NATURAL RESOURCES SYSTEMS PROGRAMME

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Annex 2: Cropping systems

2.1 Cropping profiles in the districts

Cropping systems in the transition zone of Brong Ahafo are complex and diverse. In the survey of 6 settlements, 818 farm plots and 389 farmers, over 150 different cropping combinations were found. The dominant crops cultivated include yam, cassava, maize groundnut, sorghum, plantain cocoyam, bambara beans, cowpea, tomato, okro, pepper, and garden egg. Small quantities of rice are cultivated in valley bottoms. The dominant tree crop cultivated is cashew with some farmers also investing in teak plantations.

Cassava is the most commonly cultivated crop. It is cultivated by 76 percent of surveyed farmers on 45 percent of farm plots. It is a prominent crop in both northern parkland environments and southern deciduous forest areas. Yam is also very important and is cultivated by 71 percent of farmers on 36 percent of plots. Yams tend to be more important in the northern parkland environments than in the southern semi-deciduous forest. Maize is the third most important crop, and is grown by 60 percent of farmers on 35 percent of plots. Maize is important in both parkland environments and the southern deciduous forests, but is more prominent in the southern high forest fringe areas. Groundnut is the fourth most important crop, which is grown by 48 percent of farmers on 24 percent of plots. While groundnut is normally a savanna crop it has acquired importance in some of the high forest fringe communities. Groundnut is also a crop in which women specialise. Seventy percent of women in the sample cultivate groundnuts as compared to only 29 percent of men. Fewer women cultivate yams, cassava and maize than men.

Intercropping is more common than monocropping in the transition zone, with 62 percent of farm plots in the sample being grown intercropped , as compared to 38 percent monocropped. It is only at Kokoago that (among men) monocropping prevails over intercropping. The predominance of monocropping is indicative of the commercial orientation of farming. High rates of monocropping indicate market specialisation and a focus on maximising commercial yields of a narrow crop range. Intercropping is more associated with risk management strategies that attempt to hedge against the vagaries of markets, rainfall and pest attack. Monocropping is frequently associated with use of high inputs. Maize is frequently cultivated as a monocrop using inorganic fertiliser and tractor ploughing. However, groundnut is also an important monocrop, which is cultivated without the use of fertilisers. At Kokoago the high rates of monocropping reflect the adoption of high-input farming techniques.

Figure 2.1 Main crops grown in the Brong Ahafo transition zone

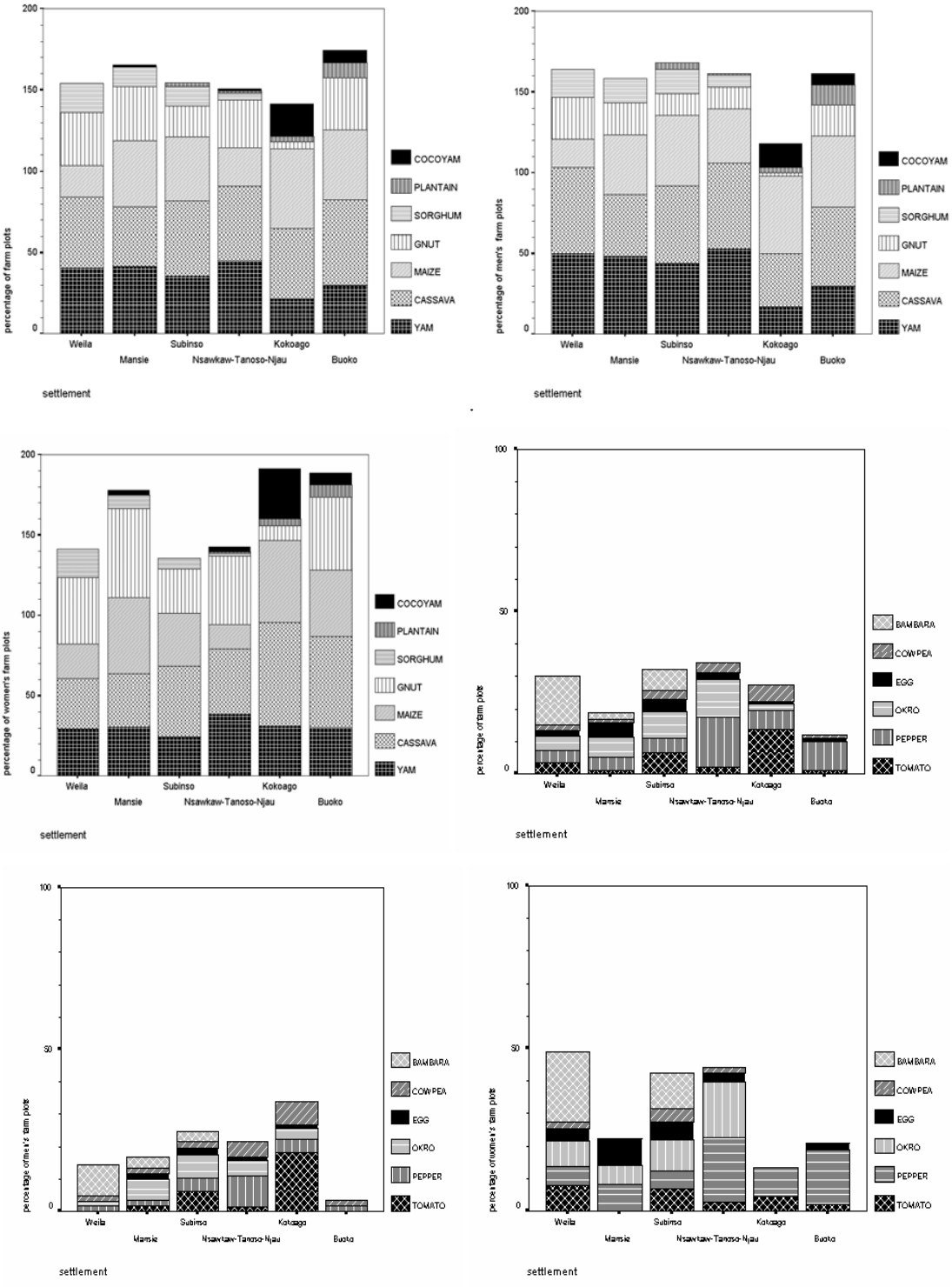

Table 2.1 Distribution of crops in men's and women's farm plots

Crop	Sex of Cultivator of plots	Percentage of plots under different crops						
		Weila	Mansie	Subinso	Nsawkaw-Tanoso-Njau	Kokoago	Buoko	Total
Yam	Male	50	48	44	53	17	30	40
	Female	29	31	25	39	31	30	32
	All	41	42	36	45	22	30	36
Cassava	Male	53	38	48	53	33	49	45
	Female	31	33	44	41	66	57	44
	All	43	36	46	46	43	53	45
Maize	Male	18	37	44	34	48	44	38
	Female	22	47	33	15	51	41	31
	All	19	41	39	23	49	43	35
Groundnut	Male	26	20	13	13	2	19	14
	Female	41	56	27	42	9	45	37
	All	33	33	19	30	4	32	24
Sorghum	Male	18	15	15	7	0	0	9
	Female	18	8	7	2	0	0	5
	All	18	12	12	4	0	0	7
Rice	Male	0	0	1	4	0	0	1
	Female	0	0	0	8	0	0	3
	All	0	0	1	6	0	0	2
Bambara beans	Male	10	3	3	0	0	0	2
	Female	22	0	11	0	0	0	5
	All	15	2	6	0	0	0	4
Cowpea	Male	2	2	2	5	7	2	3
	Female	2	0	4	2	0	0	2
	all	2	1	3	3	5	1	3
Plantain	Male	0	0	4	1	3	12	3
	Female	0	0	0	1	4	8	2
	all	0	0	2	1	4	10	3
Cocoyam	Male	0	0	0	0	15	7	4
	Female	0	3	0	3	31	8	6
	All	0	1	0	2	20	7	5
Tomato	Male	0	2	6	1	19	0	6
	Female	8	0	7	3	4	2	4

Crop	Sex of Cultivator of plots	Percentage of plots under different crops						
		Weila	Mansie	Subinso	Nsawkaw-Tanoso-Njau	Kokoago	Buoko	Total
	All	3	1	6	2	14	1	5
Garden egg	Male	0	2	2	1	1	0	1
	Female	4	8	6	3	0	2	3
	All	2	4	3	2	1	1	2
Okro	Male	2	7	7	5	3	0	4
	Female	8	6	10	17	0	0	9
	All	4	6	8	11	2	0	6
Pepper	Male	2	2	4	10	4	2	4
	Female	6	8	6	20	9	7	12
	All	4	4	5	5	6	9	8
Cashew	Male	6	5	12	24	2	2	9
	Female	2	6	1	20	0	0	7
	all	4	5	8	22	1	1	8
Teak	Male	0	2	1	0	0	7	1
	Female	0	0	0	0	1	0	1
	all	0	1	1	1	0	5	1
no of men's farm plots		62	60	98	83	94	57	454
no of women's farms plots		51	36	73	106	45	53	364
total no of farms plots		113	96	171	181	139	110	818

Table 2.2 Crops cultivated by men and women

Crop	Sex of Farmer	Percentage of farmers growing specific crops						
		Weila	Mansie	Subinso	Nsawkaw-Tanoso-Njau	Kokoago	Buoko	Total
Yam	Male	100	89	87	91	48	65	81
	Female	68	42	51	68	64	64	60
	All	86	77	71	88	55	65	71
Cassava	Male	100	68	76	82	84	81	81
	Female	64	46	77	61	91	88	69
	All	84	57	76	70	87	84	76
Maize	Male	36	75	71	59	97	88	70
	Female	36	54	51	23	96	72	49
	All	36	65	63	39	96	80	60
Groundnut	Male	57	43	22	16	7	42	29
	Female	96	77	54	77	18	88	70
	All	74	59	36	51	11	65	48
Sorghum	Male	32	32	27	9	0	0	17
	Female	32	12	11	2	0	0	8
	All	32	22	20	5	0	0	13
Rice	Male	0	0	2	7	0	0	2
	Female	0	0	0	14	0	0	4
	All	0	0	1	11	0	0	3
Bambara beans	Male	18	11	7	0	0	0	5
	Female	50	0	33	0	0	0	11
	All	32	6	14	0	0	0	8
Cowpea	Male	0	0	2	7	0	0	2
	Female	0	0	0	14	0	0	4
	all	4	2	6	4	13	2	5
Plantain	Male	0	0	8	2	7	23	7
	Female	0	0	0	4	9	16	4

	all	0	0	5	3	8	20	5
Cocoyam	Male	0	0	0	0	39	19	8
	Female	0	4	0	7	50	16	11
	All	0	2	0	4	43	18	10
Tomato	Male	0	4	11	2	52	0	11
	Female	18	0	17	7	9	4	9
	All	8	2	4	5	44	2	10
Garden egg	Male	4	4	4	2	3	0	3
	Female	13	12	9	5	0	4	7
	All	8	7	6	4	2	2	5
Okro	Male	4	14	13	9	7	0	8
	Female	18	8	20	28	0	0	15
	All	10	11	16	20	4	0	12
Pepper	Male	4	4	7	18	10	0	8
	Female	14	12	11	33	18	32	22
	All	8	7	9	27	11	16	15
Cashew	Male	14	11	9	39	6	4	15
	female	5	8	0	32	0	0	11
	all	10	9	95	35	4	2	13
Teak	Male	0	0	0	0	0	15	2
	Female	0	4	0	2	0	4	2
	all	0	2	0	1	0	10	2
No of farmers	Male	28	28	45	44	31	26	202
	Female	22	26	35	57	25	25	187
	Total	50	54	80	101	53	51	389

Table 2.3 Percentage of monocropped and intercropped plots cultivated by men and women

Sex of plot cultivator	Monocropping or intercropping	Settlement						
		Weila	Mansie	Subinso	Nsawkaw-Tanoso-Njau	Kokoago	Buoko	**Total**
Male	Monocrop	37.1	45.0	34.7	26.5	59.6	45.6	41.4
	Intercrop	62.9	55.0	65.3	73.5	40.4	54.4	58.6
	No of farm plots	62	60	98	83	94	57	454
Female	Monocrop	43.1	30.6	43.8	29.2	35.6	22.6	34.1
	Intercrop	56.9	69.4	56.2	70.8	64.4	77.4	65.9
	No of farm plots	51	36	73	106	45	53	364
Total	Monocrop	39.8	39.6	38.6	28.0	51.8	34.5	38.1
	Intercrop	60.2	60.4	61.4	72.0	48.2	65.5	61.9
	No of farm plots	113	96	171	189	139	110	818

Table 2.4 Dominant cropping systems

Percentage of plots under cropping system	Settlement						
	Weila	Mansie	Subinso	Nsawkaw-Tanoso-Njau	Kokoago	Buoko	**Total**
yam-cassava	28.3	13.5	14.0	30.2	8.6	11.8	18.5
sole maize	2.7	16.7	11.1	7.9	20.9	14.5	12.0
maize-cassava	1.8	1.0	7.6	6.9	20.1	9.1	8.2
Groundnut	14.2	10.4	8.2	8.5	1.4	3.6	7.6
cassava-groundnut	3.5	6.3	3.5	6.9	2.2	20.0	6.6
other groundnut intercrops	14.2	13.5	7.0	9.0	.7	3.6	7.7
yam-cassava-maize	1.8	10.4	8.8		3.6	3.6	4.4
sole cassava	.9	2.1	8.8	.5	7.2	5.5	4.3
sole yam	4.4	5.2	3.5	2.6	4.3	5.5	4.0
No. of farm plots	113	96	171	189	139	110	818

The dominant cropping systems in the northern parkland zone include yam-cassava intercrops , yam-cassava-maize intercrops, groundnut intercrops, maize-cassava and sole maize. In the southern high forest fringe, at Buoku, sole maize or

intercrops (maize-cassava and groundnut-cassava) are more important. Cassava monocrops are also important at Subinso and Kokoago, and tomatoes at Kokoago.

2.2 Farming strategies

Within the Brong Ahafo transition zone five styles (or underlying strategies) of farming can be found, which reflect different degrees of intensification or commercialisation of agriculture and different paths to increased production:

- Extensive cultivation using land tilling and mounding technologies within a distinct bush fallowing system in which land is rested for three of more years. Yam is frequently the most important crop in this system, but is usually intercropped with a variety of other crops. Farmers are concerned with tree regeneration, and look for well regenerated areas in which to make new farms.

- Extensive cultivation of monocrops such as maize or groundnuts, or a narrow range of intercrops, such as maize-cassava and groundnut-cassava, within shorter fallowing regimes. Farmers are less concerned with the regeneration of the tree cover, but manage soils without application of inorganic fertilisers.

- Extensive cultivation of monocrops (usually maize) using inorganic fertiliser on land which has been stumped and ploughed. Cultivation is on a permanent basis on the same tract of land.

- Intensive cultivation on smaller areas of land of vegetable crops using inorganic fertiliser. These are frequently cultivated in complex cropping sequences alternating minor season and major season cultivation, extending periods of cultivation and minimising fallows.

- Intensive cultivation of smaller areas, with complex multiple cropping sequences, which focus on risk management and matching crops to soils. These usually occur in areas which were originally cultivated with inorganic fertilisers on soils which have been stumped and ploughed, in which soils are often exhausted.

Intensification of agriculture can be achieved through:

- investment in high input agriculture on extensive land areas;
- investment in high input area over small areas in which the aim is to maximise the impact of limited investments in inputs;
- extensive cultivation through investments in large amounts of hired labour to maximise the area under cultivation and total yield;
- intensive cultivation using hired labour and intercropping which aims to maximise returns to labour by maximising returns to smaller plots.

Given the abundance of land, the low cost of land and the relative high costs of inputs and labour, farming strategies tend to focus on maximising returns to investments in inputs and labour rather than by investing in land-saving technologies.

These various styles of farming compete and interact with each other, transform the soil and environment, impact upon each other defining the space that each can occupy, and define the possible niche for the totality of cropping systems. While policies may attempt to favour one farming style, other farming styles may be able to effectively mobilise resources to challenge the cropping strategies that are officially supported by government and international policy directives.

The dominant crops vary from area to area in relation to ecology, agricultural infrastructure, market niches that farmers have learnt to exploit, and changing policy incentives and disincentives. Agricultural infrastructure, market niche and policy incentives are closely interrelated, since infrastructure development is often the result of policy directives, and policy may create new market opportunities or distort existing market options. New developments within the regional economy may also have unforeseen consequences on policy. Thus the development of a modern transport infrastructure as a prerequisite for state agricultural production, also encouraged the development of markets and of migrations of networks of farmers and labourers from the Upper West Region into Brong Ahafo. This opened up new avenues of agricultural intensification based on hired labour, which had not existed before the creation of an infrastructure based on modern inputs. This has created the potentials for new forms of commercial market production which did not exist before the creation of state farms and extension services. These adaptations of farmers to modernity and changing environments are rarely studied by the modern agricultural development sector which works with a conception of replacing stattic traditional agricultural practices with modern techniques.

2.3 Fallowing and permanent cultivation

Much of the literature on agricultural modernisation argues that population growth creates land pressures on fallowing systems. It is argued that while fallowing systems may have been efficient in the past, population growth under modern conditions creates land scarcity. This results in short fallow cycles which prevent soils recuperating from previous cycles of cultivation, resulting in a downward spiral of impoverished soils and low yields.

Data collected from those farmers who were able to calculate the duration of the last fallowing cycle on the plots they were cultivating suggests that medium fallows of between 3-6 years prevail in the Brong Ahafo transition area, with 31 percent of farmers using longer fallows of over 7 years and 10 percent fallowing for over 10 years. There is some evidence of farmers responding to land shortage by using shorter fallows - as at Buoku where 37 percent of plots were being fallowed for periods of between 1-2 years. However, at Kokoago, adoption of intensive farming methods and inputs led to equally high rates of short fallows. At Kokoago, 39 percent of farmers used short fallows of 1-2 years. At Subinso 23 percent of farmers used 1-2 year fallows despite low land pressures (see Table 2.5).

In the parkland settlements in which yam farming is the major activity, short fallows are rare . Only 5 percent of Nsawkaw , 10 percent of Weila and 14 percent of Mansie farm plots were previously fallowed for periods of 1-2 years (see figure 2.7). There also seems to be some evidence of matching crops to land and to fallow intervals on the land. This is reflected in the high percentages of monocrop cassava grown on short fallows and the high percentages of yam (usually intercropped with cassava) grown on medium-long fallows (see table 2.6). However, there is no direct correlation between specific cropping system, nutrient needs of crops, and fallow system, since many farmers have sufficient land to allow for fallows of between 3-6 years with all crops, and factors other than soil restoration are important in fallowing, including build up of pests and weeds in the soil.

Table 2.5 Fallowing intervals on farm plots

No of years land last fallowed	Settlement						
	Weila	Mansie	Subinso	Nsawkaw-Tanoso-Njau	Kokoago	Buoko	**Total**
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Continuous cropping			4.8		1.9		1.2
1-2 years fallow	10.0	14.3	22.9	5.2	39.3	36.7	21.1
3-6 years fallow	34.3	42.9	59.0	41.8	45.8	50.6	46.2
7-10 years fallow	42.9	35.7	8.6	29.9	10.3	5.1	21.1
more than 10 years fallow	12.9	7.1	4.8	23.1	2.8	7.6	10.4
No of farm plots	70	70	105	134	107	79	565

Figure 2.2 Fallow intervals

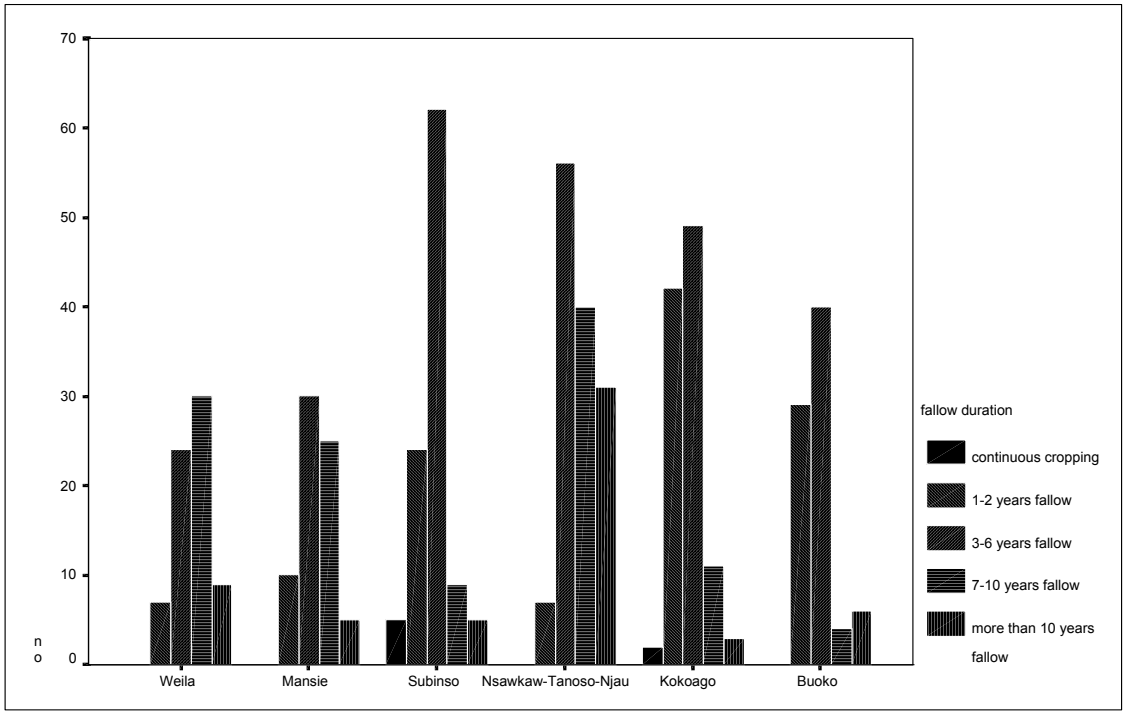

Table 2.6 Fallow intervals in cropping systems

Percentage of plots under different fallowing intervals in different cropping systems

Cropping system	Continuous Cropping	1-2 years fallow	3-6 years fallow	7-10 years fallow	over 10 years fallow	No. of farm Plots
Yam-cassava	1	12	36	36	15	113
Yam-maize	.	13	67	13	7	15
Yam-cassava-maize (%)	.	8	58	29	.	24
Maize-cassava	2	22	46	22	9	46
Sole maize	3	29	47	10	11	62
Sole groundnut	.	26	44	18	13	39
Cassava-groundnut	.	29	49	15	7	41
Sole cassava	.	42	42	12	4	26

Table 2.7 Fallow intervals for yam plots at Weila, Mansie and Nsawkaw

Settlement	Cropping system	1-2 year fallow	3-6 years fallow	7-10 years fallow	over 10 years fallow	No. of farm plots
Weila	yam-cassava	14	29	52	5	21
Mansie	yam-cassava		36	64	.	11
Mansie	yam-cassava-maize	.12	50	38		8
Nsawkaw	yam-cassava	2	28	40	30	43

2.4 Farmers' adaptive strategies

The next section examines how farmers have adapted their farming systems in response to economic development, infrastructure development, agricultural information systems, changing policy frameworks, and changing and competitive markets. It also examines how they respond to environmental and production problems which have emerged in their farming systems.

2.4.1 Ecological adaptation

Ecological adaptations include the matching of crops to specific micro-environments. The moist loving tropical forest crops of plantain and cocoyam are predominant within the localities situated in semi-deciduous forests. Within the drier northerly areas they are exploited in the gallery forest areas within valley bottom areas. On the grassy slopes of the driest area sorghum and bambara beans become more significant crops particularly at Weila. Yams are more important in the woody parkland areas of the northern transition zone where small, fast growing trees predominate. However, specific varieties of yams have also been adapted to the moist forest environments, including *Kokoase*, a forest yam that can grow in the shade of trees, and is often cultivated under cocoa trees. While groundnuts are usually exploited in savanna areas, they have also been grown from before the beginning of the twentieth century in specific grassy environments within dominant forest mosaics. Groundnut cultivation is also extending into degraded soils and soils which have been transformed by ploughing, in which it is difficult to grow other crops. Maize and cassava are grown in both the forested environments and also within the savanna-forest mosaics. Within moist forest zones it is often grown in environments which have been transformed through ploughing, in which the original forest environment has been stumped and is now replaced by grassland.

2.4.2 Impact of agricultural policy and infrastructure on farming practice

The development of a modern state agricultural sector and of a supporting agricultural infrastructure has had an important effect upon the farming systems in Brong Ahafo in both northern parkland and southern high forest fringe communities. Nevertheless, this modern agricultural infrastructure has had limited impact on farmers' own cropping systems. The effect of agricultural modernisation on agriculture at Subinso is clearly evident 2 kilometres from the former State Farm at Branam. However, at a radius of 10 kilometres and more in settlements such as Mansie and Weila, the impact of modern agricultural services become minimal, and tractor ploughing and fertiliser applications are extremely marginal. Within the high forest fringe area, the influence of high input agriculture is evident at Kokoago, with high rates of fertiliser usage and tractor ploughing services by farmers on lands which have been stumped. However, these developments are not typical of high forest fringe areas, most of which, like Buoku, use no fertilisers and hire manual labour rather than tractor ploughs. Table 2.8 shows the extent of usage of inputs and modern agricultural technologies on the various farm plots cultivated by farmers in the various settlements in the survey. Table 2.9 shows the proportion of farmers that use some fertiliser on any of their farm plots and table 2.10 shows the small proportion of farmers who hire tractor services in contrast with the overwhelming reliance by most farmers on hired manual labour. Large numbers of farmers throughout the survey area invest in hiring labour for weeding and clearing, but few farmers outside of Subinso and Kokoago make investments in high input technologies.

Table 2.8 Usage of inputs and mechanised technology on farm plots

High input usage	Settlement						
	Weila	Mansie	Subinso	Nsawkaw-Tanoso-Njau	Kokoago	Buoko	**Total**
Percentage of farm plots cultivated with inorganic fertiliser:							
Male plots	.	1.8	5.1	2.4	8.7	.	7.8
Female plots	2	.	9.6	.	8.9	.	3.3
All plots	0.9	1.1	7.0	1.0	3.3	0	5.8
Percentage of stumped farm plots:							
Men's plots	.	1.7	21.9	1.2	22.3	1.8	10.0
Women's plots	5.9	2.8	27.4	10.4	8.9		10.7
All plots	2.7	2.1	24.3	6.3	18.0	.9	10.3
Percentage of farm plots cleared with tractor:							
Men's plots	.	.	11.2	1.2	9.6	8.9	5.8
Women's plots	.	.	23.3	.9	2.2	.	5.2
All plots	.	.	16.4	1.1	7.2	4.6	5.5
No of male farm plots	62	55	98	83	94	57	449
No of female plots	51	36	73	106	45	53	364
No of farm plots	113	91	171	189	139	110	813

Table 2.9 Percentage of men and women using inorganic fertiliser

Percentage of farmers using inorganic fertiliser	Settlement						
	Weila	Mansie	Subinso	Nsawkaw-Tanoso-Njau	Kokoago	Buoko	**Total**
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Men	.	4	11	5	58	.	13
Women	.	.	11	.	18	.	3
All	.	2	11	2	41	.	9
no of men	28	28	45	44	31	26	202
no of women	22	26	35	57	22	25	187
Total respondents	50	54	80	101	53	51	389

Table 2.10 Investments in hired labour and tractor services

Sex of farmer	Hired labour and tractor services	Settlement						
		Weila	Mansie	Subinso	Nsawkaw-Tanoso-Njau	Kokoago	Buoko	**Total**
		(%)	(%)	(%)	(%)	(%)	(%)	(%)
Male	Hired labour for clearing	64	57	40	57	64	58	58
	Hired tractor services	.	.	18	2	11	.	6
	Hired labour for weeding	68	46	53	55	88	69	60
Female	Hired labour for clearing	77	81	71	71	58	92	76
	Hired tractor services	.	.	26	2	8	.	6
	Hired labour for weeding	64	62	68	51	68	76	62
All	Hired labour for clearing	70	69	46	65	55	75	63
	Hired tractor services	.	.	22	2	10	0	6
	Hired labour for weeding	66	54	60	53	79	72	61
no of men		28	28	45	44	31	26	202
no of women		22	26	35	57	22	25	187
Total respondents		50	54	80	101	53	51	389

2.5 Case studies

2.5.1 Case study 1: Kokoago - Agricultural intensification through adaptation to agricultural infrastructure collapse

Kokoago lands lie adjacent to the now defunct Subinja Irrigation project, which promoted irrigated vegetable farming with high inputs. However, farmers at Kokoago had little interaction with this project. Kokoago also lies close to the Wenchi State Farms. The farmers' first experiences of agricultural modernisation arose from interactions with these state farms and the mechanised tractor ploughing services which they introduced. However, the most important project which influenced the subsequent course of agricultural development at Kokoago was the creation of the Ghana National Reconstruction Corps (GNRC) in 1978, in its immediate vicinity. The project developed a large mechanized farm which focussed on maize production on permanent plots with applications of inorganic fertiliser. The GNRC project was not a success and in 1982 it collapsed. However, the project had three main influences of Kokoago:

1. Many inhabitants from Kokoago were employed by GNRC and they invested their wages in agricultural development in Kokoago, based on the high input variety that was promoted by GNRC.
2. The GNRC also introduced tractor ploughing services and made subsidised inputs available to farmers.
3. Farmers were further encouraged to use inputs by the provision of credit lines for input purchase.

When the GNRC collapsed, farmers at Kokoago also moved onto the lands that had been stumped for the project, and used them for maize cultivation.

Farmers at Kokoago have taken up mechanised maize cultivation with fertilisers. But large numbers of farmers also grow maize and cassava intercrops without fertiliser applications. They have also worked out new methods of intensive tomato cultivation for their own rainfed conditions. Tomatoes are planted throughout both the major rain season and the minor season. The beds on which tomatoes are cultivated are manually ridged up. During the weeding process, the tomato beds are further ridged up - the soil is scooped up and placed over the weeds and tomato stalks. This is usually carried out twice, but during dry years a further weeding and scooping up of the soil can occur. The objective of this is to conserve soil moisture. This results in a large proportion of the tomato stalks being buried under soil. The fruits are not staked, nor do they hang over the ridges. They are rather perched above the scooped-up soil ridges. Tomato cultivation is intensive, and carried out on small plots under an acre in size. Frequently maize follows the tomatoes, benefiting from the residues of fertiliser application within the soil.

The intensification of tomato cultivation at Kokoago focuses on achieving high returns to labour, rather than returns to land, and maximises the application of small quantities of fertiliser. This is achieved by intensive and complex crop rotations which focus on intricate timing of rotations between minor and major systems. The farmers attempt to grow the maximum number of crops in a three-year cropping cycle by rotating major season cultivation with minor season cultivation. This involves complex intercropping systems in which new crops may be planted during weeding, before the original crop has been harvested. After the three-year period, the land is usually fallowed for a short period. This mixed cropping-rotation system focuses on maximising the crops that can be taken from the land with minimum inputs for land preparation and

fertiliser application. Intensification of cultivation takes place on lands which have been stumped and transformed into grassland by the previous activities of state mechanised farms and by the modern mechanised agricultural infrastructure. These adaptations take place in the context of a state agricultural infrastructure that has collapsed.

Maize and tomato cultivation are mainly the preserve of men. Many women cannot afford to make the necessary investments in labour and inputs to fully participate in this sector. Many women at Kokoago farm in forest areas, growing small quantities of roots and tubers crops, such as cocoyam, yam and cassava on small farms. The women find it easier to cultivate forest land with cutlass rather than till grassland areas. The grassland areas become the preserve of men with capital, who can invest in fertilisers, tractor services or hire large numbers of labourers to gain good yields from grassland and stumped land.

The natural environment at Kokoago has been transformed considerably during the past 30 years. The original settlers came to Kokoago, to farm cocoa, from Asuie (near Techiman). The senescence of cocoa occurred during the dry phase of the 1970s and 1980s and farmers found it impossible to successfully replant it. Farmers thus moved into food crop and vegetable cultivation and found the grassland environments subsequently created by stumping and ploughing to be the most productive. Many farmers at Kokoago continue to farm with inputs in spite of the increasing costs and the vagaries of climate (eg. erratic rainfall). However, it is not clear how sustainable these farming system will prove to be.

2.5.2 Case Study 2: Subinso - decline of agricultural input technology

In its heyday Subinso was a centre of agricultural modernisation in Brong Ahafo. Being near to Branan State Farms, farmers at Subinso benefited from subsidised inputs and tractor services. During the 1970s and 1980s, government services made cheap subsidised tractor ploughing services and fertilisers available to farmers in the vicinity of the state farms. Private entrepreneurs also invested in tractors and offered tractor ploughing services to farmers. This led to the expansion of mechanised maize farming within the vicinity of Subinso and many farmers began to transfer resources from yam farming on fallowed land to permanent cultivation of maize on land which had been stumped and cleared of its tree cover. Agricultural modernisation was further enhanced by the development of the Subinso Agricultural Project, which was supported by German donor funding, German technical assistance and the Catholic Diocese of Sunyani.

With implementation of structural adjustment, divestiture of state agricultural input procurement programmes and removal of subsidisation, the foundations of agricultural modernisation were undermined and both the state farms and the Subinso Agricultural Programme have now collapsed.

While residual effects of high input farming can still be seen in the large number of stumped plots at Subinso and the usage of tractor ploughing, there has been a marked decline in the use of inputs in recent years. A survey of agricultural practices in the Wenchi district in 1993 reported that 44 percent of farmers at Subinso used fertiliser and 51 percent used tractor ploughing services (Amanor, 1993). This compared with similar surveys in settlements situated in the vicinity of State farms where there are well-developed state agricultural infrastructure and agricultural support services. In a survey of agriculture

around Ejura, for instance, in the transition zone of northern Ashanti (close to Ejura State Farm, the largest state farm in Ghana), Tripp (1993) found that 58 percent of farmers prepared their land with tractors and 66 percent of farmers used fertiliser. In contrast with this, the 1993 survey found low or no usage of inputs in other important maize-producing areas in Wenchi and Kintampo districts. Around Badu, on the fringes of semi-deciduous forest, one of the leading maize-producing settlements in Brong Ahafo, farmers used no tractor ploughing and no fertilisers. At Mansie, only 7 percent of farmers used tractor services and 18 percent used fertilisers. In the present survey, input usage at Subinso was found to have dramatically declined. Only 11 percent of Subinso farmers are using inorganic fertilisers and 22 percent are still ploughing with tractors.

Soils at Subinso have become exhausted as a result of permanent cultivation. Ploughing also destroys the organic matter layer in the soil, turning the subsoil over the topsoil. Farmers who have stumped their lands and regularly use ploughs are dependent upon fertilisers to gain good yields. Without application of fertilisers they cannot get good yields of maize. Farmers at Subinso complain of the high cost of inorganic fertiliser, as well as problems with availability. Because of the increased cost, farmers who use fertilisers have tended to reduce their application, frequently applying less than half of the recommended dose. However, the cost of fertiliser is not reflected in maize prices, since large quantities of maize are being produced in Brong Ahafo without the use of inputs. Erratic rainfall has also become a problem and investments in fertiliser will not pay off without proper rainfall. As a result of all these constraints, production of maize is declining at Subinso. Farmers are moving away from maize production into groundnuts, which do not require the use of fertilisers. They are also growing more cassava, which can provide satisfactory yields without application of fertiliser and which fetches a good price. A *gari* processing factory has been set up in Subinso, creating a steady demand for cassava. Farmers are also increasingly diversifying production, engaging in multiple cropping, planting a variety of different crops on the same land which are adapted to different environmental conditions as a risk management strategy. Areas under extensive maize cultivation are contracting, smaller areas are being cultivated with lower applications of fertilisers and farmers are experimenting with diversified cropping systems on smaller farm plots. This includes planting crops which mature at different times, and crops which are adapted to dry conditions such as sorghum and bambara bean alongside crops which require more moisture.

2.5.3 Case study 3: Buoku - commercialisation without inputs in a changing environment

Like Kokoago, Buoku is situated in the dry forest zone. It has witnessed considerable change in the environment following the 1983 bushfire calamity (when wildfires spread through the high forest zone of Ghana, destroying much of the tree growth). Buoku was originally a cocoa growing area in which the main food crops grown were plantain and cocoyam. From the 1980s onwards, bushfires have become increasingly frequent and the environment has been considerably transformed. Many of the former characteristic forest tree species have disappeared and been replaced with *Chromolaena odorata* (know in Ghana as 'Acheampong'), as well as grassy species. Farmers can no longer grow cocoa, and plantains and cassava do not grow as well in the past. With the decline of cocoa, farmers have turned to maize as a replacement cash crop. In the past, plantain and cocoyams were largely grown for domestic consumption (for, as bulky perishable crops they did not provide a stable cash crop). Groundnuts and cassava also became important cash crops.

Groundnuts have been cultivated here for many years. Older inhabitants of Buoku remember that, at the beginning of the century, groundnuts were cultivated in small plots in areas in which the dominant vegetation was a type of transitionary mosaic between forest and savanna grassland, known locally as *npenpe*, a form of open woodland with small trees. However, the areas of groundnut cultivation have increased, and this crop is largely cultivated in the drier grassland and woodland mosaics. Groundnuts are often intercropped with cassava on plots using short rotations. Thirty-nine percent of cassava/groundnut plots were made on farms using a fallow of 1-2 years, and 56 percent of the plots used a fallow of 3-6 years. Fallow intervals with monocropped maize were also short. 42 percent of maize plots were cultivated on plots which had been previously been fallowed for 1-2 years, and 58 percent on plots which had been fallowed for between 3-6 years. Both types of plots were normally cultivated for two years - 77 percent of groundnut-cassava plots were cultivated for two years and 68 percent of maize plots. However, these two cropping systems were farmed in distinct ways: all the goundnut-cassava plots were planted in mounds. By contrast, only 18 percent of maize plots were planted in mounds. Farmers identified 63 percent of groundnut-cassava farm plots as forest farms and 36 percent as savanna farms, while 81 percent of maize farms were identified as forest farms and 19 percent as savanna farms.

This suggests that the growing prominence of groundnuts cannot be seen primarily as a response to soil impoverishment. It forms part of a series of innovations which respond to changing environments and which result from the decline of cocoa, previously the major cash crop. These innovations seek to intensify food crop production in different environments in the context of a certain degree of land pressure. This in turn results from a complex of factors including appropriation of farm land by the Forestry Service for the creation of a forest reserve. Attempts to intensify crop production in more forested environments have involved planting maize. In more savanna environments, they have involved planting mixtures of groundnuts and cassava. The combination of groundnut and cassava reflects an attempt to intensify production through mixed cropping. The movement to maize, groundnut and cassava, suggest an adaptation of crops which can be farmed intensively within specific microenvironments within the locality to realise the most profitable investments in land and labour.

These two cropping systems also reflect different gender and social group interests. Sole maize production is largely the preserve of richer male farmers who can hire large tracts of land and labour. Eighty-one percent of sole maize farms were managed by men. In contrast with this 59 percent of women and 41 percent of men were involved in groundnut and cassava cultivation. Groundnut plus cassava is frequently produced by women with less access to hired labour on smaller family plots. It represents a form of intensification which seeks to gain maximum yield from smaller plots and lower inputs of labour. Thus, in the survey, 41 percent of groundnut and cassava plots were family lands as compared to 25 percent of maize plots. The average size of groundnut and cassava plots was 1 acre (the smallest plot was 0.25 acres, the largest plot was 2.5 acres [standard deviation , 0.59]). This compares with an average of 4.2 acres for sole maize plots (within a much wider range of acreages in which the largest farm plot was 30 acres and the smallest 1 acre [standard deviation, 6.96]). This suggests that maize forms the most important avenue to investment by rich farmers. Cassava-groundnut mixtures on small plots of land form the most important cash-crop avenue for farmers who cannot afford to invest in land and labour for extensive maize cultivation.

Given recent dramatic changes in the environment at Buoku, it is not clear to what extent farmers can continue to manage these two cropping systems on a sustainable basis, or if the intensive cultivation of these two systems will lead to a down spiralling cycle of declining yields, exhausted soils, degrading vegetation cover and increasing weed infestations.

2.5.4 Case study 4: Bush fallowing and intensification in the yam belt

Settlements, such as Weila, Mansie, and Nsawkaw lie beyond the area in which high input technologies have been disseminated. They have depended upon yam as their staple cash crop and have responded to such factors as the market opportunities created by the development of road transport within the Brong Ahafo region, the emergence of major food wholesale markets (such as Techiman), and the availability of hired labour, by extending production using hired labour.

Yam is a crop which requires soils rich in organic matter. It also requires a lot of sunlight. Stakes are needed for the tendrils of yam to climb up, in order to gain access to sufficient light. It thus requires an environment with many small trees, which can be used as 'live' stakes, or which can be cut as poles to make stakes on which the yams will climb. When trees are used as stakes, their canopy needs to be removed to prevent them shading out the yam. This is usually achieved by setting fire to the standing tree and burning the branches and canopy. The trees often recover later by putting out new branches and shoots and coppice. Some farmers deliberately kill the tree off by burning its base and roots, to prevent new shoots developing during the yam cultivation cycle, developing leaves and shading out the yam tendrils. Other farmers, who are concerned with preserving trees because of a perceived shortage, may choose to prepare the tree by lopping its branches.

Yam cultivation thus requires robust small trees which can easily regenerate from root shoots, suckers and coppices. The parkland zone is the ideal environment for this. Yams are not a crop which adopt easily to high input technologies. They respond poorly to fertiliser applications (Van der Zang *et al.* 1980), and often become tasteless, develop unattractive hairy appearances, and do not store well. Accordingly, the best land within the parkland environments is reserved for yam cultivation. Other crops follow yam on newly cultivated land or are planted on less well regenerated lands and lands which have grass cover. At Subinso, yams are usually grown in distinct locations, apart from the stumped lands on which maize has been grown with fertilisers. (However, there are some variations. While most farmers at Subinso considered fertilisers to have a poor impact on yams, they noted that in the Atebubu area of Brong Ahafo, farmers were successfully cultivating yams in fields which had been fertilised.)

Yam is a crop which requires considerable labour. The tubers are planted in large mounds into which surrounding organic matter is scooped. Since yam requires rich soils, it is cultivated for short periods on plots which are bush fallowed. Within the low populated parkland areas of Brong Ahafo there is still considerable land available to enable sufficient fallowing to support soil recycling, and produce good yields of yam.

There are numerous varieties of yams that have been selected by humans from their wild forebears (many of which were actually poisonous). Yams continue to be selected up to the present day, with new varieties coming in and some old varieties

becoming less popular. The most popular varieties of yams cultivated today include '*Tiller'*, '*Lariboko'*, '*Pona'*, '*Matches'*, and '*Akaba'*. All of these varieties are popular because they do not require the most fertile soils, can withstand some element of drought and can provide good yields on soils cultivated with short to medium fallows. Several varieties formerly cultivated by farmers are said to be less popular today because they were heavy feeders and required very fertile soils from areas which had been rested for many years. This included '*Dahoba'*, '*Lobre'*, '*Dongo'*, '*Sejo Siato'* (Deg language) and '*Tarikoo'* (Deg). Some respondents argued that varieties such as *Dahobo*, *Sejo Siato* and *Tarikoo*, required lands which had been fallowed for more than twenty years,. These are said to have become nearly extinct. Some farmers also allege that *Tiller* and *Matches* have become popular in areas without many trees because they can be grown without staking materials. Coursey (1967) has noted that many varieties of yams are selected by farmers on the basis of water requirements, drought tolerance, and length of maturity. Those requiring long maturation periods are grown in the wettest areas with shortest dry seasons. In wetter area farmers may grow several varieties with different maturation to achieve a greater spread of crops through the year.

Other factors determining the selection of yam varieties include, yield, reproductive capacities, and market demand related to gastronomical qualities. *Matches*, *Asana*, and *Teacher Takyi*, are recently developed or adopted yams which have rapidly spread during the 1990s. All these yams yield heavily, and can reproduce large yams from smaller sets than other yams. *Matches* gained its name from the fact that when first cultivated the sets which farmers planted were the size of a match box. Subsequently farmers have increased the size of the sets to gain larger yams.

Market preference and price factors also play important parts in determining the varieties grown. Although *Lariboko* is considered to be the superior yam locally for *ampesie* (boiled slices of yam eaten with stew), *Pona* is the preferred yam on the Accra market and also the preferred export yam to European cities. It is also a good *ampesie* variety. However, on the Kumasi market, the dominant demand is for a yam which can be also pounded into fufu. *Tiller* is the yam which best fits this role. Thus *Pona* and *Tiller* have become the dominant yams produced for the market. Other yams, which are locally recognised as important have become less important because they are not popular on the urban market. *Nkanfo*, *Tepro* and *Bronipae* are examples of yams which are less in vogue on urban markets today, and have been displaced in field cultivation. However, farmers usually integrate several varieties of yams. These include early maturing varieties, which tend to have poor storage qualities, with long-maturing varieties of water yam (*Dioscorea alata*), which can be stored over long periods and thus can meet domestic needs for most of the year. *Matches* and *Akaba* are the two most important water yams grown in the Brong Ahafo transition zone. Domestic requirements and the need for an all-year-round-income are also met by intercropping cassava and maize with yams - the maize is stored in barns and the cassava can be maintained in the soil for up to two years and is harvested when required.

Farmers have responded to intensification in yam production systems by adapting genotypes to environmental conditions, selecting higher yielding varieties that can be produced more intensively, and changing the varieties they plant to respond to market demand. They have successfully responded to the commercialisation of yam production which has developed into an important urban-market and export crop.

This capacity for adaptation stand in marked contrast to the predictions of doom which have tended to dominate the literature (Purseglove, 1978). It has been estimated that yams contribute about 16 percent of agricultural GDP (AgGDP), ranking second behind cassava which contributes 19% of AgGDP. Cocoa, the leading export crop, which receives over 45 percent of agricultural research funds, produces 13 percent of AgGDP (Plan Consult, 1993; Amanor *et al.*, 1993).

Yams are usually cultivated on newly cleared land and followed by other crops. New plots are cleared each year for the yam farms on well-regenerated land. Yams are usually intercropped and the yam is followed by other crops. At Weila, bambara bean frequently precedes yam as a crop, and is used to break up the ground. It is planted early in the minor season. After it is harvested yam mounds are prepared and the dry leaves are vines are incorporated into the mounds to enhance the organic matter. Yams are usually intercropped with a wide variety of crops of which the most popular include cassava, maize, sorghum, and vegetables. Although yam is an important crop it has received little support from agricultural services, until very recent years. The technologies used in yam farming are those of the farmers, with no recommendations for improved varieties or cultivation techniques being worked out and disseminated by the agricultural extension systems, although researchers in Kumasi at Crop Research Institute are now working on yam.

Historically, in the northern transition zone after cultivating yam husbands passed on their plots to their wives who then cultivated groundnuts. Clearing was a major constraint for women, and this arrangement enabled them to plant their groundnuts on plots which had already been cleared and mounded. Increasingly, men in the main yam growing areas are intercropping their yams with second year crops, particularly cassava and maize. With good market prices for groundnuts men are also following yam with second year groundnut. At Weila 26 percent of men now plant groundnuts and 20 percent also plant groundnuts at Subinso. As a result of this fewer husbands now provide plots for their wives. A common arrangement at Mansie is for a man to divide his old yam farm into half, and to allocate one half to his wife (wives) while he plants groundnut or cassava on the second half.

Maize is increasingly becoming an important crop in the yam farming belt, grown on fallow land without inputs. With the rise in price for inputs, maize production within the yam belt is displacing production in former high-input maize producing settlements such as Subinso, where high fertiliser prices do not reflect in the market price for maize, and soils cannot produce good yields under natural regeneration. Cassava has also become important in yam systems and is frequently intercropped with yam. The cassava tubers are planted later than the yam.

Intensification of agriculture in the yam zone is reflected in the expansion of intercropping systems which prolong periods of cultivation and diversify the range of cash crops grown. However, this is largely an attempt to maximise returns to investment to labour and to mounding rather than a response to shortage of land. This intensification of male agriculture may have a negative impact on women's agriculture as men allocate less cleared land to women.

Decline in yam production systems have been predicted for a long time, largely premised on the need of yam varieties for good quality soils, long fallows, and trees as live stakes or stake poles. This decline has not materialised and yam production has rather been commercialised. Innovations in yam production system have been based on the selection of more robust, drought resistant species that can tolerate less fertile soils (or are less heavy feeders); complex intercropping systems which maximise the cropping from one piece of land before it is fallowed; and careful land management strategies, which assure that land for yam cultivation is allowed to sufficiently regenerate.

2.6 Fallow tree resources and agriculture

In the environmental policy literature for Ghana, the Brong Ahafo region is frequently portrayed as a zone prone to desertification in which savanna is advancing and forest retreating, largely as a result of human intervention and farming practices. This literature makes no attempt to differentiate the diversity of environments within Brong Ahafo, and the different tree resources which exist in the area. Two basic types of tree formations exist in the area: dry semi-deciduous forest and savanna woodland. While the former dominates in the south of the transition zone it also occurs in riverine areas as gallery forests and on the sites of old settlements, such as at Jensoso . Within the southern area mosaics of savanna grassland and parkland also exist which may reflect relicts of earlier transformations of the environment, or which may relate to edaphic features. Distinct tree species characterise these two formations. Those in the woodland areas tend to be smaller, numerous, robust, more drought-resistant, fire resistant and able to regenerate from coppice regrowth, root shoots and suckers (Basset and Boutrais, 2000; Fairhead and Leach, 1998). Those in the semi-deciduous forest areas are often larger, taller, less numerous, more vulnerable to fire and other stresses and less able to regenerate from coppice and root shoots.

In both areas trees are valued by farmers in bush fallowing systems as playing important roles on farm. Most farmers preserve some tree varieties on their farms. In the parkland environments the most commonly preserved trees on farms include *Danielli olivieri*, *Vitallaria paradoxa*, *Parkia biglobosa*, *Pterocarpus erinaceus*, *Terminalia glaucescens*, *Anogeissus leiocarpa* , *Afzelia africana, Khaya senagalensis* and *Margaritaria discoidea. Daniellia oliveri* is recognised by farmers as having a favourable impact on soils and on crops planted in its vicinity. *V. paradoxa* and *P. biglobosa* are important for their fruits and oil extracts. Within the yam farming belts these tree resources are important for staking yams and yam farms are made in areas with large densities of small trees..

Table 2.11 Tree varieties preserved on farm plots

Tree species preserved in farm land	Settlement						
	Weila	Mansie	Subinso	Nsawkaw-Tanoso-Njau	Kokoago	Buoko	**Total**
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Daniella olivieri	24	31	35	49	.	.	
Vitallaria paradoxa	79	28	19	25	.		28
Parkia biglobosa	26	29	35	17	3	.	19
Anogeissus leiocarpa	?	17	15	17	13	7	12
Terminalia glaucescens	.	16	8	4	14	6	8
Pterocarpus erinaceus	.	10	11	8	6	2	7
Margaritaria discoidea	.	7	13	6	31	7	12
Borassus aethiopum	.	1	11	.	.	22	5
Afzelia africana	?	?	5	13	2	5	?
Ceiba pentandra	.	6	6	11	17	27	11
Khaya grandifoliola	.	7	6	13	9	2	8
Cola gigantea	.	.	1	1	19	44	10
Milicia excelsa	?	3	1	8	9	14	?
Triplochiton scleroxylon,	.	.	1	6	11	8	5
Spathodea campanulata	.	4	4	1	9	11	4
Vitex doniana	.	1	1	2	16	4	4
Antiaris toxicaria	.	.	1	3	8	13	4
Alstonia boonei	.	.	.	.	7	4	2
Terminalia superba	.	3	.	.	4	3	1
No of farm plots	112	96	171	189	139	108	815

In the semi-deciduous forest zone the most commonly preserved trees include *Ceiba pentrandra*, *Cola gigantea*, *Milicia excelsa*, *Triplochiton scleroxylon*, *Antiaris toxicaria Terminalia sp., Afzelia africana, Khaya grandifoliola*, *Vitex doniana*, *Margaritaria discoidea* and *Alstonia boonei*. The most commonly preserved species tend to be pioneer species, which are often the most robust and fastest growing species in the semi-deciduous forest. While there are many important timber resources in this forest farmers do not have rights to these trees or to royalties from their exploitation.

Farmers within parkland environments tend to preserve more trees on farm than in the semi-deciduous forest zone. Table 2.11 shows that tree species associated with parklands are preserved on a larger percentage of farm plots than those associated with semi-deciduous forests. This is not surprising given that parkland trees are usually smaller than high forest trees, and regenerate easier from coppice regrowth. However, farmers within the forest fringe area reported more problems with regeneration of trees and change in tree cover than in the parkland. Farmers at Kokoago and Buoku reported a change in the environment following the 1983 bush fire. This scenario included annual bush fires which destroyed forest trees and prevented their regeneration, expansion of grassland and areas dominated by *Chromolaena odorata*, and increasing fuelwood shortage.

However, the picture is complex. At Buoku, elderly farmers were adamant that the savanna grassland areas have existed as long as living memory, although grassland has expanded in recent times. They argued that in the past both forest and savanna coexisted. There were many high forest species in the forest including many timber trees. Most of the large timber trees have been felled by timber concessionaires, leaving only *Ceiba pentandra* and *Cola gigantea*. Farmers claim that most of this timber has been felled in recent times, mostly during the 1980s. In some areas of Buoku, species associated with savanna coexisted with forests from long ago. Some old men remember that when they were young Borassus palm occurred within thick forest. In recent times the area under Borassus has expanded as a result of increasing incidences of bush fires and Borassus has become the dominant tree is some areas which were under forest. The occurrence of Borassus in forest suggests that this there is a long history of environmental change within the area. Borassus may have established in previous dry spells. As the climate became wetter forest began to regenerate and displace the Borassus. With a subsequent dry period Borassus began to re-establish its dominance over forest species. The complexity of environmental change is also suggested by a wedge of savanna that intrudes down into the forest extending from Subinso to Buoku.

While most farmers within the semi-deciduous forest fringe concur that in recent years there has been considerable environmental change, this is not the case in the parkland areas. Here there are lively debates about environmental change which divide the farming population into two camps.

One camp concurs with national environmental policy frameworks about serious decline in the environment and narratives about increasing rural population leading to over-cultivation of the land, destruction of trees and "transformation of the land into the Sahara desert".

However, a significant proportion of farmers do not agree with this narrative and articulate counter narratives that the environment has not changed dramatically. Some farmers argue that there are more trees now than in the past, since when one tree is cut it develops coppices and root shoots which will develop into multiple trees. They argue that there may be fewer large trees than there were in the past, but there are more smaller trees than before. They argue that bush fires have always been a part of the parkland environment and that there is no recent fire crisis resulting in environmental transformation, since the trees within these environments have adapted to fire.

Within charcoal producing areas within the northern transition zone these debates about environmental degradation have become highly politicised, since there are complex struggles over the control of charcoal, and these struggles are articulated in terms of the destruction of the environment and of forests that result from charcoal production. Patterns of environmental change differ in the various ecologies of the transition zone. The dynamics of land cover change and its relationship to farming systems need to be better understood rather than posing deforestation in a general framework.

Different farming systems have different impacts on the regeneration of trees on fallow and farmland. Yam farming depends upon the regeneration of trees for yam staking, and a process of promoting cutting, pruning and fire control and regeneration. In contrast with this, high input mechanised agriculture removes all the tree cover through stumping and attempts to maintain permanent cultivated plots that are free from trees to allow tractor ploughing. The expansion of maize cultivation within the semi-deciduous forest may also promote removal of tree cover. At Kokoago grasslands and stumped lands are considered prime lands for cultivation and the remaining secondary forest patches are mainly farmed by women who cannot afford investments in labour for maize production on grassland.

2.7 Farmer adaptation, innovation, and the agricultural research system

Farming systems within the Brong Ahafo region are complex, dynamic and diverse. Underlying this complexity is the ability of farmers to adapt to changing conditions which result from changes in the biophysical, market, and policy environments. While self provisioning is still important for most farmers, all the farming systems we have investigated have cash crop sectors which focus on producing for a defined market niche in which the farmers have comparative advantage as compared to farmers in other areas. These niches change with time. In the past, when agricultural policies concentrated on subsidising and distributing inputs, farmers in the vicinity of state farms and other government agricultural projects took advantage of their closeness to cheap input delivery services to engage in high input production, stumping and ploughing land and replacing bush fallow recycling of land with permanent agriculture with inorganic fertilisers and new high yielding seeds. The main impetus for this was the cheapness of subsidised inputs and government support services and not pressures of land leading to the breakdown of bush fallowing.

Farmers away from the main centres of state induced agricultural modernisation were also initially interested in the use of inputs, but found that delivery systems were not reliable and constant. Farmers at Mansie or Weila, for instance, would find it difficult getting tractors to come to their villages to plough when necessary and they would not be able to get a guaranteed supply of fertiliser from year to year. Under these conditions of insecure access to inputs, farmers paid more attention to developing alternative modes of investing in agriculture other than through state controlled inputs. They invested in significant amounts of hired labour, mainly migrant labour from the Upper West Region[1], to expand areas under crop production and to intensify weeding regimes. Thus, the expansion of yam production was made possible by the large number

[1]This applies to the Western districts of Brong Ahafo served by the Wa-Wenchi road. In the Eastern parts of Brong Ahafo and Northern Ashanti, significantly more migrants, using the Bolgatanga,-Tamale-Yeji-Ejura/Techiman or Tamale-Kintampo-Techiman route would have come from the Upper East and Northern Region.

of seasonal farm labour migrants who come down from the Upper West to work in making yam mounds. These developments, in turn, were made possible by the development of a road transport infrastructure in the 1960s to support agricultural modernisation within the area and a feeder road programme during the 1970s. This facilitated the movement of migrants into the northern transition area of Brong Ahafo and the expansion of Techiman market into the largest wholesale food market in Ghana.

With the implementation of structural adjustment, policies of subsidisation of agricultural inputs and control over input delivery systems by state organs were revoked. Inputs were sold at market prices and input delivery systems were privatised. This has resulted in a crisis in high input agriculture. Many of the large firms engaged in production of food crops have collapsed or transferred their resources to other production niches. Demand for inputs has fallen, since the price of investing in inputs is not realised in market prices for crops. Few private companies have taken up agricultural input provisioning, outside of those working on contract farmer schemes, such as in cotton or oil palm sectors (which are not important sectors in Brong Ahafo). Farmers continuing to use inputs have difficulties in recovering the cost of their investments and in gaining access to reliable supplies.

As a result of this, food production centres have shifted to areas which produce crops without inputs and which still have productive soils. Some of the old high input maize producing areas are declining. Farmers have stopped using inputs, but their soils are no longer productive. With unreliable climate conditions production has become risky. Under these conditions farmers have responded by moving from heavy soil feeders to crops which can produce yields on poorer soils, such as cassava and groundnuts. This should not be interpreted as a retreat to self-provisioning, since there is a large demand for these crops and good market prices. With increasing perceptions of risk in crop production many farmers are also hedging their bets by engaging in mixed cropping of a variety of crops which respond to different conditions, which require different moisture regimes and which mature at different periods and respond to different rainfall patterns. Other options include diversification into intensive vegetable production, as at Kokoago.

In the northern transitional parkland areas yam continues to be the most important crop, and farmers still manage to produce yam within a bush fallowing system. However, the selection of yam varieties is a dynamic process of matching variety to land and to market demands and tastes. There is some evidence of a process of intensification in which varieties adapted to shorter fallowing strategies are gaining ground at the expense of heavy feeders which require rich soils that have been fallowed for many years. Varieties which can withstand drier periods are also being selected. Yam farming is also being intensified through mixed cropping, particularly of yam with cassava, followed by groundnut In some areas of the yam belt, sorghum and bambara beans are important crops, which provide security for dry years, In other yam farming areas, maize has developed into an important cash crop. Here maize is grown without inputs, in bush fallowing systems, in which shorter fallows are used than in yam production.

The ecotone between semi-deciduous forest and the forest-savanna mosaics has seen considerable transformation in cropping systems during the 1980s, particularly following the 1983 bush fire. During the 1960s the dominant crop in this area was

cocoa, which was planted from the 1920s. By the 1970s much of this cocoa would have suffered from senescence. While cocoa is difficult to replant outside of mature forest conditions, farmers in these northern fringes of cocoa cultivation suffered from drier periods during the 1970s and 1980s than between the 1920s-1940s, in conditions which were not really suitable for cocoa. Since 1983 bush fires have become a recurring phenomenon during the dry season, which has prevented trees regenerating and hampered attempts to regenerate cocoa plantations. As a result of the constraints on cocoa, farmers have increasingly moved into maize and vegetable production. This is a development which is also pronounced in the Ashanti Region.

The major maize production zone in Ghana is now situated in the forest-savanna ecotone. This includes former cocoa settlements which were previously dominated by forest, but also settlements which were situated in the dominantly savanna mosaics of this area, which have existed for a long period. While many of the settlements in this ecotone have experienced considerable environmental change and the transformation of a moist forest environment into a grassy environment, other environments have always been in dominant savanna mosaics. The dynamics of the processes resulting in the historical formation of these savanna mosaics, and the present transformation of moist semi-deciduous forest into grassland dominated areas remains unclear. It is not clear to what extent farming systems have altered the environment, and the extent to which a drier climate phase or even global climate change has impacted on the forest ecotone.

The farming systems in Brong Ahafo are also dynamic in that they are all competitive, seeking to establish a production niche in which they have a comparative advantage (or less of a disadvantage) on the market. The need to be competitive has been intensified by structural adjustment, removal of subsidies, competition with cheap imports of food crops leading to erosion of prices, and depression in incomes of urban people, as a result of devaluation and increasing unemployment. Failure to maintain a comparative advantage results in experimentation with new crops and a shift to new farming strategies.

This can be clearly seen at Subinso. Subinso was originally a yam-producing settlement in the low populated Deg (Mo) area. The development of Branam state farms, and development of input delivery services to nearby farming communities, enabled the more prosperous farmers at Subinso to develop high input maize cultivation. Well served by transport on the Wa-Wenchi road, Subinso became an important market centre and an area in which migrants settled to farm. With increasing pressures on land created by growing numbers of people investing in cheap inputs and tractor services, maize became prominent and yam declined as less prime environments existed for its cultivation. With removal of subsidies maize has lost its comparative advantage, and cassava and groundnuts have become leading cash crops. These two crops are able to provide yields on soils which have become exhausted or heavily disrupted by ploughing. The existence of a market centre at Subinso has enabled cassava to establish a comparative advantage as a cash crop, since there is a ready demand on the market for gari, and small gari-processing workshops have become established. This would not have been possible had Subinso been situated at the back of a feeder road.

In contrast, the more northerly and isolated settlement of Mansie was not able to establish a comparative advantage in maize production during the era of subsidised inputs, since it lay at a distance in which regular supplies and services could not be

guaranteed. With removal of subsidies and the decline of maize at Subinso, Mansie farmers now find they can fill a vacuum for maize on the Subinso market, and that they have a comparative advantage in that their soils can support maize production without the use of inputs. However, yam remains the most profitable crop at Mansie.

Surprisingly little research exists of the different niches that farmers occupy and the factors that define the boundaries between different farming systems. These factors tend to be overlooked by mainstream agricultural research which tends to lump different farming systems together in all-embracing categories, which sees a concept of "traditional agriculture" as all embracing in juxtaposition to agricultural modernisation. A large number of detailed monographs exist within a farming systems tradition, which provide very detailed studies of isolated farming systems, without an analysis of the way they fit into regional systems and the ways in which they accommodate or adapt to features of agricultural modernisation[2].

The dominant perspective in agricultural research is the systems perspective. Applied to the farming systems of Ghana, this tends to view population growth as the main motor for change, leading to a breakdown in fallowing systems and the need to replace fallowing systems with modern inputs. Older variants of agricultural modernisation stress the role of inorganic fertilisers and new crops in promoting more intensive cultivation from permanently cultivated plots. Newer variants stress the environmental damage caused by short fallow cycles, and the destruction of the environment caused by bush fallowing through slash and burn. Bush fallowing needs to be replaced, the argument goes, with more environmentally friendly technologies. Possibilities include:

- more intensive cultivation using inputs to limit the area under agricultural cultivation, to allow higher yields to be produced in smaller land areas, and enable larger areas to be preserved as forests, woodlands, and recreational areas;

- use of green manures to promote better soil recycling, improved fallowing, shorter fallowing or permanent cultivation to enable more intensive and sustainable crop production in limited areas and allow for preservation of forest and woodland areas;

- promotion of agroforestry systems to promote soil conservation, improved recycling of land and permanent cultivation in hedgerows systems such as alley cropping to enable more intensive and sustainable cropping from limited areas, preservation of trees and allow for preservation of more forests and woodlands.

The justification for the new technologies is often located in grand narratives of environmental crisis, of destruction of vegetation and soil by small-scale bush fallow cultivators, requiring new interventions and new technologies (Leach and Mearns, 1996). This is often substantiated by weak empirical data on both ecological and socio-economic dynamics. These grand narratives tend to be located in narrow commodity-focussed programmes which isolate the system components of

[2]One study which does deal with these parameters is that of J.Guyer (2000)

interest to the researchers from the wider setting in which the farming systems are located. While there is a growing emphasis on integrated research, socio-economic components within these commodity programmes largely focus on:

a) soliciting feedback on farmers' experiences of the technologies under research for fine-tuning purposes
b) understanding farmers' constraints in relation to the specific technologies of interest.

Since research does not focus on the internal dynamics of farming systems, it tends to reaffirm its own importance by seeking to present the findings of commodity programmes as the solution to complex programmes with social-economic and political dimensions. Thus, solutions to perceived problems are identified by the competence of research organisations and their linkages with international programmes and funding opportunities provided by donors.

Little research funding exists to support independent critical research. As a consequence of this, the major demonstration trials and government service recommendations concerns crops in which research services have developed a comparative advantage. These do not necessarily coincide with crops grown by farmers nor support their dominant strategies.

Mucuna trials, to cite one example of a contemporary research approach, are being developed by the extension services with the support of the GTZ programme on 'Sedentarisation of Farming Systems'. However, this programme does not present a clear overview of the potential role that Mucuna could play in the existing farming systems in Brong Ahafo, the classes of farmers who may be interested in Mucuna, the specific conditions under which Mucuna could be of interest to farmers, the conditions under which it would not be a suitable technology, and its potentials in the different environments, mosaics and farming systems within Brong Ahafo. Instead, the project reports portray a situation of crisis, resulting from bush fallowing and inappropriate farming systems, and this is used to justify the introduction of permanent cultivation to solve environmental and land pressure problems. Attempts to implement extension programmes around this narrative may alienate farmers attempting to rationalise investments in expensive labour in an area where land is freely available and cheap. In contrast with this narrative, it is possible that the areas which would be most receptive to Mucuna - and which could benefit the most from its integration into existing farming systems - may be areas in which permanent tractor-ploughing high-input agriculture was practised formerly, but where top-soils are no longer productive without the use of inputs and farmers have problems in maintaining satisfactory yields. However, the project would still need to demonstrate how farmers incorporating Mucuna into specific cropping cycles could effectively compete with farmers at another locality, who may be producing the same crops for the market within a bush-fallowing system with lower labour requirements.

Similarly, a *root and tuber programme* has been implemented within the Ministry of Agriculture with a research component carried out at the Crop Research Institute in Kumasi, with support from IITA. The research programme is attempting to introduce new yam varieties and recommendations, which support more intensive cultivation of yams, allow higher density of cultivation, respond positively to fertiliser, and remove the need for fallowing. Researchers are experimenting with new varieties developed by IITA. Trials are been conducted at Subinso. Attempts at continuous cultivation of yams for three years on a single plot have run into problems, including a large build up of nematodes and weeds in the soil. Attempts to increase the density of planting has resulted in the cutting of large number of yam stakes from areas outside the farm - the

project has purchased these from other farmers. Attempts to grow yams which do not require staking have not been successful. The project has focussed on cultivation of yam monocrops in a context in which the majority of farmers actually intercrop yam. The aim of introducing continuous cultivation of yam on the project is in danger of alienating farmers who can successfully produce yams within a bush-fallowing system which minimises the risk of pest, disease and weed build up.

By focussing on monocrop yam cultivation, the project does not take into account the rationalisation of labour inputs to land areas, in which cultivation may be extended for between 2-3 years by planting mixtures of yam and cassava followed by groundnuts. Attempts to develop continuous yam cultivation also have implications for the gender division of labour and allocation of old yam farms to women for groundnut cultivation. Finally, by focussing on introducing new improved yam varieties, and not taking into account farmers own adaptive experimentation in matching genotypes to environment, researchers run the risk of losing the opportunity of gaining considerable insight into farmers' own strategies.

Agricultural policy needs, therefore, to be more reflective, examining its own constraints and the unforeseen outcomes of its recommendations. This is most evident in the crisis which has beset the agricultural sector following the introduction of structural adjustment policies, and removal of subsidies and privatisation of input services. However, there has been a more general tendency for the agricultural sector to embrace new rhetorical approaches rooted in environmental concerns. The main objective is then to get farmers to change their farming techniques in order to preserve the environment. Unfortunately, this overlooks the necessity of understanding the shortcomings of approaches based on technological transfer of inputs as a precursor to developing new approaches which respond to these constraints.