazing land is still sufficient. All buffaloes are of the swamp type and small. Adult weight is 340 kg, and a new born calf is about 22–23 kg. After weaning at 6–12 months, calves grow slowly, but growth improves after 12 months. The body weight of calves at 12 months is 150 kg. There is a small herd of Murrah buffaloes, imported from India in the seventies, but its number has gradually declined. The outlook for dairy buffaloes in Viet Nam is not clear.

The major cause of low productivity of ruminant livestock, especially in hilly land, is lack and poor quality of feed. The main feeds are crop residues, permanent pastures and other agro-industrial by-products. Pasture area is declining steadily as the increasing human population demands more land for crops while there is a strong interest from farmers to maintain animal numbers because of the need for draught power.

Goats

Goat distribution is closely related to their owners' traditions and ecological conditions (Tran and Nguyen, 1990). Most goats, (72.7% 25 000 head) are in the northern, mountainous provinces. They are also found in coastal regions of Central Viet Nam, where the climate is hot, dry and water is scarce (21.3%). Only 6.3% are in South Viet Nam (Binh, 2002). Generally goats are raised in relatively dry areas with poor vegetation. In a harsh environment, goats perform better than other animals.

Approximately 95% of goats are local breeds: the main ones are Grass breed, Bach Thao and cross bred. The Grass breed is wide-spread in many ecological zones; they are well adapted to poor nutrition and management, small and well known for high prolificacy. Most goats are reared for meat. The Bach Thao is bigger than the Grass breed and also are dual-purpose for meat and milk; average milk yield varies from 1.5–3 litre/day over 150–165 days.

Since 1993 the demand for goat products (both milk and meat) has increased considerably but returns to farmers remain below potential due to low productivity, largely associated with feed quality. The Government places a high priority on the development of viable goat rearing; improving access by very poor communes to breeding schemes, and working with communes to improve husbandry and feeding strategies for goats are appropriate means of addressing rural poverty. Six breeds: Barbary, Beetal, Jumnapury, Alpine, Saanen and Boer were imported to improve body size and milk yield of local goats.

Most goats are privately-owned (Nguyen, 1988) by smallholders with an average of 5–7 animals. In forests, mountainous and hilly regions, many farms keep 100-200 goats. State farms just maintain some for research and breeding. Goats are kept in fields during the day, at night they are housed without feed or water. In the plains of North Viet Nam meat goats are herded, but in the South they are penned or

tethered under fruit trees. Dairy goats are kept in pens with feed and water. The management of reproduction is poor. For meat goats, bucks and does run together without controlled mating which leads to high mortality of newborn kids. However, dairy goats are very well managed.

Table 9. Dairy cattle feed resources in the south-eastern region of Viet Nam

Native grasses	Improved grasses	Forage legumes
Digitaria adscendens	*Pennisetum purpureum*	*Stylosanthes sp.*
Panicum repens	*Panicum maximum*	*Centrosema pubescens*
Brachiaria dystachia	*Digitaria decumbens*	*Leucaena leucocephala*
Brachiaria mutica	*Brachiaria ruziziensis*	*Gliricidia sepium*
Chloris barbata		*Indigofera tessamii*
Eulesine indica		
Cyperus rotundus		
Crop residues	Agro-industrial by-products	Supplements
Rice straw	Soybean waste	Mixed feed
Sugar cane tops	Brewery waste	Mineral mixture
Groundnut vines	Pineapple peel and waste	
Maize stalk	Cassava waste	
Cassava leaves	Groundnut cake	
	Cotton cake	
	Banana peel	
	Bagasse	
	Rice bran	
	Wheat bran	
	Molasses	

Source: Cuong et al. *(1992)*

Feeding systems and integration of livestock into farming systems

Dairy production is most important in the South-eastern region, where feed can come from green fodder (native and cultivated grasses, legume forages), crop residues, agro-industrial by-products and concentrates (Table 9).

The limited amounts of good roughage, combined with intensive production in peri-urban areas has forced dairies into heavy dependence on concentrates; this has increased feed competition with other livestock. Better use of local resources by improving low quality roughage, better feed management and preserving high quality green fodder by improved storage methods are the most promising strategies for reducing feed costs and dependence on other feeds. Green maize is grown and supplied by a large number of farmers to feedlot operators and dairies. Fodder production has taken over a significant portion of the maize grain area. Some farmers prefer to grow fodder maize because they can solve the year-round green fodder supply for dairy cows, and especially in the dry season.

In the North Central and South Central Coast, where fattening of one or a few cattle is common, fresh grass, cane tops, maize stover, and rice straw are supplemented with fresh *Leucaena leucocephala* leaves. Some farmers feed a concentrate mixture at 0.5% of the animal's body weight. Chopped leucaena or cassava leaves, are mixed with a home-mixed concentrate of maize, cassava meal, rice bran, salt, ground oyster shell and molasses.

In rice growing areas, weeds constitute about half of the feed (from road edges, fields and ponds) with rice straw and other crop residues. Animals are stall fed and tethered in uncropped and idle land during the growing period of the rice. Rice straw is the principal feed after harvest; other crop residues such as maize stover and legume hay are fed, when available, in the wet season. At rice harvest, paddy fields are communal grazing in the short gap between crops, which may be two or three times per year depending on the number of rice crops grown.

Rice straw, the most important feed, is readily available throughout the country, with a total 25-30 million tonnes produced annually (Bui Van Chinh and Le Viet Ly, 2001), of which part is burnt or left in the field, some is used for fuel or mixed with manure for fertilizer. Rice straw is low in available energy, protein and vitamins and imbalanced in essential minerals, but it contains a large pool of structural carbohydrates which can potentially be degraded by rumen microbes into volatile fatty acids, and thus an energy source for ruminants.

Urea treatment is the most suitable method of improving the quality of rice straw and increasing crude protein concentration and rumen degradability. A combined ration of green grass and Urea Treated Rice Straw (UTRS) increased degradation of organic matter, crude protein and crude fibre (Tuan, 2000). Replacement of grass by UTRS 50:50 for lactating cows in winter is as good as feeding grass alone in terms of milk yield, body weight gain and feed conversion (Mai Van Sanh *et al*., 2001). Treatment with urea (50 g/kg DM rice straw) preserves fresh rice straw safely and improves its nutritional value. Urea-treated rice straw is a palatable roughage that can replace elephant grass in milking cows' diets at high levels (75%), resulting in increased milk fat and without any effect on milk production (Man and Wiktorsson, 2001).

Cassava tops and *Gliricidia* can be ensiled by conventional methods, with or without additives. Ensiling reduces cyanogen content markedly by HCN volatilisation and to a lesser extent, the tannin content of the raw materials. A supplement of cassava top silage, especially with a molasses additive, to a grass diet of dairy heifers, increased the dry matter and digestible crude protein intake (Man and Wiktorsson, 2001).

Goats usually graze natural pasture or feed on leaves from trees. According to Nguyen (1972) a hectare of rocky mountain can keep 4–5 meat goats, and they can be raised on mountains with 28–52% of slope. In the plains goats graze on grass and leaves such as bananas, *Sesbania*, Jackfruit, Acacia and Cassava. Concentrates are not used for meat goats. The most important feed is grass from roadsides, fields and ponds. Crop residues are the main feed in the dry period, but their nutritive value is often below the level required for production. Dairy goats in hilly areas are commonly tethered and given supplements of high protein foliage which is bundled and suspended under the house or from trees. Plants used include *Sesbania, Leucaena, Gliricidia sepium, Flemingia macrophyla* as well as Jackfruit (*Artocarpus heterophyllus)* leaves. These are high in protein and ash (Nguyen Thi Mui *et al.,* 2001ab) Recent research has concentrated on increasing feed resources by growing crops with high yield, good nutritive value and good adaptation to hilly areas, especially in the dry season. Sugar cane and multi-purpose trees have proved to be particularly suitable. Pigs and young goats are fed sugar cane juice, the tops are fed to mature goats, peeled stems are used as a basal diet for rabbits and pressed sugar cane stalks are fed to buffaloes and cattle. Feeding systems based on sugar cane are being introduced to farmers in all hilly areas, where the intensity of land use is not high and there is a potential for growing more cane, provided a sufficiently attractive market for livestock products can be developed. Sugar cane has commonly been used as a feed for cattle in the dry season when the availability of conventional forages is limited. A model for using sugar cane as a feed for ruminants, for growth or milk production must take into account its high fibre, low protein and high energy content. Generally, when the level of sugar cane is 30% dry matter in the diet, there is a positive effect on both the liveweight gain of goats and milk production of cows (Nguyen Thi Mui *et al*., 2000). In sugar producing areas cane tops constitute 75 to 100% of the feed after the harvest and cane milling season which coincides with the dry season.

In most developing countries, crop-livestock production systems form the backbone of agriculture. Systems involve crops, livestock, land, water etc., in which these sub-systems and their synergistic interactions have a significant positive and greater total effect than the sum of their individual effects (Edwards *et al*., 1988). In Viet Nam these systems are called VAC systems and combine home gardens, fish ponds and livestock; they have been developed for a long time in many agro-ecological regions (Thien, 1998). Mixed systems account for the highest proportion of the meat producted in the country. Diversification, saving and recycling resources are their basic characteristics, which provide stability and a positive environmental impact. However, mixed farming systems bring more management complications, difficulties in isolating problems and generally lower yields compared to specialised and intensified ones. The feeding of animals in mixed crop-livestock farming systems revolves around the use of crop residues, weeds, tree leaves and planted fodders.

Grazing systems

Before 1995 in hilly land, an area of forest after burning was used for crops such as maize, rainfed rice, and cassava. With no fertilizer use there was rapid exhaustion of soil nutrients. Areas could be used for 2 to 3 years then most remained fallow for 6 months to 1–2 years, even 10–12 years and were used for grazing volunteer vegetation. Cattle, buffaloes, goats and sheep grazed these fields until fertility recovered and farmers could have the next cycle of crops. Other sources of grazing were free in common areas or land around national forests, where feed was available. Since 1995 the forest is being divided for farmers according to Government policy. Grazing is limited to land very far from farm houses inducing a high risk.

In intensive farming there is little space to keep livestock and grow improved grasses. Farmers prefer small ruminants to cattle and buffalo; they keep livestock as savings: chickens and pigs are sold to meet daily needs, small ruminants are sold to meet seasonal needs (e.g. school fees, clothing); large ruminants are sold to meet occasional needs (e.g. weddings, building special houses). In intensive crop areas ruminants are kept for draught and saving and are always stall-fed. For improved forage, cut and carry

is usual and forage is fed at night as a supplement. Under coconuts, oil-palm and rubber stall-feeding or tethering may be used.

Free grazing is only done on uncropped land, common land or fallow. In the high mountain areas of the North Northeast and North-Viet Hoang Lien Son there are two feeding systems (i) semi-intensive grazing and (ii) "feeding on the back". In the first farmers keep their stock at home and cut and carry is used during the rainy season when crops are growing. After harvest ruminants are allowed to graze the fields until the next crop and are housed at night. For the second, animals are penned all the time and farmers feed them during the day. Feed is collected from the field and forests; fodder shrubs and trees have been used to overcome feed shortage. In the North Central highlands where farmers keep big flocks (goats, sheep, cattle), animals graze forest land far from the houses. Children or a man always look after the grazing animals. At night animals are penned within a fence of Cactus, to protect them from wild animals.

Production constraints

The constraints associated with the growth and expansion of ruminant livestock production in Viet Nam are primarily:

- Dairy cattle have a long growing time and low coefficient of reproduction, and there is poor focus on genetic improvement, low knowledge about dairy production and herd management and no planning of breeding management from the government to the local level
- An insufficient number of high yield breeding stock; some provinces have brought breeds from abroad, this is only a temporary solution, and is not sustainable.
- Some areas with high potential for developing dairying such as Lamdong, Mocchau have no milk processing or marketing facilities,
- Lack of good quality feed and pasture, especially in the dry season or when drought occurs, because most farmers neither grow forage nor use the available fodder trees to supplement poor quality roughage. Shortages in feed are experienced due to inefficient use of farm by-products, and improper handling and processing of forage crops during peak supply periods or during harvesting of field crops.
- Lack of appreciation of the value of improved pasture. Only a few stock owners with over 20 dairy cows use improved pasture. Several have started introducing improved pastures on their properties but the forages are only in small patches that are generally left unattended or unprotected from free grazing animals. Expansion of improved pasture is very limited on land used for planting food crops or fruit trees. Improved pasture is based on wasteland, home garden, wild land, gravelly soil, low lying land or newly reclaimed land of too low productivity.
- The grazing system is not suitable for buffaloes and cattle since the size of the grazing areas is reduced day by day due to the conflict between buffalo, cattle production and the expansion of cropping and forestry.
- Unfavourable climate means a decline of one kilo of milk for each degree of temperature above 27 ^{o}C. Milk yield of Holsteins begins to fall above 21 ^{o}C, Brown Swiss drops at 24 ^{o}C and 27 ^{o}C for Jersey. Humidity promotes the multiplication of disease-causing organisms.
- Lack of credit for smallholders due to the large investment needed for financing milk cows and farmers must borrow with long term loans; lending procedures are very complicated and cumbersome.

5. THE PASTURE RESOURCE

The pasture area in Viet Nam is presented in Table 10. Total grassland is 534 100 ha, or 5.7% of all cultivated land, which can be suitable for crops, trees, aquaculture and forestry. The productivity of grasslands has been adversely affected due to their small extent and overgrazing; at present they are producing about 20% of their potential because of poor management. In hilly areas natural grazing is still important for feeding cattle and buffaloes.

Depending on cropping patterns from region to region, pastures in Viet Nam are classified as:

Table 10. Land suitable for crops, and pasture purposes by physiographic zone

Regions	Thousand ha		
	Cultivated land	Grassland	%
North West	560.6	113.0	1.14
Vietbac-Hoanglienson	758.2	117.2	1.19
North East	677.9	70.8	0.72
Red River Delta	764.2	4.3	.04
North Central Coast	1 008.9	80.3	0.81
South Central Coast	708.2	52.5	0.53
Central Highland	997.4	58.3	0.60
North East South	1 171.4	36.6	0.37
Mekong River Delta	2,823.6	1.1	0.1
Aquaculture	416.1		
Total	9 886.5	534.1	5.5

Source: Tran An Phong, 1995

Natural resources

In the high land, almost 70–80% of grasslands are covered with dominant species such as *Digitaria adscendens, Panicum repens, Brachiaria dystachia, Brachiaria mutica, Chloris barbata, Cyperus rotundus, Cynodon dactylon, Axonopus compressus, Eragrostis nigra, Paspalum dilitatum* and *Panicum coloratum* and shrubs or trees such as *Artocapus heterophyllus*, *Hibiscus rosa-sinensis, Flemingia* sp.

Several plants from rice and maize fields serve as forage, the majority them are weeds, and include *Cynodon dactylon, Digitaria* sp. and *Dactyloctenium aegyptium*. Other grasses used as feed are *Imperata cylindrica*, *Paspalum conjugatum* and *Cyrtococcum* sp. which grow naturally in orchards and wastelands or idle lots where most of the broadleaf species, such as *Synedrella nodiflora*, *Pseudo-elephantopus spicatus* and *Asystasia gangetica*, are also found.

In summer, most land is planted with rice, maize, groundnut, soybean and sweet potatoes. Forage from these crops provides the bulk of fodder for stall-feeding, especially for dairy cows. Urban cattle also feed on vegetable and fruit wastes. Community and government wastelands are used to some extent. Usually milking animals are stall-fed with green fodder and concentrates. Dry and draught animals are maintained on straw, maize stover, and community grazing lands. In winter all farmers sow green maize intercropped with vegetables. According to holding and herd size rice straw provides feed in winter. Other crop residues such as maize grain, maize stalk, cassava leaves, tubers, stalks and sugar cane tops, leaves or stalks are also components of livestock diets.

Improved pastures

Since the mid 1970s, a dramatic shift in the paddy growing system took place, from single cropping to two or three crops annually. As a consequence, there is a serious shortage of space and forage for livestock. With the increased demand for milk, meat, and other dairy products, some farmers cultivate large areas of Elephant grass (*Pennisetum purpureum*), *Brachiaria* sp., Guinea grass and maize. Some farmers around such big cities as Ho Chi Minh City plant grass to sell green fodder to farmers raising dairy cows and forage cut-and-carry feeding plays a vital role for dairy goats, cattle and buffalo production. Every farmer allocates a piece of land for fodder crops in irrigated areas if they keep ruminants.

Several hundred improved tropical pasture accessions have been introduced and evaluated in different ecological environments over the last 20 years by the National Institute of Animal Husbandry (NIAH), and promising forages have been identified. Ruzi grass (*Brachiaria ruziziensis*), imported in 1991, grows well on grey-soil in the South East region and hilly land of the North of Viet Nam. The cutting cycle of Ruzi grass is quite good at regrowth 40 days with yields of 25 tonnes dry matter (DM) /ha/year (Duong Quoc Dung, 1995).

In high land with low fertility soil *Panicum maximum* Hamil, *Panicum maximum* Likoni, *Pennisetum purpureum* King grass, and *Brachiaria mutica*, have good production records, from 10–23 tonnes dry matter/ha/years (Nguyen Ngoc *et al*., 1995). Other promising grasses including Guinea *(Panicum maximum)* and Signal Grass (*Brachiaria decumbens*) which are able to perform in any of the sedentary and alluvial soils in all agro-climatic zones (Table 11). *Brachiaria humidicola* and *Tripsacum andersonii* (Guatemala grass) are important on acid sulphate soil and in areas with a high water table (Dung *et al*., 1999); on all soil, Napier (*Pennisetum purpureum)* is outstanding, *Brachiaria ruziziensis, Panicum maximum* TD58*, Panicum maximum* K280*,* and *Panicum maximum* Likoni have shown vigorous growth in acid soil.

In Daklak in the Central Highlands, some 21 improved grasses and legumes which grow well have been extended to farms rearing ruminants. All are planted for cut and carry but receive neither fertilizer

nor irrigation; the edible biomass yields are promising (Table 12).

On land with slopes of 8-10° and 20-25° in the North East Region grasses such as *Brachiaria decumbens*, *Setaria splendida*, *Panicum maximum* TD58, *Panicum maximum* Ghine and *Paspalum atratum* are outstanding in terms of biomass yield with 6 cuts per year (Table 13)

On lower sites, commonly used grasses are *Pennisetum purpureum* grass, *Pennisetum purpureum* Selection, *Brachiaria ruziziensis, Panicum maximum* TD58, *Panicum maximum* K280, *Panicum maximum* Likoni. Legumes are *Stylosanthes* Cook, *Stylosanthes* verano, *Stylosanthes* seca, *Glycine* Cooper, *Centrosema pubescens* often as ground cover in plantations. Recently, the good performance of the stylo accession CIAT 184 (*Stylosanthes guianensis*) and *Flemingia macrophyla* have attracted attention due to their good seeding and acid soil tolerance.

Stylosanthes guianensis cv. Cook is high yielding and produces rich quality forage. The green yield can be 87.2 tonnes/ha/year with 4 cutting times in the wet season. In the dry season this forage can grow well when irrigation is applied. The cost of 1 kg fresh forage is about 189-199 VND with 3-5 days irrigating intervals (Le Ha Chau, 1999).

Flemingia (*Flemingia macrophylla*) is a deep rooted shrub, which can grow to a height of 2.5 m. The leaves are trifoliate and leaflets are papery with a glabrous upper surface. Flemingia can be found from sea level up to 2 000 m and has a minimum annual rainfall requirement of about 1 100 mm. It is hardy, can resist long dry spells and is capable of surviving on very poorly drained and occasionally water-logged soils. Flemingia is found on both clay and lateritic soils and is tolerant to shade and fire. Binh *et al*. (1998) reported that Flemingia in Viet Nam has an outstanding adaptation to acid (pH=3.5) soils with high contents of soluble aluminium, it grew well in soils with a pH of 4.5. Flemingia has also been used for

Table 11. Biomass productivity (tonnes/ha/year) of grasses and legumes in different regions

Forage	Longmy		Sonthanh		Bavi		Tuliem	
	Cuts/ year	DM yield	Cuts/ year	DM yield	Cuts/ year	DM yield	Cuts/ year	DM yield
P.M. Hamil	5	9.7	7	17.6	8	16.5	9	17.3
P.M. Likoni	5	8.1	-	-	9	18.9	11	17.5
P.P. King grass	5	19.0	-	-	5	22.3	6	23.6
P.P. Selection	5	17.0	5	22.9	5	20.4	6	21.8
Brachiaria mutica	4	7.6	5	12.7	5	10.2	7	15.9
Brachiaria local	4	8.8	5	13.7	6	11.2	6	11.8
Stylo Cook	5	9.2	4	8.9	5	12.5	3	6.5
Stylo Verano	4	7.8	3	8.4	2	7.2	2	6.2
Stylo Seca	3	7.6	3	10.6	3	10.5	3	9.1
Siratro	5	9.4	3	5.8	3	4.3	3	4.3
Glycine Cooper	2	3.0	3	4.9	3	5.0	4	6.4

Source: Nguyen Ngoc Ha et al., 1995

Table 12. Biomass yield of forages in Daklak area

Forage	Yield, tonnes/ha/year		
	Green	Dry matter	Protein
Andropogon gayanus CIAT 621	64.90	17.30	1.94
Brachiaria brizantha CIAT 16318	71.48	17.19	1.67
Brachiaria brizantha CIAT 6780	65.95	15.50	1.63
Brachiaria decumbens CIAT 606	68.42	16.95	1.90
Brachiaria humidicola CIAT 6886	40.88	10.50	0.89
Brachiaria humidicola CIAT 6133	54.26	13.54	1.64
Brachiaria humidicola CIAT 679	51.84	13.13	1.17
Brachiaria ruziziensis Thailand	62.68	14.56	1.27
Panicum maximum CIAT 6299	67.95	17.37	1.85
Paspalum atratum BRA 9610	55.43	14.31	1.11
Paspalum guenoarum BRA 3824	52.05	12.20	1.01
Aeschynomene histrix CIAT 9690	12.60	4.86	0.86
Arachis pintoi CIAT 17434	16.97	4.02	0.67
Centrosema plumieri 58567	18.65	3.49	0.64
Chamaecrosta rotundifolia Winn	32.63	8.70	1.49
Desmodium heterocarpon 86277	17.19	4.42	0.68
Desmodium ovalifolium CIAT 13089	15.30	5.44	0.84
Macroptilium atropurureum CV Aztec	16.88	3.77	0.68
Stylosanthes guianensis FM05-2	48.94	12.20	2.07
Stylosanthes guianensis CIAT 184	41.85	11.37	2.03
Stylosanthes hamata Amiga	28.63	7.29	1.35

Source: Truong Tan Khanh et al., *1999.*

Table 13. Yield of grass varieties planted on different slope land levels (tonnes/ha/year)

Forage	Cuts year	Slope 20-25o			Slope 8-10o		
		Green	Dry matter	N %	Green	Dry matter	N %
P.M. TD 58	6	74.9	13.2	1.28	87.0	14.5	1.62
Setaria splendida	6	93.0	14.1	1.65	117.5	15.3	1.89
Brachiaria decumbens	6	79.9	13.8	1.49	90.3	15.4	2.02
P.M. Ghine	6	61.3	9.02	1.13	75.7	11.6	1.58
Paspalum atratum	6	59.9	8.89	1.15	108.6	16.1	2.25

Source: Quang 2001

soil conservation with good results. The plant has a high leaf:stem ratio, and can provide fresh edible biomass in the range of 45 to 64 tonnes/ha/year. In addition to fresh biomass, 24 to 38 tonnes of firewood (Binh *et al*., 1998) can be produced. Twenty months after sowing Flemingia, significantly better soil fertility was achieved compared to Guinea grass planted in the same contours on sloping lands in Viet Nam (Nguyen *et al*., 2000). This improvement could be attributed to the ability of Flemingia to fix N on acid soils. Binh *et al*. (1998) showed that approximately 4 tonnes per hectare of dried leaves fell on the soil surface, which reduced the germination of weed seeds and also reduced evaporation. Flemingia has a protein content of approximately 19% of dry matter (Binh *et al*., 1998), which makes it an interesting potential source of N in livestock diets.

Among leguminous fodder trees screened, *Leucaena leucocephala* remains the best in terms of production and persistence. *Leucaena* hybrid line, KX2, tolerant to acidic soils and the psyllid insect have been successfully selected and released. *L. leucocephala* K636*, L.Pallida* K748 and KX2 appeared to have a good potential, with higher biomass or dry matter, protein yield production than common *Leucaena* and *Leucaena leucocephala* Sanvado. Planting material of KX2 hybrid can be produced both by propagation and grafting. Table 14 shows total yields of Leucaenas for two years after establishment. Overall yield of leucaenas were high (maximum 63.4 tonnes/ha/second year) showing the potential of propagated *Leucaena* KX2 hybrid when grown on acid soil limed with 1000 kg/ hectare. KX2 hybrid has the most vigorous growth including some growth in the cool season, to resist psyllid insects. This variety offered the best sources of multipurpose trees for local farming systems. It could be planted as living fence, alleys, along the contour or in the garden for cut and carry system at smallholder level. With high quality fodder and protein source from the foliage, cane be replaced for expensive concentrate feeding. The levels suggested for getting the best production were 50% dry matter of replacement from KX2 foliage for concentrate. For growing goats foliage from leucaena species can be replaced up to 100% of DM of concentrate, and although lower weight gains are obtained this is compensated for by the lower feed cost (Nguyen Thi Mui *et al*., 2001).

Trichantera gigantea is a tree native to the Andean foothills in Colombia which tolerates shade. It is not a legume but its vigorous regrowth, with repeated cutting and without fertilizer applications, indicates that nitrogen fixation by Mycorrhizae or other organisms may take place in the root zone. Edible fresh biomass of this species varies from 66.7 to 80.5 tonnes/ha/year. The advantage of this tree is that its leaves are eaten readily by pigs, rabbits and chickens. *Trichantera gigantea* has adapted well to different ecological zones in Viet Nam, the leaves are rich in protein and have high digestibility (Nguyen Thi Mui *et al* 1999). It grows better under partial shade than in full sunlight (Nguyen Phuc Tien *et al*, 2001). The protein content of the foliage varies from 13.1 to 18%. It suggests a good potential and a source of protein substitute for concentrate when feeding rabbits, pigs and small ruminants. Data on its apparent digestibility in vivo indicated that it has potential as feed for livestock. However, in contrast to most tree foliages it appears to be more palatable to pigs and rabbits than to small ruminants.

Forages for integrated cropping systems which have been successfully used in farming systems of Viet Nam, are Sugarcane and also *Trichantera* on sloping land (Binh *et al*., 1998), under bananas, under orchards, planted as hedges or in alleys with cassava.

Sugar cane (*Saccharum officinarum)* which can be used for animal feed as well as for sugar production (Preston and Murgueitio, 1992), has a high leaf area index and higher photosynthetic efficiency under strong sunshine than any other crop in the tropics (Bassham, 1978). Alexander (1985) stated that the sugar cane plant is a very efficient converter of solar energy into biomass, which is the background for the idea

Table 14. Biomass productivity of *Leucaena leucocephala* cultivars on the acid soil of Red River delta

	K636	K748	KX2 Propagation	KX2 Grafting
The first year				
Cuts	5	5	4	4
Biomass yield, tonnes/ha	39.65	45.22	54.82	48.34
Fuel, tons/ha	4.17	6.80	9.35	4.13
Edible biomass, tonnes/ha	35.48	38.42	45.47	44.13
Dry matter yield, tonnes/ha	9.91	11.55	12.00	12.01
Protein yield, tonnes/ha	2.08	2.45	2.64	2.64
Second year				
Cuts	5	5	5	5
Biomass yield, tonnes/ha	45.70	43.30	63.40	57.70
Edible biomass, tonnes/ha	43.70	39.40	51.60	49.30
Dry matter yield, tonnes/ha	11.7	10.6	15.5	14.8
Protein yield, tonnes/ha	2.69	2.33	3.57	3.4

Source: Nguyen Thi Mui et al.*, 2001*

of "energy cane". The biomass yield of sugar cane is a function of the density of the mature plants at harvest time. The individual and combined effect of management practices can have a great impact on cane growth and yield. Decreasing row spacing and returning dead leaves to the soil increased biomass yields by 20-30% and can lead to significant improvements in soil fertility (Mui N.T. *et al*., 1996a,b). The beneficial effect of sugar cane on soil fertility, especially when the dead leaves are returned to the soil, is also reported by Phan Gia Tan (1993). Sugar cane is primarily an energy source.

6. OPPORTUNITIES FOR IMPROVEMENT OF FODDER RESOURCES

Grass is a new crop for Vietnamese farmers and is only occasionally sown in small areas because of limited land holdings. However studies have been undertaken on the best methods of managing sown pasture. These include cutting management for direct feeding or conservation for use in the dry season, fertilizer application, water irrigation etc.

Positive effects of irrigation and nitrogen have been obtained on *Stylosanthes guianensis* Cook at dairy farms around Ho Chi Minh City. Edible biomass yield increased 34.5 to 50.4% when Cook was irrigated at 3-5 day intervals compared to 10 days in the dry season and use of 60 kg of nitrogen/ha per cutting could increased biomass yield and feed quality (Table 15).

The positive effect of nitrogen for intensive production of grasses is very important for increasing biomass (Table 16).

Among introduced grasses *Panicum maximum* TD58 is very promising. Cutting at 35–40 day intervals with a fertilizer application of 60–80 kg/cut/ha gave the best green fodder yield (70–80 tonnes/ha/year) and better palatability for ruminants. The application of high nitrogen levels increased protein content of the grass. This grass is highly resistant to drought and has good seed production and quality. It has been introduced widely in dairy farms in the whole country with intensive farming or integrated under fruit trees. Several farmers around Ho Chi Minh City planted this species for selling to dairy farms.

In the North East, the economic viability of dairying based on improved pastures can be more beneficial

Table 15. Effect of irrigation on edible biomass yield and feed quality of *Stylosanthes guianensis* Cook

Parameters	Edible biomass yield, tonnes/ cutting/ha			Chemical composition		
	Green	dry matter	crude protein	DM, %	CP, % per DM	Fibre, %
Irrigation interval, days						
3	29.42	5.77	1.07	19.42	18.69	26.18
5	24.08	5.14	0.96	21.02	18.88	26.68
7	19.13	4.28	0.85	22.05	20.25	26.91
10	14.58	3.63	0.64	25.08	17.88	28.48
Nitrogen fertilizer, kg/cutting/ha						
30N	24.15	5.97	1.11	24.51	18.70	31.87
45N	28.98	6.88	1.41	23.53	20.58	30.91
60N	35.02	8.05	1.73	22.80	21.51	28.04
75N	38.64	8.60	1.92	22.08	22.44	29.64

Source: Le Ha Chau, 1999

Table 16. Effect of fertilizer applied on green biomass yield of some grasses and legumes

Forage	Fertilizer regime, kg/cut/ha	Green yield, tonne/ ha/year	Region	Source
Andropogon gayanus	70N	65.35	Songbe, NES*	Man *et al*., 1999
Panicum maximum Common	50N	62.08	‘’	Tho *et al*., 1999
Panicum maximum Hamil	50N	55.23	‘’	‘’
Panicum maximum Ciat 673	50N	58.50	‘’	‘’
Panicum maximum TD58	0N	58.00	Red River Delta	Phan, *et al.,* 1999
“	25N	99.00	‘’	‘’
“	50N	128.00	‘’	‘’
“	70N	79.23	Songbe, NES	Thoa and Dinh, 1999
Stylosanthes hamata	60 P2O5	37.40	Binhduong, NES	Man *et al*., 1999
Desmodium rensoni	60 P2O5	55.03	Thainguyen, NE*	Lien *et al*., 1999

**NES: North East South, NE: North East*

through a new system of integrating them with fruit trees. Some grasses with high yields are shown in Table 17. This system saves labour for controlling weeds and preventing soil erosion under fruit trees in the five years of establishment when trees do not fully cover the soil.

Table 17. Biomass yield and feed quality of some grasses under the shade of fruit trees

Varieties	Yield, tonnes/ha/year			Chemical composition		
	Green	Dry matter	N	DM, %/ kg feed	CP, % of DM	Fibre, % of DM
Brachiaria decumbens	65.7	11.1	1.1	18.43	11.24	31.72
Setaria splendida	79.3	12.2	1.3	15.65	12.01	28.54
P.M. TD 58	60.1	10.5	1.0	16.99	12.97	30.31

Source: Nguyen Van Quang, 2001

Practical application of improved pasture in farming systems

Although cultivated pasture is new to Viet Nam, many grasses and legumes have already been planted in farms and stations. Depending on the number of dairy cattle the pastures are established in different ways.

Pennisetum purpureum is the main grass commonly planted throughout the country and has often been used in intensive farming. Recent on-farm research in Viet Nam (1997-2002) through the FAO Regional Working Group on Grazing and Feed Resources of Southeast Asia, showed that Elephant grass in intensive farming for cut and carry produced enough green feed for 8-10 dairy cattle/ha - higher than for the last 5 year period 1990-1995 (4-5 cows/ha) due to the extra investment by the farmers. This is the main feed for liveweight gains of 300 to 400 kg/ha/yr at stocking rates of 2 to 3 animals/ha. This indicated that increased benefits that can be obtained from high yielding pastures. Green yield varies from 120 to 450 tonnes/ha/year.

Guinea grass (*Panicum maximum)* and Signal grass (*Brachiaria decumbens*) and Ruzi (*B. ruziziensis*) grow well under coconuts. Para grass (*Brachiaria mutica*) is the commonest grass grown under coconuts; it can be found extensively in most areas in Binhdinh and is widely grown in Phuyen Province along the Darang river.

Several species produce high yield and nutritive sources for ruminants such as *Panicum maximum,* Pangola*,* Bermuda*, Pennisetum purpureum, Paspalum dilatatum, Stylosanthes* sp., *Avena sativa* in the North and the South of Viet Nam. Since 1980, in the north several grasses including *Digitaria* sp., *Brachiaria humidicola*, *Brachiaria dictyoneura, Tripsacum andersonii* give high yields on acid soil. In the areas with a high water-table *Pennisetum purpureum* grows well. Other grasses like *Panicum maximum, Brachiaria decumbens* grow well in many kinds of soil; even in the poor and acid conditions; they not only yield well but have high seed yields. The legumes CIAT 184 *Stylosanthes guianensis*, *Leucaena leucocephala, Desmodium intortum* cv Greenleaf and *Desmodium uncinatum* cv Silverleaf grow well in good soil and are high quality feed. In most of the farms of the North and South, forages such as *Pennisetum purpureum, Panicum maximum* TD58, *Panicum maximum* Hamil, *Panicum maximum* Common*, Panicum maximum* CIAT *673* and legumes such as *Leucaena leucocephala*, *Centrosema pubescens, Stylosanthes guianensis* Cook have been established in integrated farming systems. *Brachiaria mutica,* and *B. decumbens* grow well under coconut shade in the Central Coast. In the Coast, Central and Highland Regions, supplying 10 kg of improved fodder to F_1 Charolais, F_1 Simmental or F_1 Red Sindhi which had access to grazing without concentrate supplement increased 20-33% live weight gain (Le Viet Ly *et al*., 1995). The contribution of forage has increased milk yield of dairy cows by 10-12% (Le Trong Lap *et al*., 1999). *Gliricidia sepium* has been widely used in integrated farming; with irrigation the plant gave high yields contributing to an increase of livestock production in the dry season in the East south (Man and Wiktorsson, 2001). *Leucaena leucocephala, Calliandra, Gliricidia, Flemingia, Trichantera gigantea* have been established on sloping land to supply animal feed and prevent soil erosion. Stylo has been planted between rows of tea. *Leucaena leucocephala* grown to shade tea with 5 000 plant/ha in Tuyenquang, Bacthai provinces increases yield and quality of green tea.

Pasture seed production

Seed of some grasses and legumes can be produced in Viet Nam. Harvesting one cut of *Brachiaria ruziziensis* 75-80 days after planting, then leaving the crop for seed gave high seed yield, from 439-462 kg/ha, and good quality seeds, in addition to about 41-43 tonnes/ha/year of biomass (Vu Kim Thoa

and Khong Van Dinh, 1999). Guinea grass (*Panicum maximum* TD58*)* needs 130–150 days growth before flowering and seed formation to get 634 kg/ha/year (Phan Thi Phan, *et al*., 1999). These can replace imported seeds and the cost of production is half the imported price. Table 18 shows seed production from some grasses and legumes.

Table 18. Seed production of grasses and legumes in different ecological regions of Viet Nam

Species	Yield, kg/ha/year		Seed quality		Sources
	Total	Standard seed	Weight of 1000 seed, g	Germination %	
The North East					
B. ruziziensis	313-462	280-378	6.65	89.0	Thoa and Dinh, 1999
Andropogon	1061	603	2.69	51.7	''
P.M. CIAT 673	185	108	0.95	65.2	
P.M. Gatton	147	98	0.92	63.1	
P.M. K280	163	112	0.91	61.4	
P.M. Hamil	156	117	1.13	78.6	
P.M. TD 58	157	118	1.05	79.5	
P.M. common	287	165	0.94	62.3	
Setaria sphacelata	148	98	0.36	78.2	
Stylosanthes hamata	430	236	2.43	72.5	Man *et al*., 1999
Red River Delta					
*B. ruziziensis**	239		5.61	2.1	Dung *et al*., 1999
*B. ruziziensis***	35		6.84	46.5	
P.M. TD 58	401-593	202-272	1.42	19.0***	Phan *et al*., 1999
F. *macrophyla*	70-130		18.5	70	Binh *et al*., 1998

(*): Harvest by cutting whole bunch of seeds; (**): Harvest by shaking ripe seeds out
(***) After 1 month collecting the seeds

Leucaena produces seed throughout the country. There are currently 14,000 plants of *Leucaena* KX2 hybrids (F1 of L.L.636 * L.K748) which can tolerate acid soil and is psyllid resistant (Nguyen Thi Mui, *et al*., 2000). *Leucaena* K748 is grown as "father" and *Leucaena leucocephala* K636 is used as "mother" trees.

7. ORGANIZATIONS AND PERSONNEL INVOLVED IN PASTURE RESEARCH

Key Research Institutions and Personnel:

Department of Pasture Research and Animal Feed Plant Resources, National Institute of Animal Husbandry, Chem, Tu Liem, Hanoi, Viet Nam

Beef and Pasture Research Centre, Bavi, Hatay, Viet Nam

Mountainous Science-Technology Development Centre, Thai Nguyen, Viet Nam

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