From a technology focus to innovation development

The management of cocoa pests and diseases in Ghana

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To the cocoa farmers in Achiansah, Ntumkum and Adarkwa

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Chapter One
General introduction and overview

1.1 Introduction

In this thesis, we tried to gain an in-depth understanding of problems relating to cocoa production, especially from farmers' perspectives. This formed the basis of an action research with a multidisciplinary focus leading to the development of an integrated pest management (IPM) innovation that meets the needs of smallholder cocoa farmers in Ghana.

The Ghanaian economy depends largely on the agricultural sector which provides jobs for about 55% of the total population (GSS, 2000) and 70% of the rural population (DFID, 1998; DAES, 2001). The sector also contributes about 40 % of the Gross Domestic Product (GDP) of the country and 36% of the total foreign revenue (ISSER, 2001, 2002, 2003, and 2004, 2005).

Since cocoa was introduced into Ghana about a century ago, it has emerged as one of the most important agricultural export commodities.

Table 1.1: Export revenues for Ghana from 1998 to 2004 (US$ million)

Year	Agriculture						Non-agriculture		Total.	
	Cocoa		Timber		Non-traditional[1]					
	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%
1998	554	30.3	170	9.3	78	4.3	1,028	56.2	1,830	100
1999	550	26.2	174	8.3	85	4.1	1,290	61.5	2,099	100
2000	437	22.5	175	9.0	75	3.9	1,254	64.6	1,941	100
2001	381	20.4	169	9.1	82	4.4	1,235	66.1	1,867	100
2002	463	22.4	183	8.9	86	4.2	1,332	64.5	2,064	100
2003	818	34.9	175	7.6	138	6.0	1182	51.5	2,297	100
2004	1,071	39.2	212	7.7	160	5.9	1,290	47.2	2,733	100

Source of data: State of the Ghanaian economy (ISSER, 2005).

[1] Non–traditional agricultural export products refer to all other agricultural products excluding cocoa and timber.

Cocoa has been the highest foreign exchange earner for many years and contributed an average of 28 % of total export revenue between 1998 and 2003 (Table 1.1). The crop also contributed 3.4 % of total GDP annually during the same period (ISSER, 2001, 2002, 2003, and 2004, 2005).

1.2 Fluctuations in levels of cocoa production

In spite of the importance of cocoa to the economy, levels of production declined from 568,000 mt in 1965 to 160,000 mt in 1983 (Anon., 1999). The decline in production can be attributed to a combination of factors including the reduction in areas under cultivation during the last four decades, low productivity, and the incidence of pests and diseases (Anon., 1999).

1.2.1 Areas under cultivation

The decline in production was partly caused by a consistent reduction in area cultivated with cocoa from the early 1960s until the latter part of the 1990s (Table 1.2). A number of factors contributed to this. The decrease in the Brong Ahafo, Ashanti and Volta Regions during the 1980s was attributed to bushfires and drought in the early 1980s (Anon., 1999). Although some of the burned farms were replanted, others were either abandoned or the land was used for production of other crops (Anon., 1999). However, cocoa farmers were already shifting from cocoa to the production of food crops and other agricultural raw materials before the bushfires and drought of the 1980s (Koning, 1986; Manu, 1974; Rourke, 1974).

For instance, in an interview with farmers in the Brong Ahafo Region, Koning (1986) reported that 79% of the respondents expressed the intention to invest more in food crop production whilst 21% indicated their willingness to stick to cocoa production. Therefore, the decline in cocoa production in the 1980s cannot be attributed to drought and bushfires alone. Other factors, namely; low producer prices, overvaluation of the Cedi (the Ghanaian currency) at the time, and inadequate input supply, contributed to this decline (Koning, 1986).

Table 1.2: *Free on board* (fob) prices paid to farmers, production levels, yields, and areas harvested since 1961

Years	*Average fob price paid to farmers (%)	**Average annual production (‘000 mt)	**Average area harvested (‘000 ha)	Average yield (kg/ha)
1961-1965	67	453	1,811	250
1966-1970	42	390	1,400	279
1971-1975	37	402	1,430	281
1976-1980	31	286	1,220	234
1981-1985	42***	196	920	213
1986-1990	30	250	753	332
1991-1995	41	300	766	391
1996-2000	47	394	1,258	313
2001-2004	60	491	1,111	337

Source of data: *COCOBOD records **FAOSTATS (2004)

*** Figures for 1981/82 were excluded because it was unusually high (212 %)

1.2.2 Producer prices and production levels

Low producer prices paid to cocoa farmers have been considered an important cause of the decline in production levels (Bateman, 1974; Frimpong-Ansah, 1991). Trends of the levels of producer prices may be followed through studying the percentage of the *Free on Board* (fob) price that is paid to farmers. The fob price is the price at which the government sells cocoa to foreign buyers. It includes all costs incurred in buying and carting the beans to the port as well as a profit margin but not the cost of freight and insurance to the destination of the goods.

Generally, periods of higher producer prices correspond with relatively higher production (see Figure 1.1). From 2001 to 2005 the following trends were observed: From a producer price of about 62% of the fob price in 2001, the price was increased gradually to 70% by 2004, and production increased significantly from 410,000 mt in 2001 to over 735,000 mt in 2004. Cumulatively, the producer price was increased by 289% between the 2001/2002 and 2002/2003 crop seasons and this provided an incentive for farmers to increase output substantially over the same period (ISSER, 2004). Other factors, including the government's pest and disease control program and provision of inputs to farmers on credit under the 'hi-tech' program could have contributed to the increases in production since 2001. However, it is difficult to separate the impact of each of these factors.

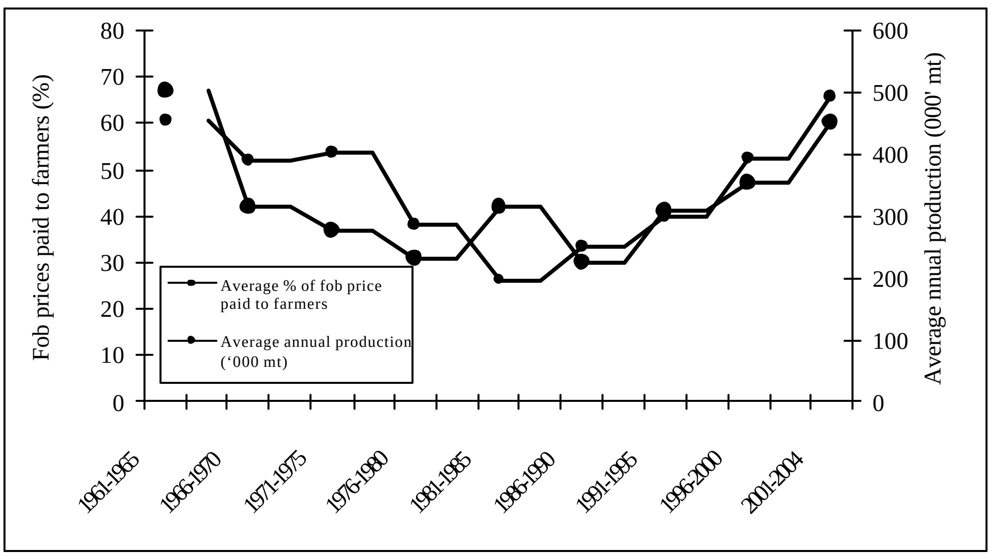

Figure 1.1: Trends in production as producer prices change: 1961 to 1994

Also, an important weakness in production figures is that during periods of low producer prices, the crop has been smuggled across the border to Cote d'Ivoire (Acquaah, 1999; Bates, 1981; Koning, 1986). In 1977 for instance, an estimated (minimum) 40,000 mt of cocoa, (representing 12% of the total production for that year), was smuggled out of the country, resulting in an estimated loss of USD$100 million in foreign exchange (Koning, 1986). Therefore, production figures recorded over the years may not reflect actual production levels.

1.2.3 Productivity

One of the major problems facing cocoa production in Ghana is low productivity. The average yield of cocoa in Ghana, estimated by the Ghana Cocoa Board, is 360 kg ha^{-1} (Anon., 1999). This is low compared to other major producers like Côte d'Ivoire and Malaysia with yields of 800 and 1,800 kg ha^{-1} respectively (Anon., 1999; Gerken *et al.*, 2001; FAOSTATS data, 2004). Average yields rose slightly from the early 1960s until the mid 1970s but dropped in the mid 1970s. Although productivity has improved relatively since the mid 1980s (Table 1.2), the levels are far below what pertains in Cote D'Ivoire and other leading producing countries.

Among the factors contributing to low productivity of cocoa in Ghana are: the aged trees; low yielding varieties; the incidence of pests and diseases; non-replacement of plant nutrients; poor maintenance practices, and the old age of cocoa farmers estimated to be an average of 55 years (Anon., 1999). The age of cocoa farmers is important because all the operations on cocoa farms such as weed control, removal of mistletoes, harvesting, and breaking of pods, are done manually, requiring physical strength.

1.2.4 Pests and diseases

Many pests and diseases cause considerable losses to cocoa, contributing to low productivity (Wilson, 1999; Wood & Lass, 1985). Cramer (1967) cited by Wilson (1999), estimates the annual loss of cocoa world-wide, as 558,000 mt due to insect pests, 368,000 mt to diseases and 337,000 mt to weeds, all adding up to 45% of potential production. Mossu (1992) puts estimated losses at 46% of potential production, 21% resulting from diseases and 25% from insect pests. The trend is similar in Ghana, where capsids (Heteroptera: Myridae) are estimated to cause losses of about 25% of potential production (Padi n.d.). The black pod, which is caused by *Phytophthora spp* is the most common disease of cocoa. Pod losses due to *P. palmivora* are estimated to be between 5 and 19% (Blencowe and Wharton, 1961; Dakwa, 1984), and losses due to *P. megakarya* is between 60-100% (Dakwa, 1987).

Other pests of cocoa include parasitic plants and epiphytes. The mistletoe is a parasitic plant found on cocoa trees, and in West Africa, the most common species is *Tapinanthus bangwensis* (Wilson, 1999). Epiphytic plants like *Bulbophyllum sp.*, *Chasmanthera dependens*, and *Cyrtorchis hamerta* also occur (Dormon *et al*, 2004).

The Cocoa Research Institute of Ghana (CRIG) has suggested that the proper control of pests and application of fertiliser can increase yields of cocoa in Ghana to over 1500 kg/ha (Anon., 1999). They recommend calendar spraying of pesticides to control capsids and the black pod disease. It is also recommended to control weeds and remove mistletoes, replace lost plant nutrients through fertiliser application, and to conduct proper shade management.

1.3 Government attempts at increasing cocoa production

Over the years, various governments in Ghana have implemented programmes aimed at raising the level of cocoa production. Between 1970 and 1979, the Eastern Region Cocoa Project was implemented at a total cost of US$ 15.6 million, with the objective of rehabilitating about 20,000 ha of existing farms, replanting 14,000 ha of farms where the crop had died or was seriously diseased, training farmers in the project area on improved methods of cocoa production, and resurfacing feeder roads, among others. At the end of the project, about 15,000 ha (75% of target) had been rehabilitated and 13,000 ha replanted (92% of target). Most of the rehabilitation, replanting, and maintenance of the farms was done by project staff with little participation by farmers, however, the costs involved were debited to the farmers when they delivered their produce at the cocoa buying centres (Amoah, 1998). A second project, the Ashanti Region Cocoa Project was implemented from 1976 to 1982 at a cost of US$21.9 million. The project provided credit for farmers to replant 17,000 ha using high yielding varieties, trained farmers in better production techniques, and provided equipment for the maintenance of feeder roads. Although the two cocoa projects succeeded in replanting about 30,000 ha of cocoa with high yielding varieties, a common feature of both projects was that many farmers were unwilling to take over the proper maintenance of their farms after completion of the projects.

A third project, the cocoa rehabilitation project, was implemented from 1988 to 1993 at an initial estimated cost of US$ 128 million. The objectives of the project were to increase cocoa production and yield to stabilise output at 300,000 tonnes annually through rehabilitation of marginal farms and replanting of about 57,000 ha. The project provided finance for technical and extension services, supported hybrid seed production and distribution, controlled swollen shoot virus disease, and funded research activities by CRIG. The ultimate objective of stabilising annual production levels at 300,000 mt was exceeded during the 1992/93 crop season with the production of 312,000 mt without the full disbursement of the estimated project costs. At the beginning of this project, government macro economic policies (including better producer prices for cocoa) rekindled farmers' interest in cocoa production and many farmers returned to their abandoned cocoa farms to rehabilitate them (Amoah, 1998). This interest triggered by better producer prices could have accounted for the attainment of the targeted production level at a lower cost than originally estimated for the project and may have been more important than the technical measures taken.

Realising that the cocoa industry would continue to play a major role in the economy of Ghana in the foreseeable future, the government adopted a new cocoa sector development strategy in 1999. This policy took a holistic approach and aimed at increasing the level of cocoa production by about 100% within 10 years. The strategy recognises that many cocoa farmers in the country use low technology in production, and argues that this is not profitable in the medium to long term. It also identified the lack of adequate and timely credit facilities as the main constraint to adoption of medium to high level technology such as fertiliser application and following the recommendations for controlling pests and diseases. In the strategy therefore, there is a proposal to set up a cocoa credit revolving fund to provide credit to cocoa farmers. The strategy also covered all the relevant areas of the cocoa industry namely; production, research, extension, internal and external marketing, quality control, processing, infrastructure, finance, pricing and taxation (Anon., 1999).

Production

Regarding production, the strategy targeted a level of 500,000 tonnes by 2004/05 and 700,000 by 2009/10 crop season to be sustained at this level. It is proposed in the strategy that farmers would be assisted to rehabilitate and replant old, abandoned and destroyed farms in old cocoa growing areas with high yielding hybrid varieties and to adopt medium to high level technology. To encourage farmers to produce the crop, the strategy was to increase the producer price from 56% of the fob price paid in 1998/1999 to 70% by 2004/2005 crop season and decrease the government levy from about 26 to 15% during the same period. Although the target set in the cocoa sector development strategy was already achieved in the 2003/2004 crop year, it is not certain that the high production level will be sustained because production dropped to about 500,000 mt in the following crop season, although this may have been influenced by climatic factors.

Research

Under the development strategy, the Cocoa Research Institute would continue to play the lead role in cocoa research but maintain strong links with MoFA, which has taken over the extension services for cocoa from the Cocoa Services Division of COCOBOD. CRIG would be funded through a levy on the fob price and supplemented with funds generated through commercialisation of research results on the use of cocoa by-products (jams, vinegar, cocoa butter, creams, soaps, liquor etc).

Extension

Before 2000, the Cocoa Services Division (CSD), which operates under COCOBOD, was responsible for carrying out extension service to cocoa farmers. The responsibility for cocoa extension, however, was shifted from the Cocoa Services Division to the Ministry of Food and Agriculture (MoFA) in 2000 as part of a new cocoa sector development strategy. The objective of this transfer to MoFA was to ensure effective and efficient delivery of extension services to all farmers (Anon., 1999).

Marketing and Quality control

The marketing system for cocoa has also undergone some changes. Until 1992, the Produce Buying Company (PBC), a subsidiary of COCOBOD bought cocoa from farmers under a monopsony. In 1992, however, there was a policy to liberalise the internal marketing system to allow licensed private companies to buy cocoa from farmers. As at 2004, 22 companies had obtained the required licence to operate. The objective is to introduce competition and improve the operational and financial performance of the marketing system. Although the government would continue to set the producer price, this would only serve as a *floor* price and Licensed Buying Companies (LBC) can pay higher prices to farmers. In the area of quality control, the Quality Control Division (QCD) would leave the initial quality check at the buying centres to the LBCs and concentrate on the final certification at the depots before shipment.

1.4 The research problem and overall objective of this thesis

To achieve the production target of 700,000 mt set in the cocoa sector development strategy by 2010, the government has taken a number of measures – policy and organisational reforms as well as direct interventions. The policy and organisational reforms include: i) increase in producer prices as an incentive for farmers to produce; ii) liberalisation of the internal marketing of cocoa; and iii) shift of extension services from COCOBOD to MoFA with the objective of ensuring effective and efficient delivery of extension services to all farmers. The direct interventions include: i) introduction of the Cocoa Disease and Pest Control (CODAPEC) programme in 2001 in response to the low adoption levels of recommended pest and disease control measures by farmers; and ii) introduction of the cocoa "hi-tech" program in 2003 to provide inputs on credit to farmers.

The CODAPEC programme involves the mass-spraying of all cocoa farms as a way of reducing pest and disease incidence. Mass spraying of cocoa farms by government is not a recent development in Ghana. It started as far back as 1956 (Leston, 1974) and some authors attributed the rise in Ghana's cocoa production in the mid 1960s to earlier mass spraying exercises and the increased use of pesticides. However, Leston (1974), disputed the claim that the rise in production was due to the mass spraying of cocoa farms. The policy of mass-spraying seems to confirm suggestions by some authors (Afreh-Nuamah, 1995; Gerken *et al*., 2001) that policy makers generally misconstrue the increased use of inputs like fertilisers and chemical pesticides as the most effective way to increase production.

The 'hi-tech' programme is a credit package under which fertiliser, insecticides to control capsids and fungicides for controlling the black pod disease are provided to farmers. Farmers are also advised to clear weeds on the farms, remove mistletoes, and adopt proper shade management practices through pruning. The government introduced the cocoa "hi-tech" programme in 2003 on a pilot basis in 46 districts across the six cocoa growing regions. In 2003 the programme covered 50,000 farmers and a total area of 40,000 ha, in 2004 it covered 125,000 farmers and a total area of 100,000 ha and in 2005 it is expected to cover 100,000 farmers and a total area of 80,000 ha.

With the exception of the producer price increases, and to some extent, the marketing arrangements, it is not yet known if the technical measures, including credit to farmers (i.e. mass spraying and hi-tech) as a strategy to increase production would attain its objectives in a sustainable manner. These direct interventions being employed to achieve the targeted level of production rely mainly on the use of synthetic pesticides. However, the sole-reliance on synthetic pesticides to control insect pests and diseases could be harmful to human health and also affect the environment in many ways. It constitutes a health risk for small farmers who usually have inadequate knowledge on how to use them safely (van Huis and Meerman, 1997); and it may destroy beneficial organisms in the agro-ecosystem (such as *Oecophylla* ant predating on cocoa capsids) and can also result in resurgence and secondary pest outbreaks (Gallagher, 1998; Gerken *et al.*, 2001; Luck *et al.*, 1977; van den Bosch, 1980; van Endem, 1996; van Huis, 1992; Waibel, 1994). Therefore, both environmental hazards and human risks that can arise from sole-reliance on synthetic pesticides for cocoa production are likely to be high if farmers followed the recommended calendar spraying regimes and/or the government continued with the mass-spraying exercise over a long period.

The low level (less than 4% of farmers) of adoption of recommended practices for cocoa production could be an indication of an ineffective research and extension system which cannot just be overcome through the CODAPEC and 'hi-tech' programmes. The current shift of extension service from COCOBOD to MoFA is not likely to solve the weak performance of research and extension and may actually affect farmer adoption of research recommendations because there is likely to be a weaker research-extension linkage between MoFA and CRIG than between the Cocoa Services Division and CRIG because the two belong to the COCOBOD.

The overall objectives of this thesis, therefore, were to explore: (i) more sustainable pest and disease management strategies; (ii) research and extension approaches, which can facilitate the development of innovations that can be used widely by farmers; and (iii) how such approaches could be institutionalised. The overall objectives are further broken down into the following specific objectives:

(i) To identify the perceptions of especially farmers, but also other stakeholders, about problems related to cocoa production in Ghana;
(ii) To explore the effectiveness and profitability of alternative pest and disease control measures to the sole reliance on synthetic pesticides;
(iii) To explore the processes through which farmers can be engaged effectively as active participants in a learning process to develop innovations that meet their needs;

(iv) To explain what factors could affect participatory innovation development with farmers;

(v) To provide insights into how the lessons from this research can be used to recommend the institutionalisation of a national system of innovation for the cocoa sector in Ghana.

1.5 Theoretical framework

For this research, a number of theoretical concepts were explored to provide insights and guidance during the research process. Theories on innovation, various forms of learning, insights from social capital, and principles of integrated pest management were explored within a broader framework of systems thinking to gain a holistic view of the cocoa sector. All the theories are not applied in every chapter of this thesis but rather, specific theories, or a combination of theories, are used in various chapters depending on their relevance to the issues under consideration.

The cocoa sector is undergoing changes that have implications for the actors in the industry. Because of the complex inter-connections between the various actors and the policy environment, it is appropriate to take a holistic view of the industry in order to explain the processes (i.e. the technical and social arrangements) that can facilitate innovation development at various levels through interactions between the actors. Innovation can also be linked closely to experiential learning or discovery learning and involves a cycle of conceptualisation, reflection, experiences/observation and action followed by a continuous cycle of conceptualisation through to action (Kolb, 1984). We also explore theoretical perspectives of integrated pest management practices as an alternative to the sole reliance on synthetic pesticides for controlling pests of cocoa.

1.5.1 A systems perspective

Analysis of the farm as a system gained prominence through the Farming Systems Research approach (Collinson & Lightfoot, 2000) and the realisation that technology cannot be divorced from the local context in which it is applied, contributed to the need for participatory technology development which aims at strengthening farmers capacity to experiment and innovate (Jiggins & de Zeeuw, 1992; van Veldhuizen *et al.*, 1997). Further, the notion of sustainability has led to concepts like agro-ecosystem analysis as a tool for decision making by a group of farmers on integrated pest management. The basic components of the agro-ecosystem analysis are among others; plant health, pest and natural enemy populations, soil conditions, and weather condition. However, in this thesis the 'system' is viewed from a broader context beyond the immediate physical environment of the farm into the policy and organisational framework within which cocoa is produced by smallholder farmers in Ghana.

Systems are coherent entities that have properties that are unpredictably different from the sums of the component parts embedded in them as well as from the environment in which they are embedded (Bawden, 2002). Systems can essentially be regarded as systems of systems (*holons)* because both the component parts (sub-systems) of any system in which they are embedded (Figure 1.2) and the environment in which the systems themselves are embedded are also systems (Bawden 2002).

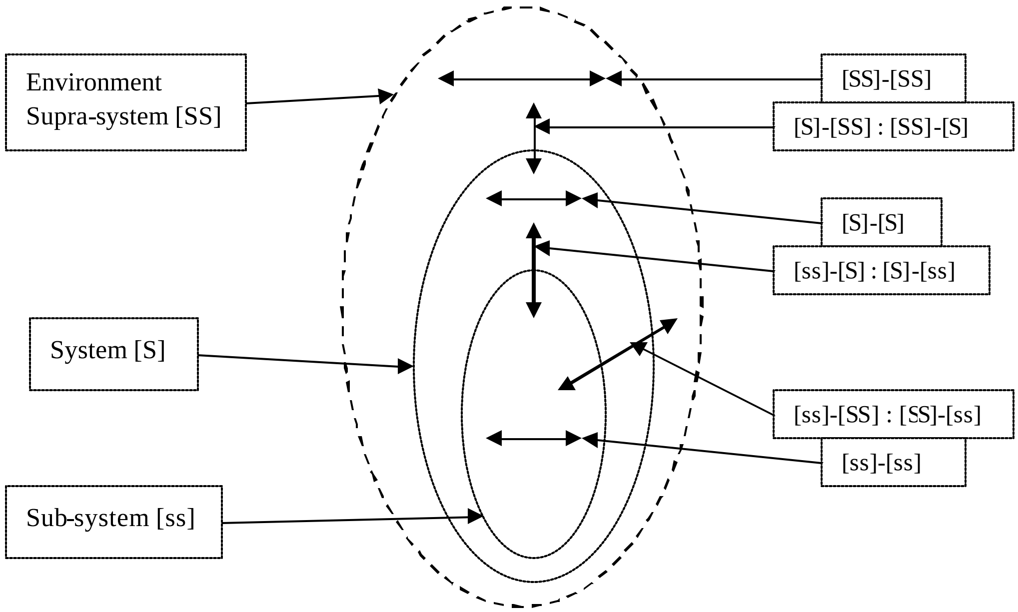

Figure 1.2: A 'systems of systems': A coherent network of embedded inter-connectedness (from Bawden, 2002)

Although the [Sub-systems]-[Systems]-[Supra-systems] hierarchy can be explored at several levels, probably infinitely, in this research three levels are identified and explored for practical reasons. The three levels explored are the policy, organisational and farmer levels (Figure 1.3).

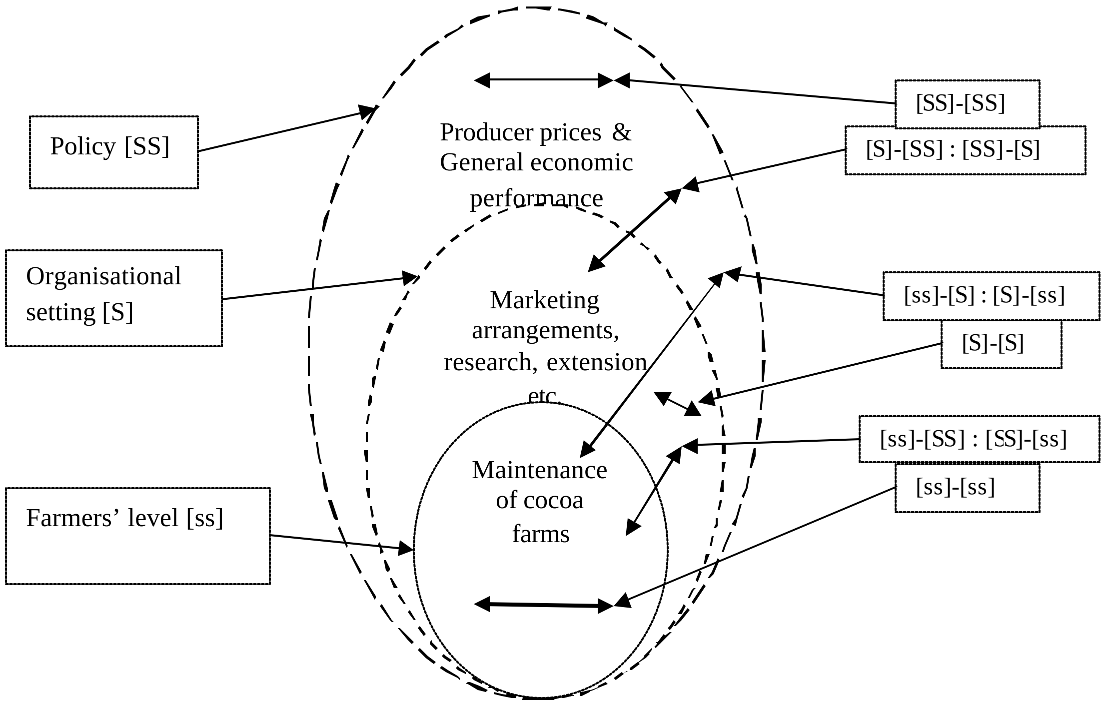

Figure 1.3: Three hierarchies of a [Supra System]-[System]-[sub-systems] in the cocoa industry.

Systems may be viewed as 'hard' or 'soft'. In hard systems the world is viewed as a complex of sub-systems connected in a way that its output is larger than the sum of the individual components. The study of hard systems also assumes predictability of outputs/outcomes based on relationships and interactions between various factors. Soft systems do not make assumptions about the nature of the world, beyond assuming it to be complex, but rather that the process of enquiry can be organised as a system of learning (Checkland, 1995). Bawden (1997) distinguishes between researched (hard) system and researching (soft) systems where the focus of the application of systems principles is to sets of human activities that need to be accomplished leading to an improvement of a complex and 'messy' situation.

This research explored both the soft and hard systems perspectives within the cocoa sector. Whilst the organisational and policy framework could be seen, to a large extent, as constituting the hard system, the actions and inactions of farmers (and other actors) constitute the soft system and greatly influences the functioning of the whole cocoa sector.

1.5.2 Innovations, learning, and actor oriented sociology within a systems perspective

An innovation involves new ways of doing things or 'doing new things' however, doing things differently can only be considered an innovation if the *new things* work in everyday practice (Leeuwis, 2004). Innovations can only be said to be complete when there is an appropriate mix and balance between the technical aspects and social-organisational arrangements (Leeuwis, 2004), and Smits (2000), defines it as the new successful combination of 'hardware', 'software' and 'orgware'. Innovations do not emerge by themselves but may be triggered by a technical novelty, policy initiative or a new social arrangement. Innovation processes should therefore include deliberate efforts to create effective linkages between technological arrangements, people and social-organisational arrangements (Leeuwis, 2004). Innovation can also be seen as an emergent property of a soft system and emerges from the interaction among the social actors (Roling & Jiggins, 1998).

In adopting a soft systems approach to researching innovations and innovation processes in the cocoa sector, other theoretical perspectives are relevant in identifying and explaining the factors contributing to innovations in the sector. For instance, theoretical perspectives of various forms of networks and learning processes by individuals and groups of farmers within networks are relevant in understanding and explaining the nature of innovations and the processes that lead to such innovations within different contexts. Again, the role of learning in innovations and innovation processes are not only influenced by the broad system as a whole but also by the interaction of various actors to the dynamics of changes taking place within the cocoa industry.

An understanding and explanation of the interactions between various actors could be made through the notion of human agency as an important theme within the context of the actor oriented approach (Long, 2001). Agency refers to the knowledgeability, capability, and social embeddedness associated with acts of doing and reflecting, that impact upon or shape one's own and others' actions and interpretations (Long 1989, 2001). In relation to innovations, it can be argued that an actors' ability to use their agency and create space for manoeuvre (Long, 2001), and their capacity to transform is constrained in various ways by their natural and social circumstances i.e. the system within which they operate. A person or network of persons can have agency (Long 1989, 2001). Therefore, the willingness and capacity of farmers, researchers, extension workers and LBCs to innovate and benefit from operating in the cocoa sector could be constrained or enhanced but could also creatively translate the changing policy and organisational framework and the social environment in which they operate.

1.6 The overall research approach

1.6.1 The Convergence of Science Project

This research was conducted as part of the Convergence of Sciences Project (CoS), which was jointly funded by the Wageningen University and Research Centre (WUR) under the INREF program, the Directorate General for Development Cooperation of the Dutch (DGIS) Ministry of International Affairs, and the Food and Agriculture Organisation (FAO), and implemented by WUR, the University of Ghana and the Université d'Abomey-Calavi in Benin. The research approach was therefore influenced by the philosophy of the project, which broadly speaking, is that science should not be the preserve of educated elite working in research stations but rather something that is practiced in everyday lives of 'ordinary' people. The project believes that the impact of research could be better if the *ordinary* farmers who are the end-users of research findings are part of the process of developing innovations. Therefore, an important objective of the project is to develop a framework for interactive science, where knowledge is collectively generated through participation of all stakeholders in the agricultural sector in Ghana and Benin. As a methodological approach in developing a framework for interactive science, CoS implemented research projects involving studies on participatory agricultural innovation processes in rural areas of Benin and Ghana, using interdisciplinary teams with active participation of many knowledge partners notably farmers and other local stakeholders.

The CoS project adopted a two-stage approach in identifying priority areas for research by first conducting technographic studies, and then follow it with diagnostic studies. Technography attempts to map actors, processes and client groups in a manner that allows the analyst to see beyond the technology itself to the problems technological approaches are supposed to solve, and to understand which parties and interests are being mobilised to arrive at solutions (Richards, 2001). The studies are used to explore technological histories, markets, institutions, framework conditions, stakeholders and contextual factors at a macro level (Roling *et al.*, 2004). In Ghana, the technographic studies were done by a team of researchers from the University of Ghana to explore the innovation landscape for a number of crops including cocoa. The technographic study on cocoa (Abekoe *et al.*, 2002) drew two main conclusions that; (i) generally, the strength of the cocoa industry lies in the organised structure of institutions from farmers (at the village level) to exporters and processors at international level, and (ii) existing research packages were expensive for resource poor farmers who face a 'closed-door' policy from the banks and therefore have to continue experimenting with the same practices they inherited from their fathers although these do not result in higher yields.

Diagnostic studies, unlike technographic studies, focus on the micro level and attempts to identify location-specific problems with farmers, analyse the problems jointly and formulate appropriate strategies to overcome them. Details of the diagnostic study carried out in this research are reported in chapter 2 of this thesis.

1.6.2 The research area

The field work for this research was carried out between September 2002 and December 2005 to collect data from farmers at the village level and also from various government and private organisations at the national and district levels. Field activities and data collection from farmers was carried out in the Suhum-Kraboa Coaltar District (SKCD), which is located in the Eastern Region of Ghana. The Eastern Region was selected because of a long history of cocoa production and also, the location of the CRIG (Tafo) falls in this region. Commercial production of cocoa in Ghana started in the Eastern Region around 1890 (Amanor, 1994) and the region remained the highest producer of the crop until 1964. Currently it is the fourth highest producing region in Ghana with an average annual contribution of 10% of national production.

The Suhum Kraboa Coalter District, with Suhum as capital, is located in the forest zone of Ghana. The temperature in the district ranges from 24 to 29°C with a relative humidity between 87% and 91% (Anon., 2000). The annual rainfall figures fall in the range of 1,270 mm and 1,651 mm (Anon., 2000). About 64% of the adult population are farmers by occupation (Anon., 2000). Cocoa, which is the main cash crop, is cultivated on an area of 8,720 ha, representing about 20% of total area under crop cultivation (Anon., 2000).

The district was selected because of the implementation of a project there in the 1970s and also its proximity to CRIG at Tafo. The Eastern Region Cocoa Project implemented in the area between 1970 and 1979 resulted in the rehabilitation of cocoa farms and the training of farmers in improved methods of cocoa production (see section 1.3). The district therefore provides opportunities for understanding the nature of cocoa production from various perspectives; historical factors and contact with research among others. Three villages; Adarkwa, Achiansah and Kojohum, were initially selected for the study in consultation with the District Director of Agriculture after initial visits to six villages with three extension agents of the District Agricultural Office. The determining factor for selecting the villages was an assessment of the relative importance of cocoa production in the villages; the more cocoa cultivated compared to other crops was the main criteria used. A fourth village, Ntumkum, was included in the last year of the field work on demand by leaders of a farmer group in the village and this provided an opportunity to explore potential strategies for scaling out the experiences and lessons learnt in the other villages. Details about the villages are discussed in subsequent chapters.

1.6.3 Participatory action research

Action research is defined as the pursuance of action and research as a cyclic process, alternating action with critical reflection (Dick, 1997a). Action alternating with reflection is the point at which action research and experiential learning intersect (Dick, 1997b). Within each action research cycle, practice informs theory, which in turn informs practice; therefore, the theories in action research tend to be about practice (Bawden, 2002; Dick, 1998), which is suitable for this research because it involved active learning and practice by both the researchers and farmers. Two main principles of action research adopted for this research are: a) non-instrumental intervention through facilitation of various activities involving cocoa farmers in the research area; and b) organisation of workshops, and both formal and informal meetings with the various actors in the cocoa sector to analyse their perceptions, goals, problems and to agree on potential solutions.

Some activities that were carried out as part of the action research process was: a diagnostic study which involved joint identification and analysis of problems related to cocoa production (see chapter 2); establishment of research plots for interaction, knowledge exchange, and learning among various stakeholders (chapters 3); facilitating socio-economic arrangements needed to make integrated pest management practices feasible on a sustainable basis (chapter 4). A forum was created at the district level to serve as a platform where the various stakeholders in the cocoa sector met every 3 months to discuss issues relating to cocoa production. This forum for interaction formed part of the overall action research process.

1.6.4 Research methods

Both quantitative and qualitative methods were used in this research. Quantitative methods usually involve surveys, in which a large amount of data is collected, using closed questionnaires, with the aim of analysing the resultant data, and making generalisations from the results. It also involves data from field experiments. Qualitative methods, however, involve fieldwork which mainly employs the use of open-ended questionnaires which are more flexible and provide richer information than standard ones (Peacock, 1986; Giddens, 1989).

Qualitative data and information was collected mainly through semi-structured interviews, formal, and informal meetings with various actors in the cocoa sector, from national, regional, district, village, and farmer levels. Another qualitative tool used was participant observation, mainly at the village, and farmer levels to understand farmers' practices. These included policy makers, researchers, extension workers, farmers, and officials of LBCs.

Specific methods, and the data and information gathered are elaborated in subsequent chapters, but below is a summary of what was collected from various actors in the cocoa sector:

(i) MoFA: information on their role as extension service providers to cocoa farmers and their linkages with research and farmers;

(ii) COCOBOD: the policy framework for the cocoa sector;

(iii) CRIG: information on research activities over the years and how findings have been transferred and received by farmers, how the current re-organisation of the cocoa sector impinged on the research activities, and links with MoFA extension and farmers;

(iv) Farmers: perceptions of the main problems facing cocoa production and of the relevance (adoption, adaptation, or rejection) of research findings, farming practices, socio-economic situation, and views on government policies relating to the cocoa sector; participation and learning processes in the innovation development process;

(v) LBCs at national and district levels: operations and issues relating to pricing and quality of beans purchased from farmers.

Some of the data collected were interpreted and validated through individual and group discussions with the relevant actors. An important and critical factor in qualitative research is the question of objectivity, reliability and validity. "Reliability is the degree to which the finding is independent of accidental circumstances of the research, and validity is the degree to which the finding is interpreted in a correct way" (Kirk & Miller, 1986:20). To further authenticate/validate (Silverman, 2001) the findings, information and data gathered from the various actors were cross checked with other relevant actors during the fieldwork. Information gathered was shared with all the stakeholders who attended quarterly meetings and participants were encouraged to express their views on all issues.

Quantitative data were limited to two main areas. The first was data collected from experimental plots jointly with farmers on their fields to determine changes in pest incidence and yields resulting from integrated pest management practices. The second was through a survey to understand in broader terms the nature of the study area, knowledge about cocoa production, the functioning of the research and extension systems and general views on government policy regarding the cocoa sector.

1.7 Structure of the thesis

In the introductory chapter, we have given a background to the importance of cocoa production in Ghana and the challenges faced by cocoa farmers and other stakeholders in the industry. The research problem and objectives have been introduced and the broad theoretical framework that guided the whole research work discussed briefly. Because of the multi faceted nature of the issues dealt with in this research, a number of theories are introduced and they are explored further in subsequent chapters. The overall approach to the research has also been introduced in this chapter.

Chapter 2 describes the diagnostic approach used in identifying the main problem faced by farmers regarding cocoa production and an analysis of the causes of the problem. Low yields were identified by farmers as the main problem faced by them. The causes of low yields were identified and categorised into either biological or social factors which are inter-related.

The analysis of causes from chapter 2 formed the basis for setting up experimental plots described in chapter 3. The experimentation phase served as a learning point on integrated pest management practices for controlling cocoa pests and diseases. Both agronomic and economic analyses of IPM practices are made in this chapter.

In chapter 4, the ways social arrangements contribute to innovations are explored. The chapter discusses socio-technical linkages and adaptations that need to be made to research findings before they become operational at the farmers' level. The chapter also explores the potential or contribution to innovation by facilitating other economic activities that create demand for otherwise waste agro products like cocoa pod husks.

Chapter 5 explains the factors that could account for observed differential outcomes of the innovation development process in three villages. Taking the innovation trajectories in the three villages as case studies, a comparative analysis of the processes is made using sensitising concepts from theories of learning and social capital in an attempt to explain the outcomes.

In the last chapter, some general discussions about the whole thesis are made, present some reflections on the research approach adopted, and draws some conclusions based on the research objectives stated in the introductory chapter. Finally some recommendations are made on possible strategies for improving the innovation system for the cocoa sector in Ghana. The relationships between the various chapters are illustrated by Figure 1.4

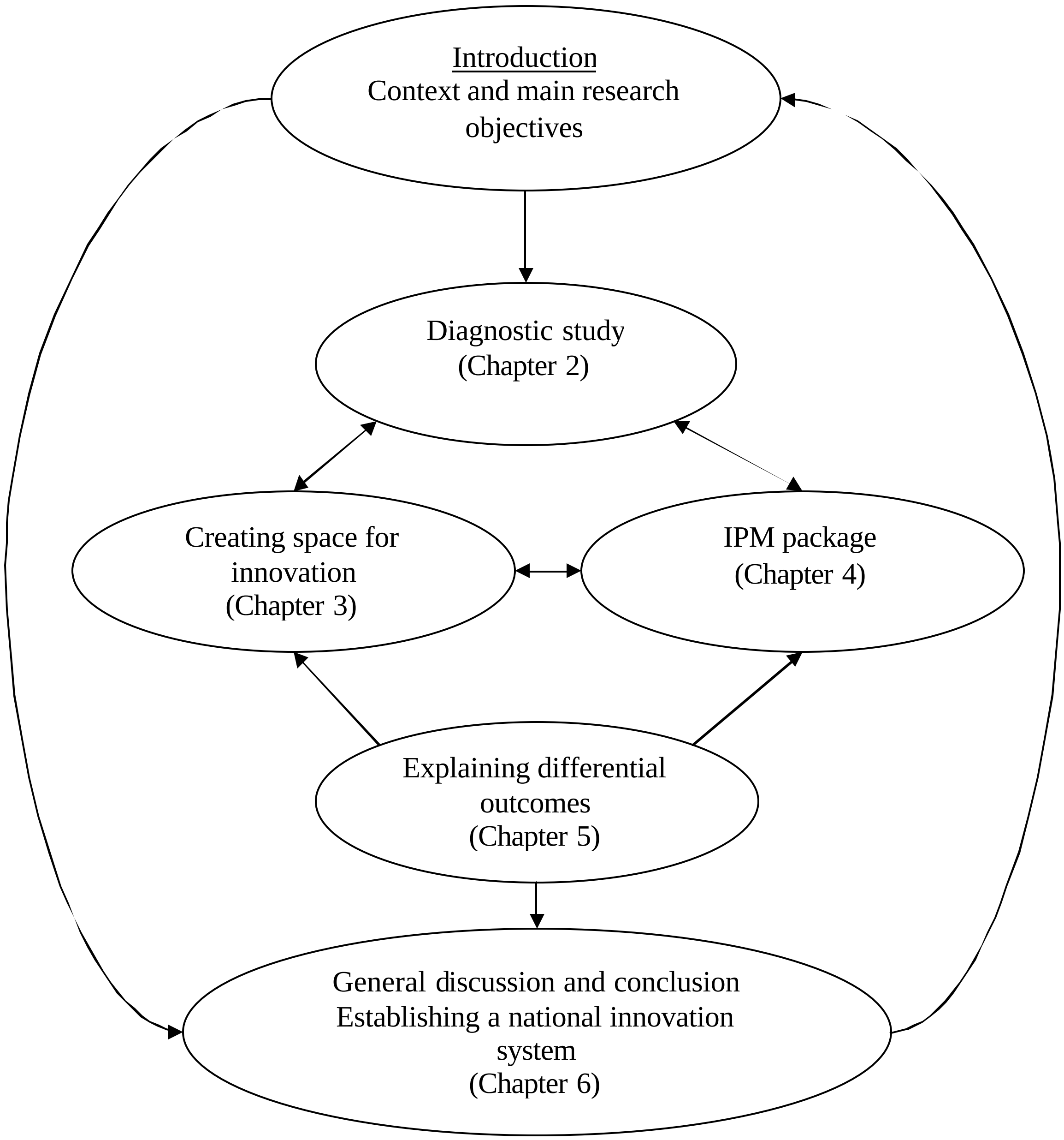

Figure 1.4: Relationships between various chapters in the thesis

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Chapter Two

Causes of low productivity of cocoa in Ghana: farmers' perspectives and insights from research and the socio-political establishment[2]

Abstract

Ghana is a major producer of cocoa in the world and relies heavily on the crop for foreign exchange revenue. However, production levels declined from the mid 1960s reaching the lowest level in 1983. Although production has increased consistently since the mid 1980s, it still falls short of the level achieved in the mid 1960s. The decline in production is a result of decreasing areas under cultivation. Another constraint in cocoa production in Ghana is low yields per ha which is attributed to the incidence of insect pests and diseases, a low producer price, and non-adoption of research recommendations by farmers. Based on the idea that current research and extension messages might insufficiently address farmers' actual problems and context, a diagnostic study was carried out to better understand farmers' views on the problems of cocoa production. The study was conducted in three villages in the Suhum-Kraboa-Coalter District of the Eastern Region of Ghana. An action research approach was followed to gather and analyse qualitative data with the objective of stimulating collective action in subsequent research activities with the farmers. Low productivity was identified as the main problem and the causes

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were classified into socio-economic and biological factors. The biological factors include the incidence of insect pests and diseases, most of which have received extensive research attention in Ghana, and epiphytes which have been neglected. The socio-economic causes were indirect and include the low producer price, and the lack of amenities including electricity, which leads to migration, with as a result labour shortages and high labour costs. From the study it can be concluded that the biological and socio-economic causes of low productivity are inter-related in such a manner that tackling them separately will not overcome the problem unless the socio-technical nature of the causes are recognized and tackled in a holistic way. In this context, current interventions by research and extension seem to ignore important aspects of the problematic situation. Although the study shows the relevance of using a diagnostic approach, it is argued that outcomes may be affected by various contextual factors, including stakeholder selection and the relationship between the researcher and the participants. Hence, the outcomes of a diagnostic study should be approached with care.

Additional keywords: diagnostic studies, participatory action research

2.1 Introduction

Ghana is one of the major producers of cocoa in the world. The crop contributes about 3.4% of total Gross Domestic Product (GDP) annually and an average of 29% of total export revenue between 1990 and 1999 (Anon., 2001) and 22% between 2000 and 2002 (Anon., 2003). However, production levels declined consistently from 568,000 Mt in 1965, falling to its lowest level of 160,000 Mt in 1983. Since the mid 1980s, production levels have risen gradually to an average of 400,000 Mt during the late 1990s (Anon., 1999; Abekoe *et al.,* 2002) which is still considerably less than the production levels attained in the mid 1960s. The decrease in production in the early 1980s was attributed by the government to adverse weather conditions, that led to widespread bush fires, destroying many cocoa farms (Anon., 1999). Although some burned cocoa farms have been replanted with cocoa, other ones have been abandoned or the land has been used for the production of other crops, thereby reducing the area under cultivation (Anon., 1999).

Generally, yields of cocoa are lower in Ghana than in other major producing countries. Whilst the average cocoa yield in Malaysia is 1,800 kg ha^{-1}, and 800 kg ha^{-1} in Ivory Coast, it is only 360 kg ha^{-1} in Ghana (Anon., 1999; undated). Reasons for the low productivity include poor farm maintenance practices, planting of low yielding varieties, and the incidence of pests and diseases (Anon., 1999; Abekoe *et al.,* 2002). Poor farm maintenance practices are attributed to the low prices paid to Ghanaian cocoa farmers (Anon., 1999). The above reasons largely represent the views and perceptions of policy makers and researchers, and not necessarily those of farmers.

In an attempt to increase production, the government has been implementing policies aimed at reforming the cocoa sector since the early 1990s. In 1999, the government adopted a development strategy with the objective of improving the performance of the cocoa sector. Under this strategy, production levels are expected to reach 700,000 Mt by the year 2010 (Anon., 1999). The resulting reforms have led to the liberalization of the internal marketing of cocoa and to increases in the producer price from 56% to 70% of the fob ('free on board') price over the period 1998/99–2004/2005 (Anon., 1999). The fob price is the price at which government sells cocoa to foreign buyers and includes, apart from a profit margin, all costs incurred in buying and transporting the beans to the port. The cocoa sector development strategy has also involved shifting responsibility for cocoa extension services from the Cocoa Services Division (CSD), a subsidiary of the Ghana Cocoa Board (COCOBOD) to the Ministry of Food and Agriculture (MoFA). In addition, since 2001, the government has mass-sprayed all cocoa farms under the Cocoa Diseases and Pests Control programme (CODAPEC) at no direct cost to the farmer. Since 2003, the government has also started an interest-free credit scheme called the Cocoa 'Hi-tech' programme, which aims at increasing productivity by providing fertilizers and pesticides. In the first year, 50,000 farmers benefited from this program, a number that increased to 100,000 farmers one year later. The 'Hi-tech' programme is managed jointly by the Cocoa Research Institute of Ghana (CRIG), COCOBOD and MoFA.

The extent to which the government's cocoa sector development strategy would adequately meet the needs and aspirations of farmers remains yet to be seen. Although the strategy attempts to tackle both economic (liberalized market and pricing policy) and technical issues, the overall strategy remains essentially a top-down linear approach with limited institutional reforms. Also, the agenda for research on cocoa is drawn up in the linear fashion of technology development and transfer (Chambers *et al.*, 1989): CRIG develops technologies that are carried by the agricultural extension system as recommendations for farmers to adopt. Some of the technologies include the development of high-yielding hybrid varieties, breeding of cocoa types resistant to the Swollen Shoot and Black Pod disease, control of capsids with insecticides, various cultural practices to control shade, and weed control (see Anon., 1997; 2000a). However, most of these recommendations have not been widely adopted by farmers, who either do not find the recommendations relevant, not applicable at the farm level, or not compatible with the prevailing systems of production. For instance, a survey of 1750 cocoa farmers in 1997/98 showed that full adoption of research recommendations for pest and disease management was only 3.5% (Gerken *et al.*, 2001).

It has been argued by many that the most promising way to make research findings and government policies relevant and acceptable to farmers is to base research and policy assumptions on the needs as expressed by the farmers and on the difficulties they face. In the early 1970s, farming systems research and on-farm research were introduced to help researchers better understand farmers' technology needs and attempt to meet those needs (Okali & Sumberg, 1986; Chambers *et al.,* 1989; Ashby, 1991). Although farming systems research has helped in improving the understanding by scientists of production systems and in identifying gaps in existing technologies, it still has some limitations. One criticism of farming systems research is that it pays little attention to policy issues (Okali *et al.,* 1994). Other shortcomings include the late involvement of farmers, mostly at the testing and adapting stage of technology development – which was basically a linear technology development process – rather than in the initial stage of identifying and prioritizing research problems. It is also characterized by initiatives coming from researchers and not from farmers, who are given a reactive rather than a proactive role. So one of the major challenges of farming systems research and extension that remained was how it could be made into a genuinely participatory activity in which farmers are not passive recipients of technology but key players in identifying, analysing, designing and implementing research activities (Conway, 2001). Following the shortcomings of farming systems research, farmer participatory research has been proposed (Okali *et al.,* 1994). Two key principles of farmer participatory research are: (1) farmers actively seeking and testing new techniques and ideas, and (2) the potential synergy through interaction of formal agricultural research and farmers' own research (Okali *et al.,* 1994). The aim of participatory research at a technological level is for the stakeholders to understand the characteristics and dynamics of the agro-ecosystem within which the community operates, to identify priority problems and opportunities, and to experiment with a variety of technological options based on the ideas and experiences derived from indigenous knowledge and formal science. Although the proponents of farmer participatory research have tried to distance it from farming systems research, Okali *et al.* (1994) argue that they share many common roots. A limitation of participatory research with farmers is that it tends to have a strong local and technology focus and frequently fails to address wider social issues. In other words, by focusing on 'appropriate technology', there is a risk that current social arrangements and conditions are taken for granted and left intact, even if these conditions would merit change. This is at odds with recent insights from innovation studies, emphasizing that successful innovations consist of a coherent package of both new technical devices and practices *and* new social-organizational institutions and relationships at various societal levels (see e.g. Rip, 1995; Geels, 2002; Leeuwis & van den Ban, 2004).

Taking into account these earlier attempts at involving farmers in research and the challenges that were encountered, a project called 'Convergence of Sciences' was set up. This CoS project is experimenting with a farmer participatory research approach that adopts technographic and diagnostic studies as a method of identifying opportunities for both social and natural science investigation, and grounding such research and its design in farmers' needs (see Röling *et al.*, 2004). During the initial phase of the CoS project, cocoa was identified as an important public crop in Ghana and was one of three crops on which technographic studies were carried out. The technographic study on cocoa identified the incidence of pests and diseases as a major problem facing cocoa production. It also identified, amongst other things, poor extension services, weak farmers' associations, and low producer prices, as affecting the cocoa industry. Whereas technographic studies focus on the national level and aim at identifying opportunities for innovation by mapping the technological landscape in a specific sector (e.g. cocoa), diagnostic studies identify and analyse specific research problems with the active participation of farmers, evaluating options and selecting possible solutions that would work in their conditions. Therefore, as a follow up to the technographic studies on cocoa, the objective of this study was to use a 'diagnostic' approach to determine farmers' perceptions about the problems facing cocoa production vis-à-vis the views from research and government officials, as a first step in an interactive participatory research process with farmers.

2.2 Materials and methods

2.2.1 Research approach

An action research approach has been adopted for the whole research process, including this diagnostic study. In action research, theory and practice are constantly reviewed through experience, reflection and learning (Bawden, 1991; Scoones, 1995; Dick, 1997a, b). This approach was useful for the study because it brought some commitment on the part of the farmers and other stakeholders, an important pre-condition for further joint action and learning in subsequent research activities.

To collect information on the social dynamics and perceptions of farmers, qualitative methods were adopted in gathering data and information for the diagnostic phase. Various tools and techniques such as the problem tree, scoring, and ranking exercises, were used in a participatory manner to gather and analyse qualitative data for joint planning and collective action in subsequent research phases. Semi structured interviews were also used to gather the views and seek clarifications on issues raised by farmers, from extension agents, researchers, Licensed Cocoa Buying Companies (LBC) and policy makers.

2.2.2 The study area

The diagnostic study was carried out between September 2002 and February 2003 in the Suhum-Kraboa Coaltar District in the Eastern Region of Ghana. The district, with Suhum as capital, is located in the forest zone. The average daily temperature in the district ranges from 24°C to 29°C with a relative humidity between 87 and 91% (Anon., 2000b). Annual rainfall varies between 1270 and 1651 mm (Anon., 2000b). Out of a total population of about 170,000 inhabitants, 64% are farmers by occupation (Anon., 2000b). About 40% of all farmers in the district cultivate cocoa (Y. Dotse, District Director of Agriculture, personal communication) on an area of 8720 ha, representing about 20% of the total area under crop cultivation (Anon., 2000b).

The Suhum-Kraboa-Coaltar District was selected because of a long history of cocoa production and its proximity to CRIG. Another reason is that the implementation of the Eastern Region Cocoa Project in the study area between 1970 and 1979 resulted in the rehabilitation of cocoa farms and the training of farmers in improved methods of cocoa production (Amoah, 1998). Three villages, Adarkwa, Achiansah and Kojohum (Figure 2.1), were selected for the study in consultation with the District Director of Agriculture after initial visits to six villages with three extension agents of the District Agricultural Office. The determining factor for selecting the three villages was an assessment of the importance of cocoa production.

Adarkwa

Adarkwa is about 8 km from Suhum. The main occupation of the people in the village is farming with cocoa as a major crop. All cocoa farmers produce food crops in addition to cocoa and some of the male farmers engage in other income-generating activities like tapping palm wine and masonry. For the women, petty trading is common.

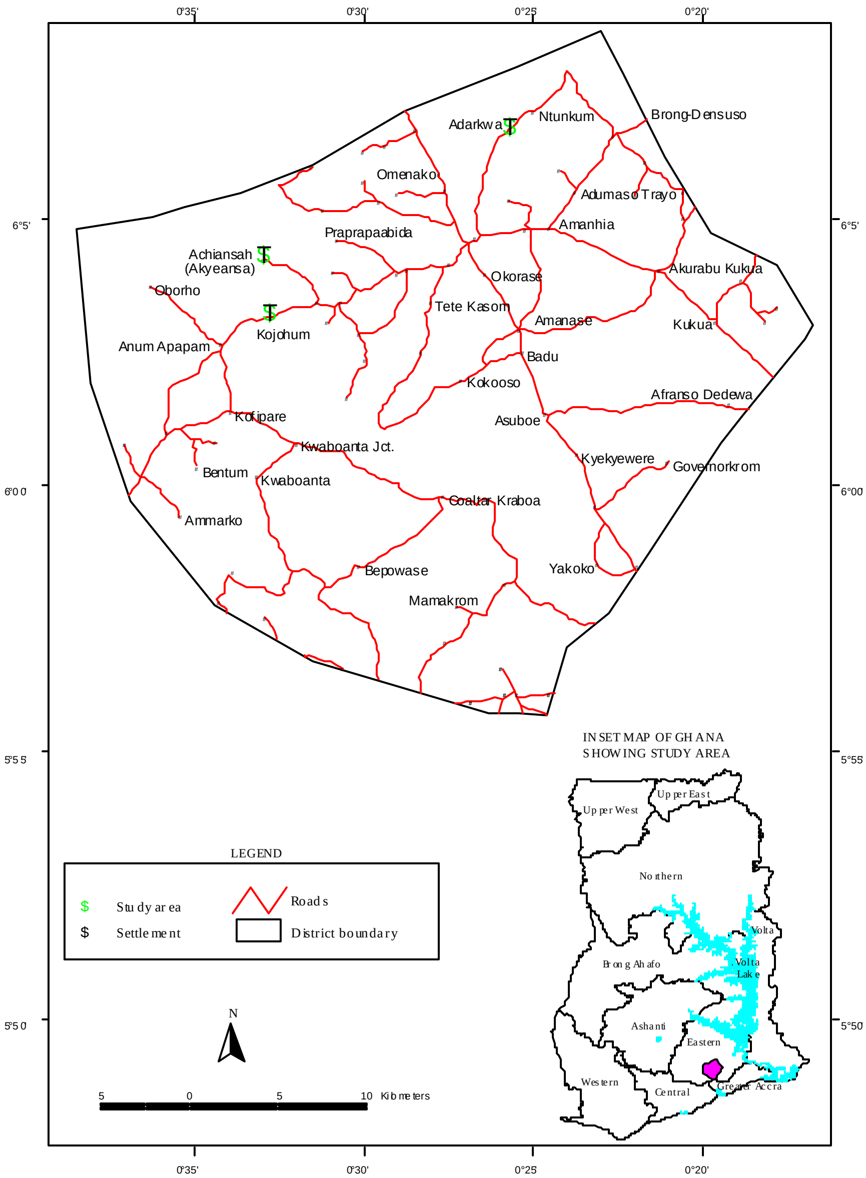

Figure 2.1. Map of Suhum-Kraboa-Coalter District, Ghana, indicating study areas

Generally, women who did not own cocoa farms helped their husbands on their farms. All cocoa farmers in the community were invited to participate in the study.

Achiansah

Achiansah is about 20 km from Suhum and is located in one of the major cocoa growing areas in the district. The Agricultural Extension Agent (AEA) helped in selecting two of his farmers' groups for the study; the Victory Farmers Group and the *Gye se wobre* Group. The Victory Farmers Group has 16 members all of whom are Akwapims and also belong to the same church. The *Gye se wobre* Group is made up of 15 farmers belonging to the Krobo ethnic group, and has a somewhat broader interest in both crop (including cocoa) and livestock production. The expression 'Gye se wobre' literally means 'you must work hard before you can achieve your objectives'. The farmers in both groups are descendants of migrant farmers who settled at Achiansah in the early part of the 1920s with the objective of growing cocoa.

The AEA had been working with these two groups since 2000. The decision to select specific farmer groups was the result of the experience with an 'open' invitation to all cocoa farmers in Adarkwa, which turned out to be cumbersome because of the large number of farmers who turned up for meetings. Therefore, existing farmer groups were selected instead, which resulted in relatively more homogenous groups in the sense that they had come together to interact with the extension agent on agricultural issues. Selecting farmer groups with whom the AEA had been working for some time also provided a different scenario from Adarkwa and hence an opportunity to observe and learn from any difference that this approach could make in determining the outcomes of the study.

Kojohum

The third village, Kojohum, is about 30 km from Suhum. The village serves as a centre for many settlements of cocoa farms within a radius of about 2 km. However, after six months Kojohum was dropped from the study because we made little progress probably due to the approach adopted for selecting farmers in this village. We did not select particular farmer groups (as we did in Achiansah) or invite all cocoa farmers in the community (as was done in Adarkwa). Instead, the chief farmer invited representatives from five surrounding villages and hamlets to Kojohum, the village where he lives. This is a normal practice when they have to meet and discuss issues relating to cocoa production or development issues in general. This approach seemed attractive as it offered a different scenario from the other two villages. Unfortunately, different people kept turning up and on each occasion the new persons attending the meetings had not been briefed by the previous participant thereby retarding progress (only about four out of 20 farmers attended the meetings regularly). This situation defeated the action research philosophy where the continuity in the action, reflection and learning cycle is an important ingredient.

2.2.3 The research process

In each village, the process started with a community meeting followed by community mapping, participatory problem identification, analysis, prioritization and action planning. The overall research process is illustrated in Figure 2.2. This paper presents the results of the process from community meeting up to the prioritization phase. The methods used in the different research sites are summarised in Table 2.1.

The study started in Adarkwa with a community meeting to explain the objectives of the study to the farmers, followed by similar meetings in Achiansah and Kojohum. The participatory action research philosophy of the study was explained to the farmers who were encouraged to be frank and open in their interaction with us (I was supported by a research assistant and the AEAs working in each village) and to learn from each other. The objective of the community mapping step was to bring to the open the resources available in the community through visualization. The pictorial representations of information formed a central element of participatory analysis and learning by stimulating participants' memories and facilitating discussions by both literate and illiterate participants (see Pretty *et al.*, 1995). Farmers showed a lot of enthusiasm in sketching maps of their community. Because of the large number (126) of farmers present in the case of

Adarkwa, sub-groups were formed enabling each person to participate in the exercise. Each sub-group produced their own sketch of the community and the leader of each sub-group presented their sketch to a plenary session. The fun and enthusiasm created a good atmosphere for interaction and this was capitalized upon to carry the farmers' interest and enthusiasm into the next step by asking them to recollect that exercise on the next meeting day when problem identification commenced. In Achiansah and Kojohum, each of the farmer groups mapped their community for the same reasons as in Adarkwa.

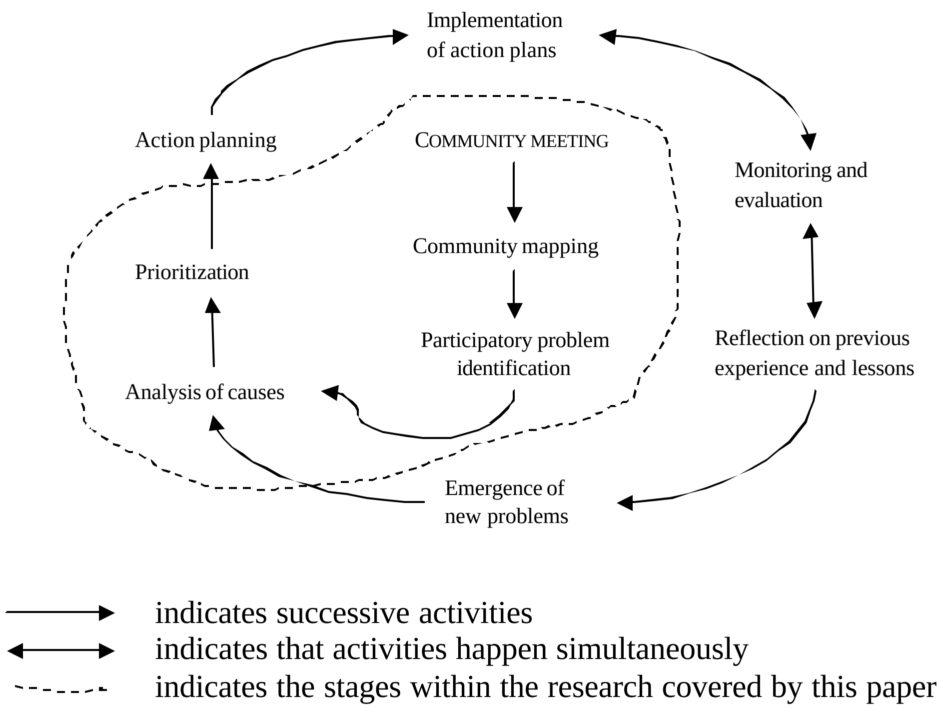

Figure 2.2. Overall set-up of the action research

The next phase involved problem identification. Farmers mentioned all the issues considered as problems that affected cocoa production. In Adarkwa about 30 issues were listed after which the issues were discussed in detail and analysed. The farmers explained the cause and effect relationship between the issues and categorized them into main problem, causes and effects of the problem. In Adarkwa, a problem diagram was constructed to show the relationship between the categories of issues listed. Because of the large number of issues that were raised at Adarkwa, the use of the problem tree technique was appropriate in facilitating the visualization of the relationships between different factors. The groups in Achiansah raised fewer issues, which were easy to relate to the main problem (which they had identified and low yields), therefore, it was not necessary to use the problem tree. Kojohum was dropped from the study at this phase because of inconsistencies in problem identification and analysis resulting from different persons representing their villages at each meeting.

A pair wise matrix ranking technique was used for determining the relative importance of the causes of low cocoa yields identified in Adarkwa. In this method, a matrix was developed where the farmers compared each item they listed as a cause of low yields directly against all the other causes. This turned out to be extremely cumbersome and difficult because of the large number of factors under consideration (16 × 16 matrix) and it took two meetings to complete the process. As a result, the simple techniques of scoring and ranking were adopted with the Achiansah groups. After the exercise, each factor in the matrix was reflected upon in order to increase our understanding of the complex situation in terms of relationships between causes, problems and effects. In the action planning, specific strategies and activities were identified through discussions involving the nature of causes. In the case of pests and diseases, the mode of spread and the type of damage was discussed. Strategies were agreed upon through negotiations after considering the options available and the role that various stakeholders could play in tackling them.

Table 2.1. Processes and methods used in the three study areas for the identification and prioritization of the causes of low cocoa yields

Stages in the diagnostic study	***Research sites***			
	Adarkwa	Achiansah (Victory Farmers Group)	Achiansah (*Gye se wobre* Group)	Kojohum
Community meeting	The whole community was invited.	The 16 members of the group were invited.	The 15 members of the group were invited.	Four representatives of 5 surrounding villages were invited.
Problem identification and analysis	Problems were identified and listed by all members of the community present. A problem diagram was used to show the relationship between the main problem, its causes and the effects.	Problems were identified by members of the group. The main problem was identified and causes listed and discussed.	Problems were identified by members of the group. The main problem was identified and causes listed and discussed.	Problems were identified by representatives the surrounding villages. The main problem was identified and causes listed and discussed. The process however stopped during the analysis phase.
Prioritization (ranking) of causes of main problem	All members of the community present prioritized the causes using a pair wise ranking technique.	Members of the group prioritized the causes using a simple scoring and ranking technique.	Members of the group prioritized the using a simple scoring and ranking technique.	
Action planning	Strategies to overcome the listed causes of low yields were drawn by all members of the community present at the meetings.	Strategies to overcome the listed causes of low yields were drawn by the group members.	Strategies to overcome the listed causes of low yields were drawn by the group members.	

Semi-structured and informal interviews were held with some farmers to get a better understanding of issues that were not exhaustively discussed during group meetings. They also provided a better understanding of the history of cocoa production in the area, which was important in getting the right context of the issues discussed during group meetings. Notable among the farmers interviewed was the Chief of Adarkwa, (Nana Adarkwa Yiadom II) who is 80 years old and knew a lot about the history of cocoa production in Ghana. Also, officials of some Licensed Buying Companies (LBCs) were interviewed. They included the Regional Manager of Kuapa Kooko Ltd, the Managing Director of Federated Commodities Ltd (FEDCO), purchasing clerks of Kuapa Kooko Ltd, FEDCO, Adwumapa Ltd. Informal interviews were also held with officials of the Ghana Cocoa Board, the District Cocoa Officer at Suhum, and some scientists at the Cocoa Research Institute. Most of these discussions were to clarify issues that farmers had raised and to feed back that information to the farmers in subsequent meetings.

Some information was gathered during visits to the research location through participant observation. This was done during meetings by observing the interactions between the farmers and who spoke about the issues. This was useful in providing some explanations about the views expressed by different people and, in some cases, why they took particular positions.

Validations were done in two stages, firstly through community feedback meetings with each group in their communities, and secondly through a workshop to which all the actors in the cocoa sector were invited. The actors included researchers, cocoa LBCs, commercial and rural banks, the Cocoa Services Division, and staff from the extension services of MoFA. After presenting the results of the study, each category of actors was invited to comment. Although the issues raised by farmers had been discussed with the other actors independently, bringing everybody together in this validation workshop allowed for a more representative forum for mirroring diverging perspectives on the situation. The workshop also helped to develop a better mutual understanding of the problems and to explain why some of these persisted for such a long time.

2.3 Results and discussion

2.3.1 The problems in Adarkwa

The main problem identified by the farmers in Adarkwa was the low yields of cocoa, which were attributed to several factors. The causes and effects of low yields are illustrated in Figure 2.3. Issues about mistrust (among fellow farmers, government officials especially regarding government policies on cocoa, LBCs, research, etc.) kept surfacing as part of the reasons why certain causes persisted although ‘mistrust’ was not specifically listed as a cause of low yields. Also, the farmers ranked the low producer prices to coca farmers and the lack of electricity as the two most important causes of low yields (see Table 2.2).

Figure 2.3. Problem Diagram constructed jointly with farmers in Adarkwa.

2.3.2 The problems in Achiansah

The Victory Farmers Group identified low yield as the main problem facing cocoa production, estimating that current yield levels were between half and one-third of what they obtained 15–20 years ago. A remarkable difference between causes identified by farmers in this group and those in Adarkwa was the focus on technical issues rather than on socio-economic and infrastructural development.

The group did not focus on lack of infrastructure although the members live in a deprived outskirt of Achiansah (at about 2 km distance) with a very poor road leading to the community; they have no electricity, no schools or other social amenities. The only non-residential building in the community is the church.

The *Gyese wo bre* group identified low yields as the main problem facing cocoa production. They explained that they obtain an average of 248 kg ha^{-1} against 496–620 kg ha^{-1} 15–20 years ago. The average yields given are difficult to verify because the farmers do not keep records of production levels or areas under cultivation over the years. The farmers identified the causes of low yields, scored and ranked the causes as presented in Table 2.2

The *Gye se wobre* group identified both technical and socio-economic causes of the low yields. These included the incidence of capsids and Black Pod disease and the difficulties in acquiring spraying equipment and pesticides to control these pests. The group was unhappy with the fact that in 2001 the government took over the spraying of their farms under the 'mass spraying' exercise. They would have preferred that the government paid the money for the mass spraying to them directly or indirectly through better producer prices. However, they admitted that they had not sprayed their cocoa to control capsids or the Black Pod disease for at least 10 years until the government started the spraying exercise and also that most farmers would not

Table 2.2. Causes of low yields as ranked by the farmers in Adarkwa and Achiansah (Victory Farmers Group and the *Gye se wobre* Group), and their relative importance

Ranking	Adarkwa (n=62)		Achiansah (Victory farmers Group) (n=14)		Achiansah (*Gye se wobre* Group) (n=15)	
	Cause	Relative importance (%)	Cause	Relative importance (%)	Cause	Relative importance (%)
1	Low producer price	20	Mistletoe (*T. bangwensis)*	17.5	Capsids	16.6
2	Lack of electricity	18.7	Epiphyte (*Bulbophyllum spp.)*	15.7	Non-availability and high cost of spraying equipment for pest and disease control	16.4
3	Lack of labour	17.3	Capsids	13.6	Black Pod disease	15.7
4	Inability to buy inputs & lack of capital	14.7	Swollen Shoot disease	12.5	Mistletoe (*T. bangwensis)*	11.9
5	Inability to replant old farms & lack of labour	13.3	Shield bugs	10.7	Non-availability on open market of pesticides (confidor; a. i. imidacloprid) for capsid control	7.6
6	Swollen shoot disease & mistletoe (*Tapinanthus bangwensis)*	9.3	Epiphyte (*Chasmanthera dependens.)*	9.6	High cost of input	6.1
	Cause	Relative	Cause	Relative	Cause	Relative

Ranking	Adarkwa (n=62)		Achiansah (Victory farmers Group) (n=14)		Achiansah (*Gye se wobre* Group) (n=15)	
		importance (%)		importance (%)		importance (%)
7	Capsids, orchids, woody climbers, termites, & stem borers	5.3	Stem borers	7.1	Insufficient capital and no access to credit	5.7
8	Black Pod disease	1.4	Black Pod disease	6.4	Epiphyte (*Bulbophyllum spp.)*	4.6
9			Black ants	3.9	Swollen Shoot disease	4.0
10			Termite	3.0	High interest rates	3.5
11					Stem borers	2.3
12					Non-availability of hybrid seedlings or pods	2.3
13					High labour costs	1.7
14					Sudden death of cocoa trees around a tree locally called *cocoa gbe tso* (literally 'the tree that kills cocoa') *	1.6

[*] This problem was mentioned by two farmers only: most others did not know about it. Enquiries at CRIG could not confirm that the tree was responsible for the death of the cocoa trees around it

spend their money on buying pesticides even if better producer prices were paid. The farmers also complained that the people recruited (the spraying gangs) by the government to spray the farms were not doing a good job. They argued that because the spraying gangs are paid on the basis of area covered, they aim at covering as much acreage as possible rather than patiently spraying the canopy to target the capsids.

The group identified other socio-economic causes, including the level of producer prices paid by government to cocoa farmers, difficulties in accessing credit, high cost of labour, and high interest rate charged by moneylenders.

2.3.3 Persistence of pests and diseases, and their effect on yield

The biological causes identified by the farmers were pests and diseases, parasitic and epiphytic plants. The incidence of pests and diseases has persisted and contributed to low yields because of inadequate crop management (Figure 2.4). We analysed the farmers' understanding and perception of the biological causes of low yields vis-à-vis the views of actors like researchers, extension workers and policy makers.

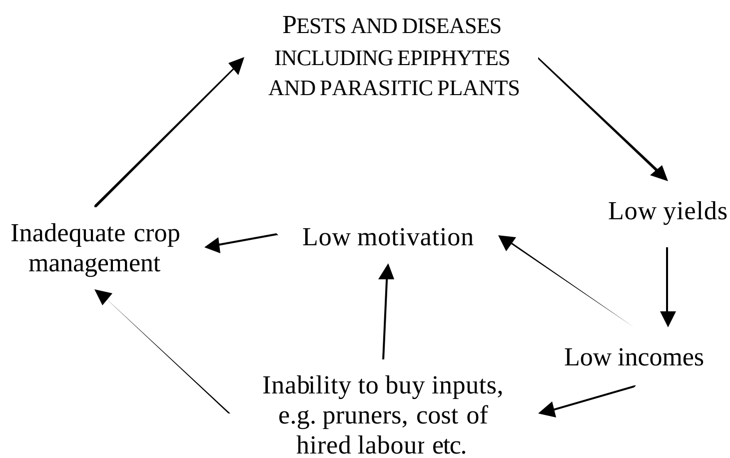

Figure 2.4.Effects of pests and diseases on yields

The incidence of cocoa pests and diseases as a cause of low yields has been known and documented by many researchers over the years. Insect pests such as capsids, shield bugs, and diseases like Black Pod and Swollen Shoot have received extensive research attention (Thorold, 1975; Wood & Laas 1985; Anon., 1997; Acquaah, 1999; Wilson, 1999). The farmers were very familiar with these pests and diseases and admitted receiving information from extension agents about control methods. Most farmers, however, did not control any of these pests and diseases and attributed this to the high costs of pesticides, spraying equipment, and labour. The farmers argued that their inability to buy the necessary inputs was due to the low producer prices paid by government. This point will be discussed below.

During the problem-analysis phase in the three study areas, it turned out that although the farmers had in-depth knowledge of some of the common pests and diseases, in some cases they did not know their mode of spread. An example is the Black Pod disease. Farmers admitted receiving advice on both chemical control as well as agronomic practices like shade management to reduce humidity, but they did not know the mode of spread probably because of the invisibility of the spores of the fungus to the naked eye. In situations where farmers could easily visualize the mode of spread, it was easy for them to explain and appreciate the direct benefit of adopting certain practices. An example is the spread of mistletoes. Here the farmers were aware that birds fed on the seeds and spread them to other trees when they clean their beaks after feeding. The same mode of spread was recorded by Wilson (1999). According to Wood & Laas (1985), however, mistletoes are spread through the birds' faeces. The seeds pass through the birds' digestive system undigested and germinate on the bark of young branches. For the farmers the birds cleaning their beaks and leaving seeds behind was visible but they did not know about the seeds spreading via the faeces. Also other authors observed that farmers have good knowledge about objects in nature they can easily observe whereas less conspicuous ones may escape their attention (Van Huis *et al.*, 1982; Bentley, 1992; Van Huis & Meerman, 1997).

The parasitic mistletoe *Tapinanthus bangwensis* was identified as a cause of low yields in the study area. Epiphytes identified were *Bulbophyllum* spp., *Chasmanthera dependens* and *Cyrtorchis hamerta*. The Victory Farmers Group ranked mistletoes and *Bulbophyllum* spp., as the two most important causes of low yields. In Adarkwa, the farmers ranked the parasitic and epiphytic plants as the second most important causes of low yields after the socio-economic ones. Mistletoes have been documented as parasitic plants of cocoa (Thorold, 1975; Wilson, 1999). However, there is little information on *Chasmanthera dependens* and *Cyrtorchis hamerta* as epiphytic plants on cocoa and their impact on cocoa yields.

Although epiphytes have been observed as pests of cocoa (Thorold, 1975), it was not expected that a group of farmers would rank them as the most important cause of low yields because generally, epiphytes have not been considered as major pests of cocoa by formal research. This is evidenced by the fact that a review of 24 publications by CRIG and the Cocoa Services Division between 1977 and 1997 (see Anon., 1997), which formed the basis of extension messages on cocoa, did not mention anything on the incidence and control measures for epiphytes. Discussions with a researcher at CRIG as well as with farmers, suggested that epiphytes have become major pests in the study area because of long neglect and non-maintenance of cocoa farms (Kojo Acheampong, personal communication).

Bulbophyllum spp. have a very aggressive root system that covers the stem completely if not removed in an early stage. Where the root system covers the stem completely, it is possible that the epiphyte will interfere with the development of buds on the plant's stem (Thorold, 1975), probably causing substantial yield loss. Thorold (1975) reported that studies in Nigeria on foliaceous epiphytes did not show any apparent effect of their presence on the number of pods per tree. Observations at Achiansah, however, showed that although the incidence of *Bulbophyllum* spp. is not prevalent on the farms, in isolated cases where they occur, they appear to have a smothering effect on the infested trees: the trees showed signs of dying. At CRIG, work on *Bulbophyllum* spp. has been ongoing since 2000.

2.3.4 Inter-relationship of socio-economic and biological causes of low yields

From the results, it appears that farmers' inability to carry out adequate pest and disease control measures can be attributed largely to socio-economic factors. The most important ones are the low producer price of cocoa leading to low investment in crop management, labour shortage and high cost of labour, and poor infrastructure in farming communities.

In Adarkwa, out of 16 causes of low yields identified (Table 2.2), the farmers ranked the price paid for cocoa as the most important cause of low yields.

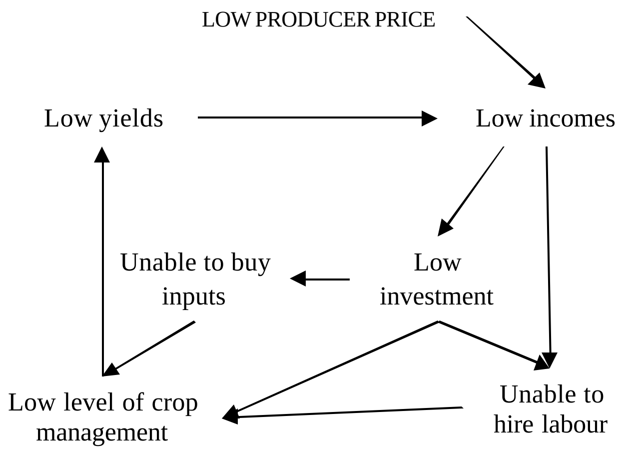

Figure 2.5. Effects of low producer prices on yields

Both the Victory Farmers Group and the *Gye se wobre* Group expressed their displeasure at the producer price of cocoa although they did not list it as a direct cause of low yields. The farmers articulated the relationship between the low producer price and low yields as illustrated in Figure 2.5. A low producer price leads to low income per unit of cocoa produced. The farmers contended that they do not invest part of the income from cocoa in their farms because what they earn is not adequate to meet their needs. They also argued that it was the government that benefited most from cocoa because it does not only tax their produce directly but also enjoys taxes from the numerous LBCs. In the farmers' view, the one who benefits from cocoa production most should be responsible for the enterprise and therefore the government should invest in cocoa farms by providing free or subsidized inputs. They illustrated their relationship with the government as one of an *abusa* system, where the government is behaving like the landlord and taking two-thirds of the revenue, as is the normal practice with the *abusa* tenure system. The farmers' reference to the *abusa* system symbolizes their feeling of being cheated by the government, which – in their view – does not meet its responsibilities as the prime beneficiary. At the same time, it is indicative of the farmers' perspective regarding the 'ownership' of cocoa production and its problems.

A low producer price as a disincentive to cocoa farmers has been noted by some researchers (Koning, 1986; Acquaah, 1999) and by the government of Ghana (Anon., 1999). In the 1983/84 season, when the lowest cocoa production level was recorded in Ghana, the producer price paid to farmers was 21.3% of the fob price (COCOBOD Records cited in Amoah, 1998). Currently, as part of the government policy in revamping the cocoa sector, producer prices have been increased to 68% in 2003 and are expected to reach 70% in 2004. These increases are intended to motivate farmers to produce more cocoa. However, the farmers do not believe that the government is paying anything close to 68% of the fob price and they quote the world market price to support their position, but the world market price is different from the fob price. Government, on the recommendation of the Cocoa Price Committee, sets the fob price and the farmers have a representative on that committee. The fob price usually differs from the world market because of the 'forward sales' policy of the COCOBOD. This means that cocoa delivered to foreign buyers at any point in time has already been sold at an earlier date and the price at which it was sold is not necessarily the same as the world market price at the time it is delivered.

The government considers many factors when setting the producer price of cocoa. Among these factors are world market price trends, the objective to establish a price stabilization fund, the general expectation of farmers that the producer price should only be increased or at least maintained irrespective of the trend of world market prices, and the anticipated effect of producer price on the farmers' morale (Amoah, 1998). Because of the farmers' perception of being cheated by government, they question why they are not allowed to sell their cocoa freely on the international market like with fruits such as pineapple. The farmers do not have adequate knowledge of the complex nature of international trade on primary commodities like cocoa and therefore do not realize that they cannot easily sell their produce directly on the international market. They attributed the smuggling of cocoa to neighbouring countries by some farmers to the low producer price, a point also noted by Koning (1986) and Acquaah (1999). A significant observation during the study was that extension messages focus on technical issues and not on government policies so most farmers were not aware of the government policy regarding producer prices and how the farmers' share of fob is determined. Such information is only available at a high level of the COCOBOD and not available to farmers and extension staff in the field.

In Adarkwa, the lack of electricity was ranked as the second most important cause of low yields. The farmers showed a direct relationship between the lack of electricity and youth migration to the cities (Figure 2.6). Youth migration creates labour shortage, leading to a high cost. Youth migration also leaves the aged farmers in the village to take care of the farms. The relatively old age of cocoa farmers, estimated at 55 years, (Addo, 1973; Anon., 1999) was listed as one of the reasons for the low production of cocoa over the years.

Cocoa production requires many cultural practices that are labour intensive: four weeding rounds per year, removal of mistletoes and epiphytes, shade management through pruning, and removal of basal chupons (new shoots at the base). In addition to the cultural practices there are other labour intensive activities like harvesting, breaking the pods, fermenting and drying the beans. Various researchers have estimated the labour requirements for cocoa production: Bray (1959) 136 man-days per ha over 10 years; Urquhart (1961) 105 man-days per ha over 8 years; Becket (1973) 109 man-days per ha over 10 years. However, Okali (1973), estimated the annual labour requirement of 1–12 months old cocoa at 45.6, of cocoa between 13 months to full bearing at 16, and for a full bearing crop at 12.3 man-days per ha. Since these studies were made, there has been no mechanisation of cocoa production hence these findings remain valid. The only way an old cocoa farmer can meet his/her requirements is to either hire labour or to rely on family labour. Most farmers cannot afford the costs of hired labour or are not willing to invest capital in it. The high labour requirement for young cocoa farms (Okali, 1973) coupled with the problem of labour shortage contributes to the difficulties farmers face in replanting their old cocoa farms.

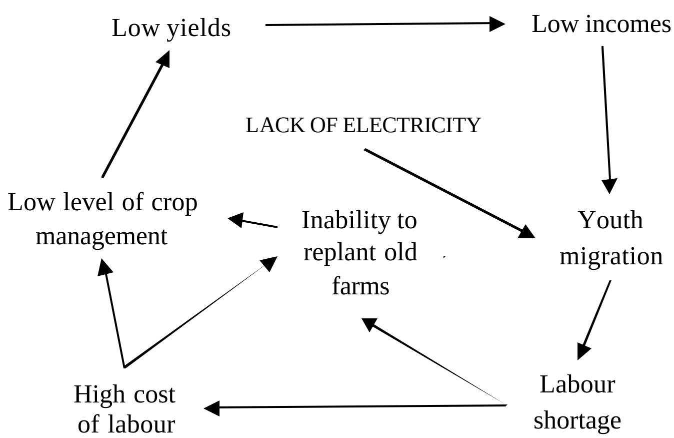

Figure 2.6. Effects of lack of electricity on yields

The farmers explained that in the 1950s and 1960s foreign migrants constituted a large proportion of the work force on the cocoa farms. Addo (1972) estimated that before the 'Aliens Compliance Order' of 1969 about 47% of the permanent employees on cocoa farms in Ghana were migrants from neighbouring countries but that this percentage fell to about 25 thereafter. The provisions of the Order state that alien residents in Ghana without the necessary immigration papers are to obtain them within a period of two weeks from the date of publication of the Order. Failure to do so necessitated their departure from the country. The problem with inadequate labour for cocoa production could probably have started at this point in time. It is estimated that 56% of the labour on cocoa farms not employing permanent labour is from the farmer, his/her spouse, children and other dependants (Addo, 1973). Therefore, the current out-migration of the youth from their villages to the cities due to lack of social amenities like electricity has aggravated the labour scarcity problem. So it is not surprising that the farmers in Adarkwa ranked the lack of labour as the third and the high cost of labour as the fifth most important cause of low yields (Table 2.2).

2.4 Reflections on the diagnostic approach

The most valuable contribution that a diagnostic approach offers to research is the potential to bring farmers' perceptions and needs into focus when defining research problems and therefore increasing the likelihood that research would be working on problems that address the real needs of farmers. However, it is important to critically consider how and to what extent certain factors can affect the findings of diagnostic studies. These include factors like the method of selecting farmers, the context in which the study is carried out, the history of the community, the people present during data collection and analysis, and the way working methods and tools are introduced and used.

Although the three groups of farmers who took part in this study identified low yields as the main problem they face with cocoa production, the method used in selecting the farmers appears to have affected the extent to which the causes of low yields either tilted towards socio-economic or technical factors. Dealing with a situation in which all cocoa farmers in the community were invited to be part of the study, as in the case of Adarkwa, seemed to have tilted the focus of discussions towards socio-economic issues. On the other hand, in Achiansah, where the farmer groups selected had previously been working with the extension agent, their focus was more on technical issues. One reason for this could be that in Adarkwa the heterogeneous environment created by so many people with varying interest did not only create a very open atmosphere for discussions but also generated ideas on a wide range of issues. Another reason could be the proximity of Adarkwa to the district capital, where the farmers see many amenities that are not available in their village. In contrast, the groups in Achainsah focused on technical issues probably because their minds were conditioned by working with the Agricultural Extension Agent and by their perception of us belonging to MoFA. It is possible that the farmers in Achiansah were telling us, perceived as being staff of MoFA, what – in their opinion – we wanted to hear. This view is strengthened by the fact that the Achiansah group only brought out the issue of low producer price during the analysis and action planning phase, five months after the study had started when a lot of interaction had taken place and an appreciable level of trust had been built between them and us.

In Kojohum, the network structure between farmers in communities around Kojohum gave the impression of a promising study but the village was dropped after it became obvious that communication within the 'perceived network' of farmers was not effective because there was no feedback to the communities from the representatives attending the meetings. Also, the farmers did not see an immediate benefit because each time a new person attended the meeting he/she came up with the suggestion to provide credit or free inputs like cutlasses and boots, and seemed less interested in engaging in a long-term trajectory of collaborative work. Considering the distances that some of the farmers had to walk to attend the meetings there was little incentive to motivate the same person to consistently attend on behalf of his/her community. Therefore, in such circumstances, it might be better for researchers and extension workers to visit the farmers in their hamlets and interact with them at that level.

A shortcoming of the diagnostic study is that the nature of some causes of the main problem, especially some social ones, and the reasons why they have persisted are not possible to fully understand in the relatively short period of six months that this study lasted. So the objective of identifying problems and basing research on an analysis of the problem may not be achieved if diagnostic studies are treated as a 'stand alone' study. However, if the study is carried out as part of a flexible action research programme – as is the case with this study – where it serves as a first step to put relevant problems on the agenda for further inquiry and action, then the nature of the problems can become clearer as they are probed beyond the diagnostic phase. Research can then focus on tackling the root causes more effectively as they become clearer and better understood in the research process beyond the diagnostic phase.

2.5 Conclusions

From this study, it can be concluded that the cocoa farmers in the study area recognized low yields as the major problem facing cocoa production in Ghana. They attributed this to various causes that can be categorized into socio-economic on the one hand and technical or biological on the other. Since these two categories of causes are closely inter-related it would have been better to look at them holistically; their separate treatment in some sections of this paper was a matter of convenience. The farmers attached a high level of importance to the socio-economic constraints even though these have an indirect relationship with the main problem. They were able to articulate and make clear links between the socio-economic and technical factors. For instance, issues like the producer price paid to farmers, the – in their view – exploitative behaviour of the government, the lack of social amenities like electricity, and the way these affect labour, non-investment and lack of maintenance of the cocoa farms were clearly demonstrated by farmers.

Another significant conclusion from the study is the way research methods can affect the results obtained. Although the issues raised by farmers as constraints were similar, the three different groups of farmers in the study ranked the importance of the issues differently. In Adarkwa, where a community approach was adopted, and hence a more heterogeneous group participated, the main focus of the farmers was on socio-economic constraints although they recognized the importance of the technical issues. In contrast, the relatively more homogenous farmer groups in Achiansah ranked the technical causes as more important although they articulated the impact of socio-economic constraints as well. So the results of diagnostic studies need to be treated with care and cannot be taken at face value or generalized. Also, when preparing such a study, it is important to reflect critically on the implications of choices made regarding boundaries of the discussion, selection procedures and methods used, as well as on how previous contacts may affect the outcomes.

A caution when using a diagnostic approach which focuses on farmers' perspectives is that farmers' perceptions may not always be a balanced or valid reflection of the situation because of inadequate information on certain issues. This was evident in the case of the fob price. However, it exposed communication gaps between the COCOBOD on the one hand and extension workers and farmers on the other. Such communication gaps –for instance on how producer prices are determined– creates room for mistrust and the objective of motivating farmers with higher producer prices is not achieved as some of them monitor world market prices on the radio. It would be beneficial to all stakeholders if COCOBOD takes steps to bridge this gap. It is therefore important that a diagnostic study should look at multiple stakeholders and gather information from all of them to gain an understanding of the broader context of problems diagnosed.

Finally, the diagnostic approach raises awareness of shortcomings in the technology development and dissemination process and potentially identifies areas that researchers and policy makers need to direct their attention in order to facilitate the development of coherent innovations. Our study of social and technical factors and problem perceptions revealed that the current policy emphasis on increasing prices, introducing high-yielding varieties and stimulating specific pest control measures is likely to yield limited success since certain important social and technical issues are overlooked. Such neglected issues include the problem of epiphytes, out-migration and labour shortages, and diverging interpretations regarding the distribution of 'ownership', responsibilities and benefits of cocoa production between farmers and government. A coherent package of social and technical solutions for cocoa production in Ghana will have to include arrangements and strategies for tackling these problems. In connection with this, it is important to note that reflection is needed on which organizations will have to take the lead in dealing with these issues, as there may well exist a vacuum in this respect. For example, it is questionable whether current mandates of research and extension organizations in Ghana allow and/or equip such organizations to work on arrangements for reducing labour shortages, the provision of amenities and/or on facilitating dialogue between farmers and government regarding the division of benefits and responsibilities. In any case, it is the ambition of our ongoing action research with farmers to work on locally adapted innovations for cocoa production that include a more balanced mix of technical and social arrangements. As part of this trajectory, we also hope to contribute to a reflective dialogue among regional and national institutions involved in cocoa production, including also organizational bodies that may not have been previously looked at as relevant in this respect.

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Chapter Three
Effectiveness and profitability of integrated pest management for improving yield on smallholder cocoa farms in Ghana[3]

Abstract
Many pests infest cocoa and contribute to low yields in Ghana and other producing countries. In Ghana, synthetic pesticides are recommended for controlling the insect pests, and a combination of synthetic pesticides and cultural practices for diseases and weeds. Because of the high cost of pesticides and low producer prices, farmers in Ghana are not motivated to adopt the research recommendations for pest management. Also, the emphasis on using synthetic pesticides can affect both human health and the environment. With an objective of improving yields through relatively friendly environmental practices, an integrated pest management (IPM) package, using aqueous neem (*Azadirachta indica* A. Juss.) seed extracts to control insect pests and cultural practices for diseases, weeds and parasitic plants, was carried out in an action research on farmers' fields with their active participation. The package improved yields significantly and were more profitable than the farmers' normal practices. However, there were constraints to adoption by farmers because it was labour-intensive and also, neem was not available in the community and had to be bought from another village 100 km away. These constraints must be addressed otherwise, like many other research recommendations, this package will not be adopted by farmers.

Key words: *Azadirachta indica*, Capsids (Heteroptera: Miridae), *Phythophthora spp*.

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E. N. A. Dormon, A. van Huis and C. Leeuwis. Effectiveness and profitability of integrated pest management for improving yield on smallholder cocoa farms in Ghana

3.1 Introduction

Annually, 30% of cocoa produced worldwide is lost through the incidence of pests and diseases (Lass, 2004). In Ghana, the main pests of cocoa are capsids, shield bugs, mealybugs, the mistletoe, epiphytes and various weed species whilst the most common disease is the blackpod. Farmers in Ghana do not control these pests and diseases in accordance with research recommendations (Gerken *et al.*, 2001, Humado, 1999) and this leads to relatively low yields which are approximately 360 kg ha^{-1}, compared to 800 in neighbouring Cote d'Ivoire and 1800 kg ha^{-1} in Malaysia (Anon., 1999). Farmers in the research area attributed their non-adoption mainly to economic factors: high costs of inputs; low returns on their investment due to low producer prices; not having adequate capital, and difficulties with accessing credit (Dormon *et al.*, 2004).

Capsids (Heteroptera: Miridae) cause damage to the cocoa crop through feeding. They create lesions on the pods, stems and leaves which may become infected by fungi, notably *Calonectria rigidiuscula.* This fungus causes wilting and may ultimately lead to death of the tree (Willson, 1999). The most important species of capsids in Ghana are *Distantiella theobroma* (Dist.), *Sahlbergella singularis* (Hagl.) and *Helopeltis* sp. (Acquaah, 1999; Wood & Lass, 1985). Capsids cause 25 to30 % crop losses in Ghana (Padi 1997; Padi, n.d.). Low density populations are considered to be harmful, with an estimated economic threshold of six capsids per ten trees (Padi & Owusu, 1998). Capsids are inconspicuous making scouting by farmers an inappropriate option and therefore, the recommendation is to control them through prophylactic spraying of synthetic pesticides monthly from August to October and in December.

The shield bug, *Bathycoelia thalassina* (Heteroptera: Pentatomidae), is an economically important pest of cocoa in Ghana (Owusu-Manu, 1977; Panizzi, 1997). The pest is widely distributed in most cocoa growing areas of Ghana, but it is more abundant in certain areas, including the Suhum-Kraboa-Coalter District (Owusu-Manu, 1977). They are found mostly in the upper parts of the trunk and they feed on young cocoa pods, causing premature ripening (Owusu-Manu 1977, 1990; Willson, 1999; Wood & Lass, 1985). It is recommended to control the pest with insecticides from early August or September when the population starts building up until end of November (Owusu-Manu, 1977).

The black pod disease occurs in all cocoa growing regions of Ghana and is caused by *Phythophthora spp* (Wood & Lass, 1985; Wilson, 1999). *Phythophthora palmivora* occurs in all the six cocoa growing regions but *P. megakarya* occurs mainly in the Ashanti, Western and parts of the Brong-Ahafo Regions (Akrofi, *et al.*, 2003). The fungus infects flower cushions, shoots, leaves, seedlings, roots and pods (Wilson, 1999). Blackpod spores may be spread through rain splashes, by living vectors such as ants, and by the wind, and newly infected pods covered with sporangia can act as infection sources for up to 14 days (Wood & Lass, 1985). Husk pieces on the ground add infective material to the soil, whilst root infection is an important part of the annual cycle of the fungus (Akrofi *et al.*, 2003; Wood & Lass, 1985) but farmers usually leave diseased pods lying on the ground (Akrofi *et al.*, 2003). In Ghana, yield losses due to *P. palmivora* are between 5 and 19% of annual output (Blencowe & Wharton, 1961; Dakwa, 1984) whilst that of *P. megakarya* can be as high as 100% (Dakwa, 1987). It is recommended to control the disease by removing diseased pods and/or applying fungicides during the rainy season (Akrofi, *et al.*, 2003). However, most farmers do not adopt these recommendations or do so only partially (Akrofi, *et al.*, 2003; Henderson, *et al.*, 1994; Opoku *et al.*, 1997).

The mistletoe (*Tapinanthus bangwensis*) is a parasitic plant found on some forest trees including cocoa. They affect yields by extracting water and nutrients from the cocoa plant, and eventually, may kill the branch beyond the zone they parasitise (Willson, 1999). In Ghana, farmers consider mistletoes as a major problem in their cocoa farms (Dormon *et al.*, 2004). The recommended control measure is to remove the parasitic weeds manually with cutlasses or pruners.

A number of epiphytes that grow on cocoa trees were identified in the research area. They are *Bulbophyllum* sp., *Chasmanthera dependens* and *Cyrtorchis hamerta* (Dormon *et al.*, 2004). There is no conclusive evidence about their effect on yield (Wood & Lass, 1985). Field observations in the research area indicate that these epiphytes are not abundant, however, cocoa trees with *Bulbophyllum* sp. were not productive and showed signs of dying. These epiphytes can be controlled by removing them with a cutlass or pruner.

To reduce the incidence of pests and diseases, and to improve yields, the government, in 2001, introduced the Cocoa Disease and Pest Control (CODAPEC) program which involves 'mass-spraying' of all cocoa farms using synthetic insecticides and fungicides against capsids and the blackpod disease respectively (Anon., 2002). This program is not only expensive but also faces administrative and logistic difficulties (Asante *et al.*, 2002).

The present strategies and recommendations for managing pests and diseases of cocoa has three main problems; (i) most farmers do not adopt the recommendations and this contributes to low yields, (ii) the recommended pest management practices rely solely on synthetic pesticides, which has environmental drawbacks, and (iii) the government intervention through the CODAPEC program may not be a sustainable option for environmental reasons and also not cost effective because it is calendar-based rather than need-based.

Using synthetic pesticides on such a wide scale can affect human health and the environment by contaminating sources of drinking water (Waibel, 1994; Gerken *et al.*, 2001). Synthetic pesticides can also induce resistance in pests, destroy natural enemies which can lead to resurgence and secondary pest outbreaks, and may result in the 'insecticide treadmill' (Gallagher, 1998; Luck *et al.*, 1977; Prakash & Rao, 1997; van den Bosch, 1980; van Endem, 1996; van Huis, 1992). Examples of secondary pest outbreaks in Ghana are *B. thalassina* which became a major pest of cocoa because of the widespread use of synthetic insecticides to control capsids. *Tragocephala* beetles and the moths *Eulophonotus myrmeleon* and *Metarbela* sp. became important after Dieldrin was used to control mealybugs (Wood & Lass, 1985; Willson, 1999).

The objective of this study therefore, was to explore the possibility of using a pest management strategy which does not rely on synthetic pesticides, is applicable and also appropriate for smallholder cocoa farmers. We hypothesise that an IPM package (Figure 3.1) using aqueous neem seed extracts (ANSE), on a need-base to control insect pests, phytosanitary measures for blackpod, and other cultural practices can reduce pest and disease incidence to improve cocoa yields.

The neem plant (*Azadirachta indica* A. Juss.) contains a complex array of compounds which have diverse behavioural and physiological effects on insects (Schmutterer & Hellpap, 1989), deterring the development of resistance (National Research Council, 1992; Rice, 1993).

Repellence, anti-feeding, oviposition deterrence, growth and reproduction inhibition, and other effects have been attributed to neem compounds – azadirachtin, gedunin, nimbinen, salanin, meliantriol, 1,4-expoxazadiradion, selannoacetate and deacetylnimbinen (Jones *et al.,* 1989; Schmutterer, 1990). About 413 species of insects, belonging to the orders; Isoptera, Ensifera, Thysanoptera, Heteroptera, Homoptera, Hymenoptera, Coleoptera, Lepidoptera and Diptera, are sensitive to neem products in one way or another (Schmutterer, 1995, 1998). The seed and leaf extracts have a systemic effect and is active at low concentration with negligible mammalian toxicity (Lowery *et al.*, 1993). In laboratory and field evaluation of aqueous neem seed extracts, Adu-Aheampong (1997) and Padi *et al.* (2003) showed that 200 g/l of ANSE can be effective in controlling capsids. Considering the broad insecticidal properties of neem extracts, we believe that it is also capable of controlling *B. thalassina*, which, like capsids, belong to the order Heteroptera.

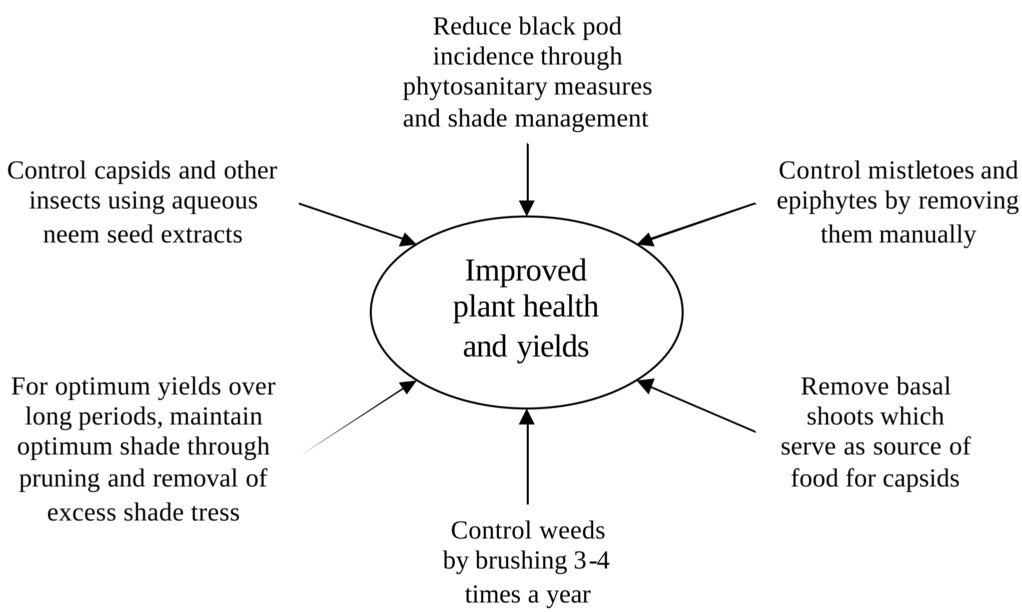

Figure 3.1: Proposed IPM package aimed at improving plant health and yields of cocoa in Ghana.

For blackpod, Soberanis *et al.*, (1999) showed that in Peru, weekly removal of diseased pods reduced *P. palmivora* by 35 to 66% and the economic returns compensated for the increased labour. Their study also showed that removal of diseased pods was 32% more profitable than the control with fungicides. We therefore chose, in this study, to use phytosanitary measures (removal of diseased pods from trees and the ground) and shade management to control blackpod. Mistletoe, epiphytes and weeds were controlled using cultural practices.

We recognise that farmers will only adopt this package if they find it feasible to implement and also profitable.

3.2. Materials and methods

3.2.1 The Study area

The research was done in Achiansah and Adarkwa, both villages in the Suhum-Kraboa-Coalter District of the Eastern Region of Ghana. The district has a history of cocoa production spanning a century. It is located in the forest zone, with an average daily temperature between 24 to 29°C, a relative humidity between 87% and 91%, and annual rainfall between 1270 and 1651 mm (Anon., 2000).

3.2.2 Demarcation of experimental plots

Twenty-four experimental plots, each 30 x 30 m (900 m^2), were initially demarcated. The proposed IPM package (Figure 3.1) was implemented on 12 of the plots and the other 12 were left as control. However, the farmers started implementing some of the IPM practices on the 12 control plots, which we now refer to as 'Farmers' adopted-IPM (FA-IPM), therefore 12 new control plots, now called 'Farmers' Practice (FP), were demarcated to bring the total number of 'treatments' to three (Table 3.1). The three treatments were replicated five times in Adarkwa (involving four farmers) and seven times in Achiansah (with five farmers), making the total number of plots thirty-six. The distance between plots was 30 m.

Table 3.1: Description of the three ‘treatments’

Plots	Description of treatment
Integrated pest management plots (IPM)	Remove all blackpod infested pods both on trees and on the ground; control weeds on average thrice a year; remove all mistletoes; control shade for optimum light penetration, remove basal shoots, and control capsids and other insect pests with aqueous neem seed extracts
Farmers’ adopted IPM (FA-IPM)	Remove all black pod infested pods both on trees and on the ground; control weeds twice a year on average; remove all mistletoes; control shade; remove basal shoots and rely on government mass-spraying for capsid control
Farmers’ original practice (FP)	Control weeds once a year, remove = 50% of the mistletoes, remove = 25% blackpod-infested pods on the trees and on the ground, and rely on government mass-spraying exercise for capsid control

3.2.3 Preparation and application of ANSE

Neem seeds collected from Kordiabe, a village in the greater Accra Region, were grinded in a corn-mill. The grinded seeds were soaked at a concentration of 250 g/l for 18 hrs and a double-folded mosquito net was used to filter the suspension. The extract was applied on calendar-basis in 2003 following the existing recommendations, but in 2004 and 2005, it was applied ‘need-based’ by examining the extent of capsid damage to pods monthly, and when more than 25% of pods had lesions on them, the neem extract was sprayed at a rate of 8.5 litres per plot (±100 l/ha) using a motorised knapsack sprayer. In 2003, a total of four applications were made in September, October, November and December; in 2004 it was in April, October, November and December, and in 2005, in March and April. In order to obtain uniform coverage, spraying was done by systematically aiming the nozzle up the trunk of each tree, into and across the canopy and then down the trunk of the adjacent tree as described by Owusu-Manu (1997).

3.2.4 Determination of effectiveness and profitability of the IPM package

Three main factors were considered in evaluating the impact of IPM. These were: (i) changes in pests and disease incidence after implementation, (ii) impact on yields, (iii) relative profitability.

Changes in pest incidence

To determine changes in pest and disease incidence, damage on pods was used as a proxy indicator. On IPM plots, a system of grading harvested pods was established jointly with the farmers to evaluate IPM impact. From May 2003 to September 2005, all ripe and healthy pods were harvested monthly whilst matured and immature diseased-pods were removed as a sanitation measure. Pods were categorised into five grades depending on the level of pest injury on them and the effect on the beans irrespective of which pest caused the injury and at what stage of pod maturity. The five grades were: pods with 0% (1), 25% (2), 50% (3), 75% (4) and 100% (5) damaged seeds. Category 5 also included pods that failed to mature because of pest or disease attack. Beans from the mature diseased pods, that were not completely damaged, were included in the harvest data.

Comparison of yields from the IPM practices and controls

Yields from the IPM plots were compared with the two other treatments, namely: FA-IPM and FP. The data was taken from trees in a 20 m x 20 m (400 m^2) inner perimeter demarcated in the plots. A tree population count was made for the inner perimeter of each plot where 30 trees were randomly selected and tagged. Between November 2003 and September 2005: pods were harvested from the tagged trees monthly; they were opened; the beans were removed and fermented, dried, and weighed. Yields were subjected to a one-way ANOVA test using SPSS version 12 to determine significance in differences between the treatments.

Relative profitability of the three treatments

The profitability of the IPM package was determined by calculating the additional income per ha, and returns on the additional investment in adopting the IPM package or the FA-IPM. These were calculated as follows:

(i) Yield from 30 trees was converted to yield per ha as follows:
Average number of trees per plot of 20 x 20 m = 35
Therefore average number of trees per ha = (10,000 m^2 / 400 m^2) x 35 = 875

(ii) Rate of return on additional investment = [(Marginal revenue) – (Marginal cost) / (Marginal cost)] x 100%

(iii) Additional Income (I) = Marginal Revenue (MR) – Marginal Cost (MC)
Where; Marginal Revenue (MR) = Additional Yield (kg) x Price /kg (Price / kg = ¢9,000 which is equivalent to US$0.99[4])

Additional yield = $Y_{ti} - Y_o$

where; Y_{ti} = Yield of treatment (IPM or FA-IPM) and Y_o = Yield of control (FP)

Yield / ha = (number of trees / ha) x (average yield / tree)

To assess returns on additional investment for IPM and FA-IPM, two scenarios were considered:

(a) The present situation where government pays for capsid control in the study area

$Y_{(IPM)} = CL_{(i)} + CL_{(ii)} + CL_{(iii)} + CL_{(iv)}$

(b) Assuming farmers paid for cost of capsid control

$Y_{(IPM)} = CL_{(i)} + (CL_{(ii)} - CL_{(fp)}) + CL_{(iii)} + CL_{(iv)}$

$Y_{(FA\text{-}IPM)} = CL_{(i)} + CL_{(iii)} + CL_{(iv)}$

Where:

Y = Marginal cost (MC)

$CL_{(i)}$ = Cost of additional labour for weeding

[4] US$1.00 = ¢9,089 This was calculated using monthly inter-bank rates quoted by the Bank of Ghana in 2005 (http//www.bog.gov.gh/

$CL_{(ii)}$ = cost of neem seeds, transportation, processing and labour for spraying the extracts

$CL_{(iii)}$ = estimated cost of labour for removing diseased pods and other cultural practices

$CL_{(iv)}$ = additional cost of harvesting, fermenting, drying and transporting additional pods and beans

$CL_{(v)}$ = cost of weeding and basic cultural practices

$CL_{(fp)}$ = cost of capsid control under FA-IPM or FP without government intervention

For both FP and FA-IPM, the cost of capsid control is included in the calculation of the second scenario, where we assume that farmers bear the full cost of pest management. This is calculated using the cost of confidor in 2003/2004 and cocostar in 2004/2005, which were the pesticides used in the two years respectively and a frequency of twice a year.

All cost of labour are real cost estimated from interviews with farmers except the cost of harvesting, fermenting, drying and transporting pods and beans which was calculated as ¢1,745 / kg (+/- US$0.19) using the prevailing cost of ¢20,000 / man-day of labour in the study area, and basing the time required on a survey by Abenyega and Gockowski (2001).

3.3 Results

3.3.1 Effectiveness of IPM in reducing pest incidence

The IPM treatment resulted in a marked reduction in pest and disease incidence within five to six months from the start of implementation in both Achiansah and Adarkwa. Although, the trend was sustained in Achiansah, it fluctuated after the initial reduction in Adarkwa (Figure 3.2).

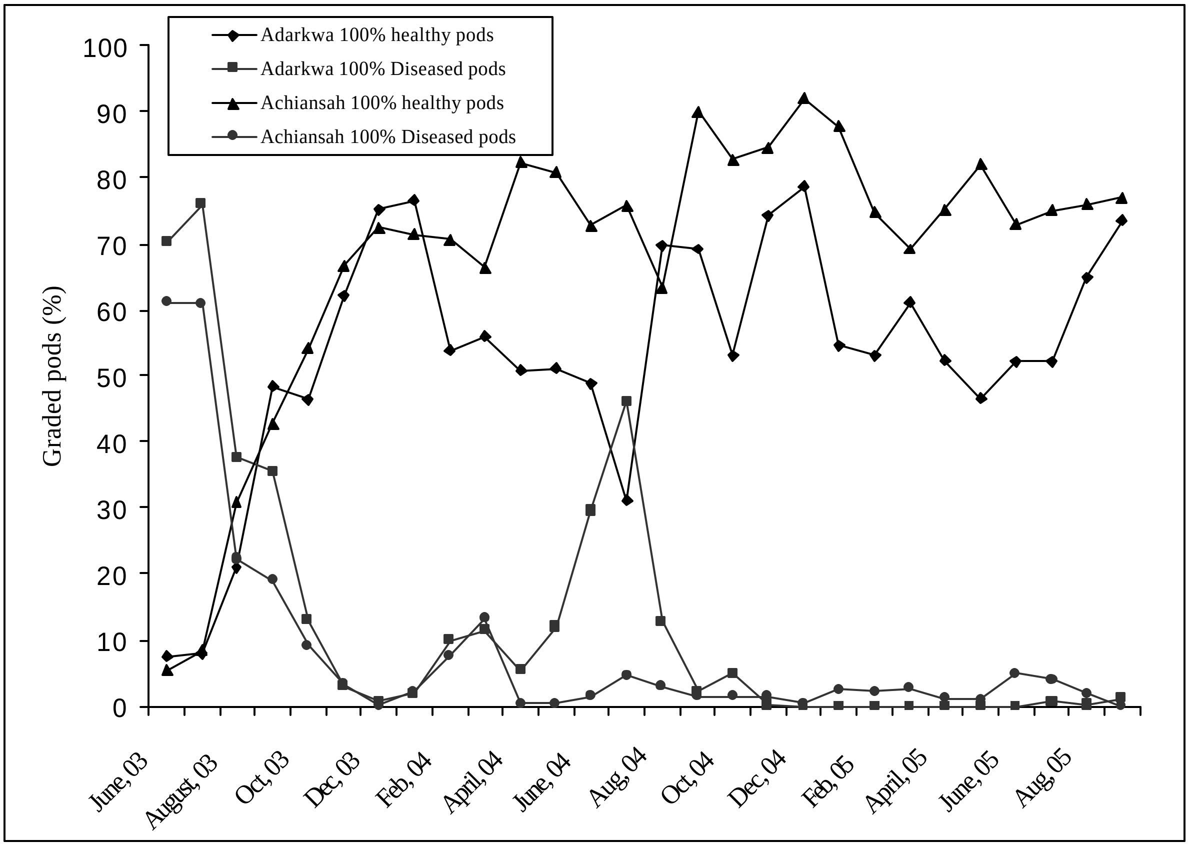

Figure 3.2: Average changes in ‘fully diseased’ and ‘completely healthy’ cocoa pods harvested from IPM plots in Achiansah and Adarkwa from June 2003 to September 2005

3.3.2 Impact on yield

Yields from the IPM package in both villages became increasingly higher over time compared with the controls but were generally higher in Achiansah than Adarkwa (Figure 3.3).

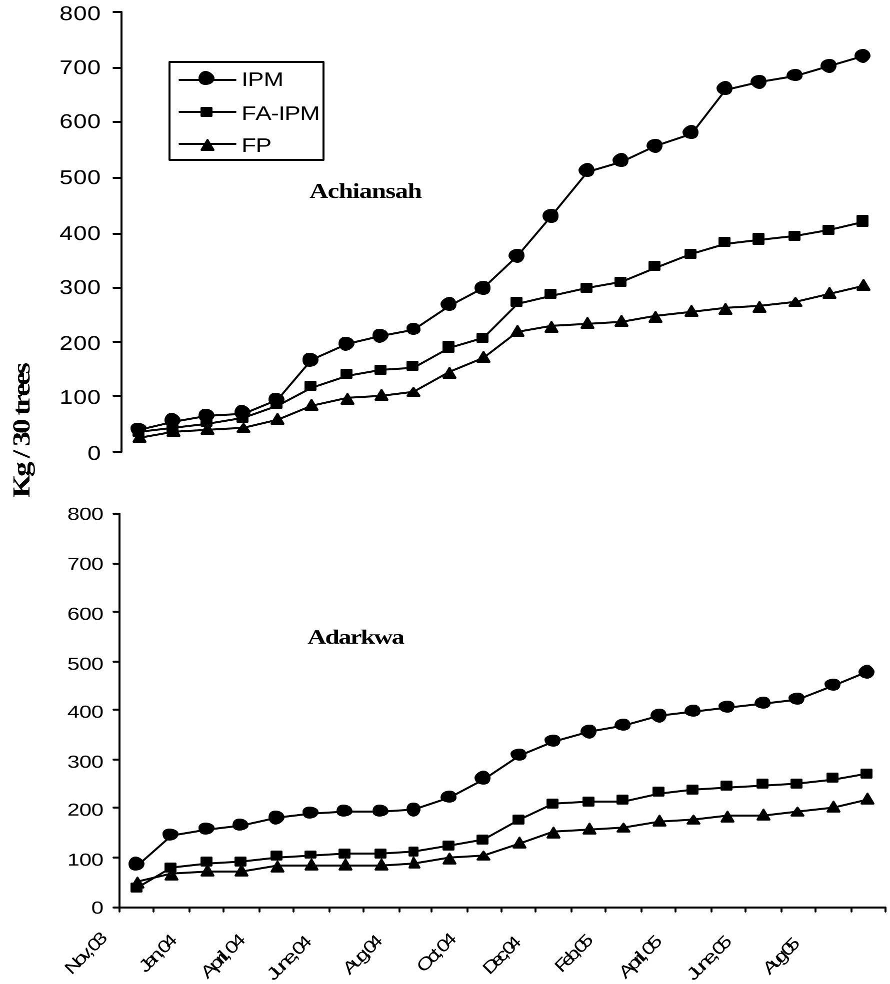

Figure 3.3: Cumulative mean cocoa yields from the three treatments in Achiansah and Adarkwa

In the first year, there were significant differences in yields ($p < 0.05$) between IPM and FP practices in Achiansah but no difference between IPM and FA-IPM and also between FA-IPM and FP (Table 3.2). In the second year, however, all three treatments were significantly different from each other. Yield from the IPM package was almost three times higher than the farmers practice and double what was obtained from the adapted control (Table 3.2).

Table 3.2: Mean cocoa yields from the three 'treatments' in the villages Achiansah and Adarkwa

Treatment	Mean yield (kg/30 trees) during crop season	
	2003 -2004	2004-2005
Achiansah		
IPM	38.14 [a]	64.49 [A]
FA-IPM	27.14 [a b]	32.67 [b]
FP	21.00 [b]	22.29 [c]
Adarkwa		
IPM	44.60 [A]	50.48 [A]
FA-IPM	24.86 [b]	28.98 [b]
FP	19.43 [b]	24.50 [b]

Means per village not followed by the same letters in columns are significantly different (P= 0.05; A= P= 0.01)

In Adarkwa, the mean yield from the IPM treatment was significantly higher ($p < 0.01$) than the controls for both years and in the second crop season about twice as high as the farmers' original practice. Yields between the FA-IPM and FP practice were not different in both crop seasons (Table 3.2).

3.3.3 Relative profitability of the IPM package

Profitability of the treatments was considered in two scenarios; (i) the present situation where the government bears part of the cost of pest management through the CODAPEC program, and (ii) assuming that farmers will bear the full cost.

<u>Relative profitability under direct intervention by the government</u>

In both villages, profitability, and returns on additional investment, generally followed an increasing trend with time. In Adarkwa, both additional income and returns in the first and second years were similar for FA-IPM but both increased substantially in the second year for IPM (Table 3.3). In Achiansah, for FA-IPM there was an increase in additional income of about US$100 / ha in the second year but returns were similar to the first, however, additional income tripled in the second year and returns doubled (Table 3.3).

<u>Relative profitability assuming farmers take full responsibility for pest management</u>

Assuming that farmers were fully responsible for pest management, additional income for FA-IPM will be the same in Adarkwa for both years but returns would increase by about 50% in the second year. For IPM, additional income would increase by about US$60 / ha and 50% more on returns. In Achiansah, both additional income and returns would double in the second year for FA-IPM and for IPM additional income would triple and returns doubled (Table 3.4).

Table 3.3: Estimated income and returns on additional investment from considering present situation where government bears part of pest management cost

Year/Month	Practices	Yield kg/ha	Total revenue (US$)	Marginal revenue (US$)	Capsid control (US$)	Original labour cost (US$)	Additional labour cost (US$)	Marginal cost (US$)	Total income (US$)	Additional income (US$)	Returns on additional investment (%)
Adarkwa											
Nov ' 03 to Sept '04	FP	567	561			110			451		
	FAIPM	725	718	157		141	32	32	545	125	387
	IPM	1,301	1,288	727	119	251	143	262	775	465	178
Oct ' 04 to Sept '05	FP	715	707			139			569		
	FAIPM	845	837	129		164	27	27	646	103	382
	IPM	1,482	1,467	759	61	286	149	210	971	549	261
Achiansah											
Nov ' 03 to Sept '04	FP	613	606			119			487		
	FAIPM	792	784	177		154	36	36	594	141	391
	IPM	1,112	1,101	495	119	215	98	217	669	278	128
Oct ' 04 to Sept '05	FP	650	644			126			517		
	FAIPM	953	943	300		185	60	60	699	240	400
	IPM	1,881	1,862	1,219	61	363	238	299	1,200	919	307

Table 3.4: Estimated income and returns on additional investment from assuming farmers were to bear the full cost of pest management

Year/Month	Practices	Yield kg/ha	Total revenue (US$)	Marginal revenue (US$)	Capsid control (US$)	Original labour cost (US$)	Additional labour cost (US$)	Marginal cost (US$)	Total income (US$)	Additional income (US$)	Returns on additional investment (%)
Adarkwa											
Nov ' 03 to Sept '04	FP	567	561		50	110			400		
	FAIPM	725	718	157	50	145	32	83	491	74	90
	IPM	1,301	1,288	727	119	255	144	212	770	514	242
Oct ' 04 to Sept '05	FP	715	707		29	139			540		
	FAIPM	845	837	129	29	169	26	55	613	74	135
	IPM	1,482	1,467	759	61	291	149	182	966	578	318
Achiansah											
Nov ' 03 to Sept '04	FP	613	606	-	50	119			437		
	FAIPM	792	784	177	50	158	36	87	539	91	105
	IPM	1,112	1,101	495	119	219	64	133	699	362	272
Oct ' 04 to Sept '05	FP	650	644		29	126			489		
	FAIPM	953	943	300	29	189	60	88	666	211	239
	IPM	1,881	1,862	1,219	61	367	180	213	1,254	1,006	472

3.4 Discussion

The extent of yield increase seems to depend on the sustained effort of removing diseased pods from the fields, and other cultural practices (controlling weeds, removing mistletoe and epiphytes, managing shade etc) together with neem application (controlling capsids) as evidenced from the results in both villages (Figures 3.2 and 3.3; Table 3.2). Usually, low external input technologies are labour-intensive and farmers may not adopt them if the labour requirements are too high (Tripp, 2006) and this was a challenge in this study. The generally higher yields in Achiansah was realised because the farmers there worked as a group and used reciprocal labour arrangements to implement the labour-intensive cultural practices in the package. This, to a large extent, explains the differences in the results from the two villages.

Improvements in yield in the second year for IPM treatment can generally be attributed to the cumulative effect of reduced pest incidence and better plant health with time. It is expected that the same results, or maybe, even better can be expected in the years to come if the IPM practices are carried out adequately. Partial adoption of the package gives mixed results. Where the cultural practices are implemented effectively, as in Achiansah, yields in the second year are better than the farmers' original practice otherwise they remain the same, as in Adarkwa, and is not worth adopting.

Although the impact of ANSE on the results cannot be separated from the cultural practices, the potential for ANSE in controlling both capsids and blackpod could have contributed to the significantly higher yields in the IPM treatment compared with the others, where confidor and cocostar, which controls only capsids, was applied. The toxicity of ANSE on capsids has been reported (Adu-Acheampong, 1997; Padi *et al.*, 2003) whilst repellence and insect growth disruption properties were demonstrated by Duindam (2006). Neem extracts are also known to have fungicidal properties (Achimu & Schlösser, 1992; Locke, 1990, 1995; Singh *et al.*, 1980), and Duindam (2006), showed that 150 g/l of ANSE significantly inhibited the growth of *P. palmivora* by up to 40% in an in-vitro test. Diseased pods covered with sporangia and still hanging on the trees are the dominant source of inoculum (Akrofi *et al.*, 2003) but the farmers' practice over the years is to leave such diseased pods to hang on the trees. Although these were removed on both IPM and FA-IPM plots, spraying 250 g/l ANSE into the canopy of IPM plots to target capsids could have contributed to inhibiting the spread of the fungus from diseased pods that could not be removed. It could also have provided protection for fresh pods against infection. Furthermore, the impact of capsid feeding is high when fungi infect the pods and shoots through the lesions created by the capsids (Willson, 1999; Wood & Lass 1985), but this effect could have been minimised by the fungicidal properties of ANSE.

Assuming that returns is a good basis for decision making, and considering that informal interest rates can be 100% per annum, farmers in the two villages can be advised to adopt the IPM package because returns in all cases were above 100% and as high as 472% for Achiansah in the second year. Returns increased with time because the cost of pest management decreased from the second year whilst yields increased during the same period. The cost of pest management decreased because at the start of the experiments, the long neglect of the farms had led to high weed infestation, high incidence of mistletoe and epiphytes, and high incidence of blackpod and capsids. Controlling these pests and diseases required a lot of labour from the beginning, however, with time, the labour requirement decreased as the incidence of these pests and disease reduced. Also, the cumulative effect of improving plant health with implementation of the IPM resulted in the yields increasing with time. As long as the producer price is high enough to make farmers realise returns that are considerably higher than 100%, farmers would be motivated to adopt the IPM package if the required inputs are available to them.

Actual data on the environmental impact were not taken however, the environmental cost of the controls, which relied on synthetic pesticides, would be higher than that for the IPM. Calculations for cost of pesticide used in crop production do not include the indirect costs to society due to their effects on the environment. When the costs to society is considered, the cost curve shifts upwards making the cost of pesticides used in calculating production costs lower than the actual cost (Waibel, 1994).

Synthetic pesticides affect beneficial and natural enemies of capsids (Wood & Lass, 1985) such as *Oecophylla longinoda*. Although broad-spectrum pesticides such as neem extracts cannot be completely free of any side effects, several studies have shown that, overall, their effect on beneficials are tolerable and considered negligible when compared with most synthetic pesticides

(Schmutterer, 1990; Schmutterer, 2002). Whereas synthetic pesticides affect the beneficial insects in the cocoa ecosystem (Leston, 1970; Wood & Lass, 1985), Duindam (2006), in a study in the same research area showed that *O. longinoda* sprayed with 200 g/l of ANSE did not abandon their nests after 28 days, an indication that the effect of neem extracts on them was minimal.

We conclude that a combination of cultural practices and ANSE can improve cocoa yields significantly and is a profitable option for farmers to adopt. The two most important pests of cocoa are capsids and the blackpod disease, therefore a single formulation like ANSE that could control both offers great potential for use in cocoa production as an alternative to using synthetic pesticides and when combined with adequate control of other pests, and phytosanitary measures to control blackpod, yields can improve significantly in a profitable manner.

Although the IPM package gives higher returns, it requires higher labour and capital investment but farmers are constrained by both production factors, moreover, neem is not readily available in the community. If these constraints are not adequately addressed, the package, like many other research recommendations for pest management, will not be adopted by farmers; therefore further studies were conducted to explore ways of addressing these constraints (Dormon *et al.*, forthcoming). The present study was unable to separate the impact of ANSE and other factors in the IPM package on yield but this could make the potential of neem for cocoa production clearer, therefore, further studies are needed in this regard.

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Chapter Four
Creating space for innovation: the case of cocoa production in the Suhum-Kraboa-Coaltar District of Ghana[5]

Abstract

Most cocoa farmers in Ghana do not adopt research recommendations because they cannot afford the cost, therefore, yields are low. Integrated pest management (IPM) technologies that rely on low external inputs were tried with a group of farmers. The technologies included using aqueous neem seed extracts to control capsids; removing diseased pods to reduce blackpod incidence; controlling mistletoes, epiphytes, weeds, and managing shade. Although yields increased significantly, adoption was constrained by technical, social and economic factors. The objective of this action research was to organise relevant social and technical arrangements necessary to overcome the constraints. The study concludes, that an IPM package which is labour-intensive and also requires some capital, can only be adopted by resource-poor farmers when the necessary economic, social, and organisational 'space' is enlarged to develop them into complete innovations. On the basis of the findings, it is suggested that regular innovations can be realised at farmers' level and may be disseminated through extension agents, while system innovations require co-designing with other stakeholders to suit network-specific circumstances. Therefore, the role of extension agents, which currently emphasise technology transfer, must be broadened

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to include facilitation of social and economic network building around such technological packages to address the constraints to adoption.

Key words: Integrated pest management, action research, regular and system innovations, peer education, networks.

4.1 Introduction

Cocoa is an important export crop for Ghana, contributing about 30% of the total foreign revenue (ISSER, 2001, 2002, 2003 and 2004). Efforts are being made by the government to increase production from an average of 400,000 mt in the late 1990s to 700,000 by 2010 and sustain it at that level (MoF, 1999). This targeted level of production can be achieved either by increasing the area under cultivation or by improving productivity. Establishing new farms involves clearing forests as cocoa is grown in the wetter parts of the country. Therefore, from an environmental point of view, increasing productivity seems to be a better option.

Cocoa yields in Ghana are lower than those in other major cocoa producing countries. For example, in Ghana, yields are approximately 360 kg ha^{-1}, compared to 800 kg ha^{-1} in neighbouring Cote d'Ivoire and 1,800 kg ha^{-1} in Malaysia. The low yields of cocoa in Ghana are, among other factors, due to inadequate control of pests by farmers. The main pests of cocoa in Ghana include capsids (Heteroptera: Miridae), *Bathycoelia thalasina* (Heteroptera: Pentatomidae), black pod (*Phytophthora palmivora and P. megakarya*), mistletoe (*Tapinanthus bangwensis*), various epiphytes, climbers, and weeds.

The Cocoa Research Institute of Ghana (CRIG) carries out research on pest management, while the Ministry of Food and Agriculture (MoFA) disseminates the information through field extension agents following a transfer of technology (ToT) model. Elsewhere, this model has not been very successful because generally, technologies developed do not consider adequately the socio-economic conditions under which most farmers operate (Biggs, 1990; Chambers, 1983; Chambers & Ghildyal, 1985). In Ghana, the pest management recommendations include the application of synthetic insecticides on a calendar basis, to control capsids and fungicides to control blackpod. However, farmers in Ghana face problems with lack of capital and access to credit, and high cost of recommended inputs like pesticides and labour. Consequently, most farmers do not adopt the recommendations for cocoa production although they are aware of them (Humado, 1999). A study in 1997 showed that only 4% of cocoa farmers adopt recommended pest control measures fully (Gerken *et al.*, 2001).

Between 2003 and 2005, researchers from the Convergence of Science Project (CoS) together with two groups of farmers in Achiansah and Adarkwa, both villages in the Suhum Kraboa Coaltar District of the Eastern Region of Ghana, combined a number of existing pest management technologies into a package of integrated pest management (IPM) practices to control cocoa pests. The overall objective was to design a pest management strategy that is environmentally-friendly and can be adopted on a wide scale by farmers in a sustainable manner. This was preceded by a diagnostic study in the later part of 2002 which identified low yields as the main problem facing cocoa farmers. The low yields are caused by a combination of biological, social and economic factors (Dormon *et al.*, 2004).

The IPM package doubled yields in one village and tripled it in the other. In both villages the package also doubled incomes compared with farmers' practices (Dormon *et al.,* in prep. (a)). However, social, technical and economic factors constrained adoption by farmers.

This paper presents part of the research undertaken with the farmers to address these constraints. The paper describes the stages through which an IPM package was developed by bringing together the technical, social, organisational and economic components to create a complete innovation. Stage 1 provides the background to how the technical package was put together and the results obtained whilst stage 2 describes attempts at disseminating the technical package to other farmers and the constraints to adoption. Stage 3 focuses on further development of the technical package into an innovation which farmers can adopt.

4.2 Theoretical framework.

Between the 1950s and 1970s, many studies were conducted to explain why and how people adopt technologies and new practices (Havelock, 1973) which resulted in the development of technology adoption models. A well known model of technology adoption/diffusion was proposed by Rogers (1983, 1995). Rogers' model identified stages of the adoption process, factors that affected adoption, diffusion, and various adopter categories. Whilst Rogers' model is useful in revealing the social, economic and personal characteristics of adopters, its focus on individual characteristics of farmers rests on the assumption that technology adoption is an individual effort and process. However, Leeuwis (2004) argues that technology and innovation adoption is not an individual process, but results from a coordinated effort and action in a network of interdependent actors. Rogers' model also assumes that what is on offer as a technology or innovation is relevant without making adequate room for farmers' rationality regarding the various factors influencing their choice. Its philosophy is based on task division between research, extension and farmers in a linear fashion; the ToT mode of thinking, which has been criticised extensively (Chambers, 1983; Chambers & Ghildyal, 1985; Leeuwis, 2004; Röling, 1988).

Innovation has often been confused with technical output of research. However, recent insights in innovation studies indicate that innovation neither originates from research nor science only, but rather, is the application of all types and sources of knowledge to achieve desired social and/or economic outcomes (Hall, 2005). These insights highlight the interactive character of the innovation process and suggest that innovators rely heavily on their interaction with a range of institutions in the innovation system (Brown & Eisenhardt, 1995; Keld & Salter, 2005; Leeuwis, 2004; Lundvall, 1992; Szulanski, 1996; von Hippel, 1998). Other authors similarly argue that innovators tend to innovate in teams and coalitions based on 'swift trust', nested in communities of practice and embedded in a dense network of interactions (Brown & Deguid, 2000; Scott & Brown, 1999). Therefore, innovation should be seen more as the outcomes of interactive and evolutionary processes where networks of organisations, together with the institutions and policies that affect their innovative behaviour, bring new products into economic and social use (Edquist, 1997; Freeman, 1987; Lundvall, 1992).

Innovations thus must be seen as a collective achievement and their design results from multi-faceted processes, involving different sets of actors (Hall & Clark, 1995; Geels, 2002a, 2002b; Geels, 2004; Leeuwis, 2004). They can be seen as a '*novel working whole*' (Leeuwis, 2004; Roep, 2000) and to be complete, they must be a successful combination of 'hardware' (technologies), 'orgware' (social-organisational arrangements) and 'software' (new modes of thinking or mindsets) (Smits, 2000). The process of designing an innovation is, therefore, not straightforward and controllable; it is rather one of network building, social learning, and negotiations to develop shared understanding to solve a problem or overcome tensions in a given situation (Leeuwis, 2004).

Regarding dissemination, many authors have criticised the tendency for extension organisations to promote pre-defined technological improvements, which are sometimes developed by researchers with little understanding of farmers' problems and priorities (Chambers *et al.*, 1989; Hagman *et al.*, 1998; Leeuwis, 1989; Röling, 1988). It has also been argued that locally developed innovations and knowledge cannot be transferred through ToT approaches (Röling & van de Fliert, 1994; van Schoubroeck, 1999). This is because innovation is location-specific, and their (re)design and adoption is a collective effort by different sets of actors. To scale up tailor-made innovations to different contexts, it must include elements encompassing new processes of learning and negotiations to fit specific circumstances.

With insights from the sociological and economic models of technology adoption, Boahene (1995) developed a theoretical model for the adoption of the cocoa hybrid variety in Ghana and tested it in the Kwahu South and Suhum Kraboa Coaltar Districts of the Eastern Region. The model indicates that access to improved knowledge has a positive impact on adoption in a similar manner as the awareness stage in Rogers' (1983) adoption process. The model also shows that the farmers' economic position regarding resources like bank loans, income, land, and labour, affects profitability and adoption. Although Boahene (1995) recognised the multi-dimensional nature of technology adoption processes and incorporated both social and economic elements in his model, it does not provide answers to how the necessary information and resource-oriented factors can be harnessed to promote the development of innovations. Adoption of research recommendations for cocoa production remains low and therefore, there is a need to explore how to adapt and combine the necessary social, organisational, economic and technological conditions into innovations that work under farmers' conditions.

4.3 An overview of the research design

The overall research objective of this study was to develop environmentally-friendly and sustainable pest management practices that farmers can adopt, and strategies for introducing such innovations elsewhere. There are many definitions and views on what constitutes sustainable practices in agriculture (Pretty, 1998). However, sustainability in this context is viewed through a holocentric worldview, where systemic thinking and practices adopted aim at improving the relationship between people and their environments, which are inter-related (Bawden, 1993). Cocoa farmers in Ghana operate under diverse, complex and resource-poor conditions and obtain relatively poor yields. Under such conditions, the challenge for sustainability is to increase yields without using expensive external inputs and without damaging natural resources (Pretty, 1995).

To achieve the above objective, an action research was conducted under farmers' conditions using an interactive participatory approach with farmers (Pretty *et al.*, 1995) to develop innovations through an evolutionary process, the outcome of which could not be predicted at the beginning. The approach was similar to the farmer-first-and-last model, beginning with an appraisal of farmers' problems and constraints (Chambers & Ghildyal, 1984) through a diagnostic study (Dormon *et al.*, 2004). The process approach used left room for modifications, additions, and re-organisation of the various elements of the innovation as the actors (farmers, extension workers and researchers) introduced new ideas along the way in a continuous learning process. Bawden (1991) refers to this kind of action research as *praxis;* that is practice which is informed by critical theories and achieved through conscious commitment to methodological enquiry. Our praxis in this research evolved over time with increasing insights in theories outlined earlier as we facilitated the innovation development process by engaging farmers in joint experimentation, observations, discussions, evaluation and planning.

The first stage was to develop a technical package of existing pest management technologies. This package was tested on several experimental plots established with farmers on their fields to determine its technical feasibility and profitability. We then investigated the extent to which positive results of the package diffused to farmers in the community.

In the second stage, a deliberate effort was made to introduce the package to another community using farmers as peer educators and studying adoption by participants and non-participants. In the third stage, constraints to adoption were identified leading to re-design and expansion of the package to take on board additional technical, social, organisational and economic elements. The overall design is summarised in Figure 4.1.

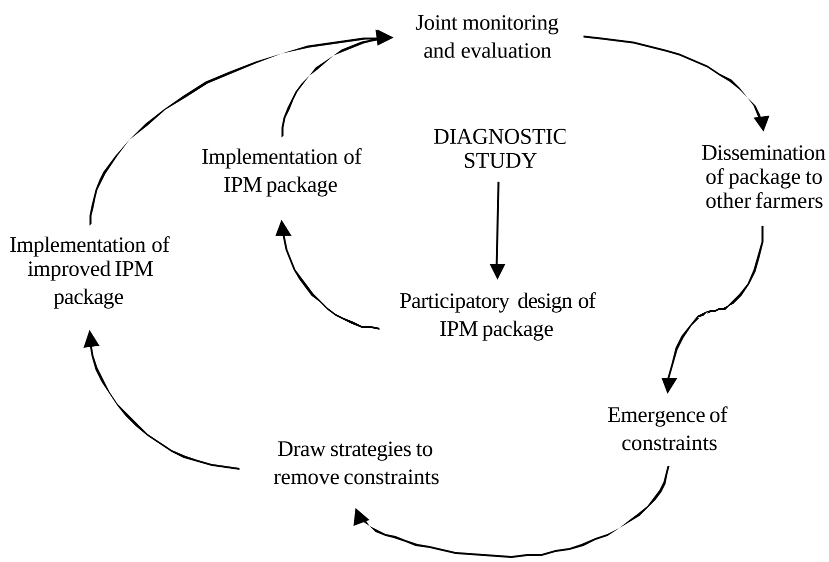

Figure 4.1: Overall research approach

The process is described in three stages in which the objective, research approach, results obtained, shortcomings, and additional elements required to make the innovation more suitable to farmers' conditions are explained under the various stages.

4.4 Stage 1: Developing an environmentally-friendly IPM package

During a diagnostic study in the research area, low yields were identified as the main problem facing cocoa farmers (Dormon *et al.*, 2004). Possible causes were identified, and analysed. Because pests and diseases emerged as major issues, the objective was to develop a pest management strategy using technologies that are least harmful to the environment (Table 4.1). Based on this objective, the first author, together with a group of farmers, established 18 experimental plots, 30 x 30m each, on the farmers' fields and implemented the IPM package jointly with them. The plots were established in locations where other farmers would pass on the way to their farms.

The technologies selected relied on low external inputs to meet the farmers' conditions of low capital, inadequate and expensive credit facilities. Capsids were controlled by spraying aqueous neem (*Azadirachta indica*) seed extracts on need-basis (= 25 % of pods harvested had lesions). To reduce the incidence of black pod, the strategy was to rid the field of the source of infection by removing all diseased pods and either burn or bury them. After harvesting and breaking the pods, susceptible plant material like pod husks were disposed off through drying and burning or burying. Mistletoe and epiphytes were removed and some cocoa trees were pruned. Weeds were also controlled three to four times a year. The technologies implemented in the package are summarised in Table 4.1.

Table 4.1: Technologies and strategies used to reduce various causes of low yields

Causes of low yields	Strategies and technologies to minimize yield reducing factors
Capsids and other insect pests	Aqueous neem seed extracts applied only when needed
Black pod disease	Removal of diseased pods and disease susceptible husks Removal or pruning of trees in over shaded areas
High incidence of mistletoes, epiphytes, weeds and too much shade	Removal of mistletoes and epiphytes Weed control 3-4 times/year Removal or pruning of cocoa and shade trees
Low capital, inadequate supply and high cost of credit, high cost and unavailability of labour at certain times of the year	Selection of low external input technologies

The results showed that the aqueous neem seed extracts were not only effective against the target pest (capsids) but also against other insect pests like *B. thalassina* (Heteroptera: Pentatomidae), stem borers (*Eulophonotus myrmelon)* and pod borers (*Acrocercops cramerella).* Later studies showed that they were effective against *P. palmivora* as well (Duindam, 2006). The sanitation measures against black pod proved to be effective and reduced disease incidence. From the results, we concluded that the package can increase yields significantly. (Dormon *et al.*, forthcoming (a)).

The technologies selected were, however, labour-intensive and difficult to adopt by individual farmers with little working capital to hire labour. The farmers had complained earlier of labour shortages and the high cost of labour (Dormon *et al.*, 2004), hence the IPM package at this stage did not sufficiently take into account farmers' social constraints. An interesting observation was that the Achiansah farmers implemented the practices using reciprocal labour arrangements and were, as such, more effective in terms of reduction in pest incidence and obtained better yields than the Adarkwa farmers who worked individually (Dormon *et al.*, forthcoming (b)).

Another observation was that the IPM practices did not disseminate to other farmers in the community who were not directly involved in the project, although the results of the experiments were clearly visible to most of them. To investigate this observation, all the farmers in Achiansah were invited to a meeting. Out of 35 farmers who attended the meeting, only two had made some attempt to adopt the package although all those present had seen the experimental plots and about 50% of them had made direct enquiries from the participating farmers. Their main reason for not adopting the package was its labour-intensiveness.

The conclusion at this stage was that without a deliberate effort to solve the labour issue, as happened with the Achiansah group, other farmers in the community would not be able to adopt the package. Meanwhile, the farms in the village are all on a contiguous stretch of land and cross-over effects of pests and pathogens from non-participating farmers would make effective pest management by a few farmers difficult. Therefore, getting the other farmers in the community involved was important for effective pest management.

4.5 Stage 2: Disseminating the package, with reciprocal labour arrangements as a component

The objective in stage two was to introduce the technical package to other farmers using reciprocal labour arrangements as a component. This was implemented in two villages:

a. Achiansah, one of the communities in which the project carried out the IPM activities.

b. Ntumkum, a village about 30 km away but within the Suhum District, where some of their farmers heard about the IPM practices and expressed interest to learn about them.

4.5.1 Dissemination within Achiansah

Dissemination within Achiansah started in March 2005 and happened in two stages. The first was a meeting with farmers in the community (where experimental plots had been established since 2003) to assess their awareness of the IPM package. The second was to use the farmers who had been involved earlier in the experiments as peer educators to assist other farmers to learn and understand the principles behind the technological package.

Thirty-five farmers from the community attended the meeting. Four farmers, on whose farms IPM experimental plots were established, described the technologies, processes, and outcomes of the experiments, especially the impact of reciprocal labour arrangements. The farmers on whose fields experimental plots were established volunteered to assist the 'new' farmers to learn and implement the IPM package on their farms. To ensure that the technologies were implemented effectively, three groups (with 10 members each) were formed. All the farmers at the meeting agreed that one of the farmers on whose farms experimental plots were established, should be made a leader/peer educator for each group. The groups were advised to use reciprocal labour arrangements to implement the technologies on their farms to overcome the labour constraint. Each group planned their meeting and working days. The members of each group worked on each other's farm, removing mistletoes and blackpod-diseased pods, pruned some cocoa trees, and removed or pruned some shade trees. After the group work, each farmer was expected to continue carrying out these activities on his/her own farm.

In the first six months, an average of 60% of the 30 farmers in the three groups had continued to work reciprocally and adopted all the technologies in the package, except the use of neem to which they did not have access.

4.5.2 Introducing the package at Ntumkum

Using three farmers from Achiansah as peer educators, a demonstration plot of 30m by 30m (900 m^2) was demarcated on one of the farmers' fields and the peer educators took 21 farmers through the various IPM practices. This plot served as a platform for the farmers to observe changes that occurred as a result of the IPM package. Immediately after working on the experimental plot for the first time, ten farmers present volunteered to form a reciprocal labour group, who worked in turns on each other's farms to implement the technologies that were demonstrated in the plot. A field visit was also organised for the farmers to visit Achiansah and Adarkwa to observe the results of the IPM package in the two villages (i.e. the success and failure factors).

All the 10 farmers (100% of those who volunteered and formed the group) adopted all the technologies in the package except the use of neem because it was not available locally. Other farmers showed interest in joining the group. Consequently six more farmers joined and they re-divided the group into two, each with eight members, using the same labour arrangements to implement the technologies.

4.5.3 Remaining inadequacies of the IPM package in stage 2

The package still had shortcomings and was incomplete as an innovation because there were a number of constraints that affected its adoption (Table 4.2). The constraints were:

i) The neem seeds were not available in the community and had to be bought from Kordiabe, a village in the Accra Plains which is over 100 km away. Therefore, individual farmers had no access. In Achiansah, some of the farmers started planting the tree in the community, but it will take between 3-5 years before it starts bearing fruit and 10 years before it is fully productive (National Research Council, 1992). Also, after acquiring the seeds, it has to be milled but corn-mill operators are reluctant to mill it because of the bitter taste which will contaminate food products (e.g. cereals) when milled after neem.

ii) The IPM package is labour-intensive, especially regarding black pod control, removal of mistletoe, epiphytes, and weed control. Although a reciprocal labour arrangement was used, there was no guarantee that this would last for a long time because previous experience with such labour arrangements in the two villages had not been sustainable, according to the farmers.

iii) Although the IPM package relied on low external inputs, some working capital is still required to purchase neem seeds, farm equipment and implements (spraying machines, pruners, cutlasses etc) but credit is either not available or expensive. In 1999, for instance, on average, farmers could borrow from the Agricultural Development Bank at 34 to 36 % interest rate per annum. Although this rate has dropped to about 25% in 2005, farmers still have to travel long distances to negotiate credits. In many cases, therefore, farmers have to rely on money lenders who charge between 50 to 100 % interest for three months (200 to 400% per annum), making lack of cash one of the major constraints to adoption of recommended practices (Anon., 1999).

Table 4.2: Constraints to adoption of technologies in the ICM package

Causes of low yields	Technologies/strategies proposed to overcome yield-reducing factors	Constraints
Capsids and other insect pests	Aqueous neem seed extracts sprayed on need basis	Seeds not available. No processing facility available in community
Black pod disease	Removal of diseased pods and husks Proper shade management Use of reciprocal labour arrangements	Because of the labour-intensiveness and high labour cost, there is little motivation to do this over a long period.
High incidence of mistletoes, epiphytes, weeds and poor shade	Removal of mistletoes and epiphytes Weed control 3-4 times/year	Labour-intensiveness, high labour cost, and sustainability of reciprocal

management	Proper shade management	labour arrangement
Low capital Inadequate and high cost of credit Labour expensive and unavailable at certain times of the year	Low external input technologies	Some capital required to purchase neem seeds and basic farm implements (e.g. spraying machine, pruners, etc.) needed

4.6 Stage 3: Further development of the IPM package into an innovation

The need for a third stage arose because of the outstanding constraints identified in stage two.

4.6.1 Background and approach

From stage 2, it appears that the IPM package will not be adopted effectively and on a wide scale, unless the remaining constraints identified (Table 4.2) are addressed. Another constraint that had not yet been tackled in the earlier stages was a complaint by the farmers that Purchasing Clerks of the Cocoa Licensed Buying Companies were cheating them by adjusting their weighing scales to read less than the actual weight. A quick survey, by first weighing cocoa beans with the farmers at home and then letting them take it to the LBCs for weighing, revealed that the scales of four different LBCs had been adjusted downwards between 5 to 12 kg. Farmers usually sell in weights of 30 or 65 kg, therefore they lose between 5 and 12 kg for each load of beans. This was a disincentive for farmers to invest their capital and labour in cocoa production. The objective at this stage was to design additional technical, socio-organisational, and economic arrangements necessary to overcome the constraints and make the package relevant and useable by farmers in a sustainable manner on a wide scale.

The theoretical basis for further development of the package hinges on the notion that explorative search for innovative opportunities is greatest where it spans both organisational and technological boundaries (Rosenkopf & Nerkar, 2001). In terms of the earlier introduced metaphor of ‘hardware’, ‘orgware’ and ‘software’ (Smits, 2000), the technologies constituted the 'hardware' and the labour arrangements were part of the 'orgware' in stage 2. However, parts of the 'hardware' (processing neem), and 'orgware' (organising collection and transportation of neem) were largely absent hence the innovation was still not complete. Further insight was drawn from literature which suggests that most rural people depend on multiple sources of income like petty trading, casual labour, and agricultural production, among others (Carney, 1998) A number of authors have also suggested that non-farm income provides liquidity to buy farm inputs and assets to increase production and spur profitability of agricultural production (Hazell & Röell, 1983; Machethe *et al.,* 1997; Reardon *et al.,* 1994). Boahene (1995), showed, through empirical analysis of his model on adoption of the cocoa hybrid variety that at the decision stage, information-oriented factors (access to extension information, education, and network information) influence adoption significantly. For their implementation, however, farmers need additional resources like bank loans and hired or cooperative labour. Therefore, it was necessary to explore opportunities that could link economic enterprises to the technologies and at the same time provide cash for liquidity.

The approach adopted was twofold: (i) design technical and social-organisational elements to overcome the constraints identified in stage 2 and (ii) create linkages between capsid, black pod control, and other farm management practices with non-farm economic activities. To achieve this, the two groups of farmers from Achiansah and Ntumkum were assisted to prepare proposals for grants from a program under the Ministry of Food and Agriculture (MoFA) that supports Farmer Based Organisations (FBOs). The MoFA program is a fund established to support farmers' groups who can prove that they have an innovative idea that can enhance their farming practices, improve their incomes, and also benefit other farmers in their community. Our role as researchers was to make the groups we were working with aware of this opportunity and helped them to develop a proposal to apply for a grant. The grants received by the farmers were used to acquire processing equipment and establishing economic enterprises which have direct linkages with pest management.

In addition to the supply of equipment, the grant also covered the cost of training the group members. The training covered group development and dynamics, conflict management, record keeping, savings mobilisation and credit management, basic bookkeeping, and entrepreneurial skills like business planning, basic financial management and marketing. This training was necessary to enhance the ability of the farmers to put the knowledge and facilities acquired into use efficiently.

4.6.2 Processing of neem seeds

A corn mill was required to facilitate processing neem seeds and this was acquired by the farmers, as a group, through the grant from the Ministry of Food and Agriculture. This mill was not used solely for neem processing; otherwise it would be under-utilised. Therefore, it was designed in a such a way that one set of grinding teeth could be replaced by another. The first set is used to mill neem seeds and the other for milling cereals for community members at a fee to generate income. The same equipment was provided to the two groups of farmers. Having the means to process the neem seeds makes it possible for the farmers in the community to apply neem extracts as a pesticide.

4.6.3 Linking black pod control with soap making

Through interactions with the farmers in Achiansah during the research, it was realised that the women, previously, used the pod husk to make local soap; the African Black Soap (*Alata Samina)* for bathing and a white version for washing clothes and household utensils. They also processed palm fruits into palm oil and palm kernel oil, some of which they combined with the husk to make the soap. These were important sources of income for the families. However, they had stopped doing this because processing the oil manually was tedious. To make these soaps, the pod husk is dried, burnt into ash which has a high level of potash and then combined with either the palm oil or kernel oil to make the two types of the local soap. The women expressed interest in re-activating these economic activities if they could have access to simple processing equipment. This provided an opportunity to link control of the black pod disease directly with activities that could motivate the farmers to take away the pod husk from the fields, because the husks becomes a raw material for making the soap. Meanwhile, pod husks left on the field provide a medium for the complete life cycle of the fungus causing the black pod disease (Akrofi *et al.*, 2003; Wood and Lass, 1985). Taking them off the farm therefore, would reduce that source of inoculum for new infection. A second set of equipment was purchased to process palm oil and kernel oil from the grant received from the Ministry to support the soap making enterprise.

4.6.4 Capital for various farm operations and acquisition of farm assets

The two types of equipment did not only facilitate processing, they also generated income which could be used to organise and purchase neem seeds from long distances, hire labour, acquire basic farm tools like cutlasses, and meet the cost of farm management practices like removing mistletoes and controlling weeds. In the case of the Ntumkum group, they were not interested in producing soap but were rather interested in grasscutter (the rodent *Thryonomys swinderianus)* and snail (*Achatina achatina)* farming as an income generating activity. Their grant, in addition to covering entrepreneurial skills, also covered training in technical production of snails and grasscutters. The income from these economic activities would increase the farmers' capital and reduce the need for credit which is not only difficult to access but also expensive.

4.6.5 Cheating by LBCs

Although dealing with the cheating by Purchasing Clerks was not directly part of the innovation, stopping such malpractices would motivate farmers to invest their capital and labour in cocoa production. To overcome this cheating, the research team, the District Director of Agriculture and the farmers, collaborated and wrote a proposal to the Suhum-Kraboa Coaltar District Assembly, which is the highest administrative and political authority in the district, to set up a Task Force to check the downward adjustment of scales by the Purchasing Clerks. After persistent follow-ups, the Task Force was formed with legal backing from the Assembly to randomly check scales of LBCs operating in the district and fine anyone found to have adjusted their scales. The Task Force was made up of two members of the Security sub-committee of the Assembly, a representative of the security agencies, the Quality Control Division of COCOBOD, the Ghana Standards Board, Cocoa Services Division, Department of Food and Agriculture, and two farmers' representatives. This gave the farmers some confidence that the cheating will subside and make their investments worthwhile.

4.6.6 Outcomes of developing the IPM innovation in the third stage

The strategies and outcomes of linking the technical package with social-organisational and economic activities in both villages are summarised in Table 4.3 and Figure 4.2.

Table 4.3: Evolving constraints in various episodes and technologies/strategies to overcome them

Identified causes of low yields	Stage 1: Technologies and strategies	Stage 2: Constraints identified during implementation	Stage 3: Creating further space for technology adoption
Capsids and other insect pests	Need-based use of aqueous neem seed extracts	i) Seeds not available ii) No processing facility in the communities	Source for grant to purchase processing equipment
Black pod disease	i) Removal of diseased pods and husks ii) Proper shade management	Labour intensiveness, and high cost: tackled by organizing reciprocal labour arrangements, however farmers considered it not sustainable	Use reciprocal labour arrangements but also introduce soap-making enterprise making use of pod husks as a raw material to motivate farmers to take them off from the field
High incidence of mistletoes, epiphytes, weeds and poor shade management	i) Removal of mistletoe and epiphytes ii) Control weeds 3-4 times/year iii) Proper shade management	Labour-intensive: tackled by organizing reciprocal labour arrangements but not considered sustainable by farmers due to previous experience	Use reciprocal labour but also use income from processing equipment and economic enterprises to meet some of labour cost
Low capital, inadequate and high cost of credit, high cost of labour	Selection of low and not expensive external input technologies	Some capital still required to purchase neem seeds and basic farm implements (e.g.	Income from economic enterprises to support capital requirements (e.g. to purchase neem seeds

and unavailability at certain times of the year	spraying machine, pruners, etc.)	from long distances)
Cheating by Purchasing Clerks of LBCs		District Assembly was persuaded to set up a Task Force to check, at random, the accuracy of weighing scales and punish those found to have adjusted their scales

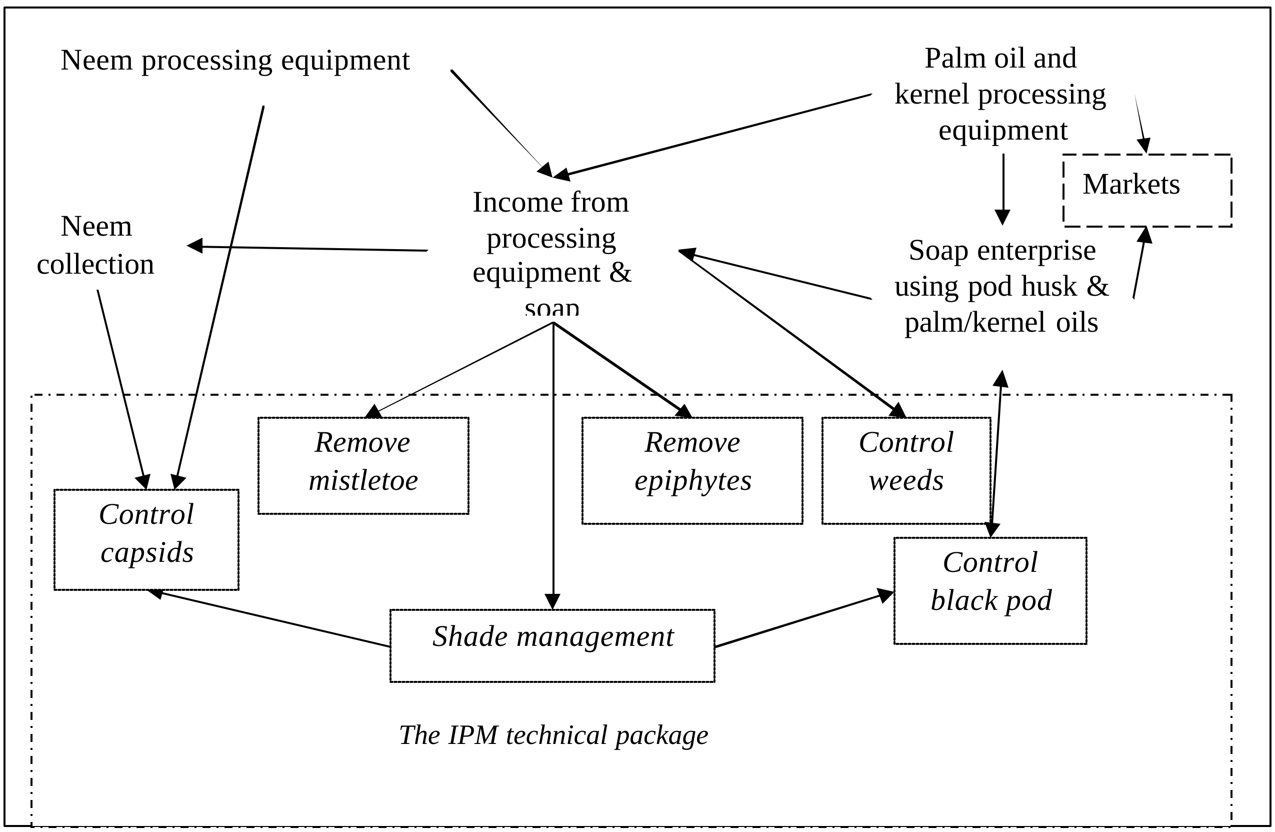

Figure 4.2: Overview of the social-organisational, economic and technical arrangements which formed the 'complete innovation' in Achiansah (from Dormon *et al*, 2006b)

Although the farmers at Ntumkum faced exactly the same constraints and impediments to sustainable adoption of the IPM package, processing palm oil and palm kernel oil was replaced with grasscutter and snail farming but the concept of innovation remained fundamentally the same.

4.7 Discussion

In the discussion, we reflect on lessons learnt in this research and conceptualise the development of innovations with different degrees of complexity. We also suggest that whereas relatively simple innovations could be disseminated, it is only the basic concept of those with complex socio-organisational components that can be introduced elsewhere, because they have to be adapted to local circumstances.

4.7.1 Innovations with different degrees of social complexity

As defined earlier in this paper, innovations are a combination of technical, economic, and social-organisational arrangements required for solving specific problems. In developing innovations that farmers can adopt easily, both the technical and social components must be co-designed in order to increase the chances of sustainable adoption (Geels, 2002a; Smits, 2000).

Innovations have been categorised into 'regular' and 'system' innovations (Abernathy & Clark, 1985; Geels, 2002a; Kemp *et al.,* 2001; Leeuwis, 2004). To facilitate a better understanding of developing innovations at varying levels of complexity, we suggest classifying them not only into 'regular' and 'system' innovations, but also on the role of local and formal organisations (Figure 4.3).

Regular innovations do not challenge the main technological and social-organisational rules, goals and arrangements underlying the farming system (Abernathy & Clark, 1985; Leeuwis, 2004). In the case of cocoa, for instance, a regular innovation would be for farmers to rely on the government to spray pesticides against capsids and black pod under the 'mass spraying' exercise whilst they use reciprocal labour to control weeds, which is a pre-condition for their farms to be sprayed, instead of doing so individually. From this study, we can argue that regular innovations, like simple labour arrangements to implement technologies, can be designed easily by farmers with little or minimal support from external agents.

System innovations require and incorporate a fundamental re-organisation of social relationships, technical principles and/or rules (Abernathy & Clark, 1985; Geels, 2002a, 2002b). In this study, we argue that 'systems innovations' have varying degrees of complexity and are developed at different levels namely (i) farmers' level and (ii) network organisational level.

Farmer level system innovations require and incorporate re-organisation of social relationships, technical principles and existing systems of farming where farmers have some control over the elements and process of innovation. These elements include new technical philosophies, the labour arrangements and community mobilisation for learning new ways of doing things better. For this level of 'system innovation', the involvement of field extension agents, who may introduce new ideas or take farmers' ideas and facilitate farmer experimentation and learning of new principles (e.g. pest management using economic thresholds), is important. An example of such an innovation is the IPM technical package in this study, using aqueous neem seed extracts on need basis instead of synthetic pesticides on calendar spraying, combined with the reciprocal labour arrangement to facilitate implementation.

Network level 'system innovations' incorporate the re-organisation of social relationships, economic and technical principles, and rules of the existing farming system and practices where farmers have little or no control over some elements of the innovation development process like acquiring facilities required for processing neem, facilitating new networks, and introduction of certain economic activities all of which are inter-dependent. The inclusion of soap-making and setting up a Task Force by the District Assembly to check cheating by LBCs are examples of elements of the innovation development process that require external involvement and assistance to make the innovation complete. To design and develop this type of system innovation in the absence of well organised farmer organisations, the involvement of extension field agents, district and middle level officials are likely to be required to facilitate the re-organisation and introduction of new elements to attain complete innovations. Its sustainability may be facilitated by state institutions and administrative bodies that can provide the right political and legal environment to support the development of the innovation by reviewing existing legal frameworks or introducing new legislation, like setting up the Task Force by the Assembly. Other examples that the study did not address, but which may be relevant, include: introducing a grading system, and payment for quality; provision of basic infrastructure like roads and electricity, which facilitate the movement of farm produce to markets and can reduce out-migration to improve availability of labour.

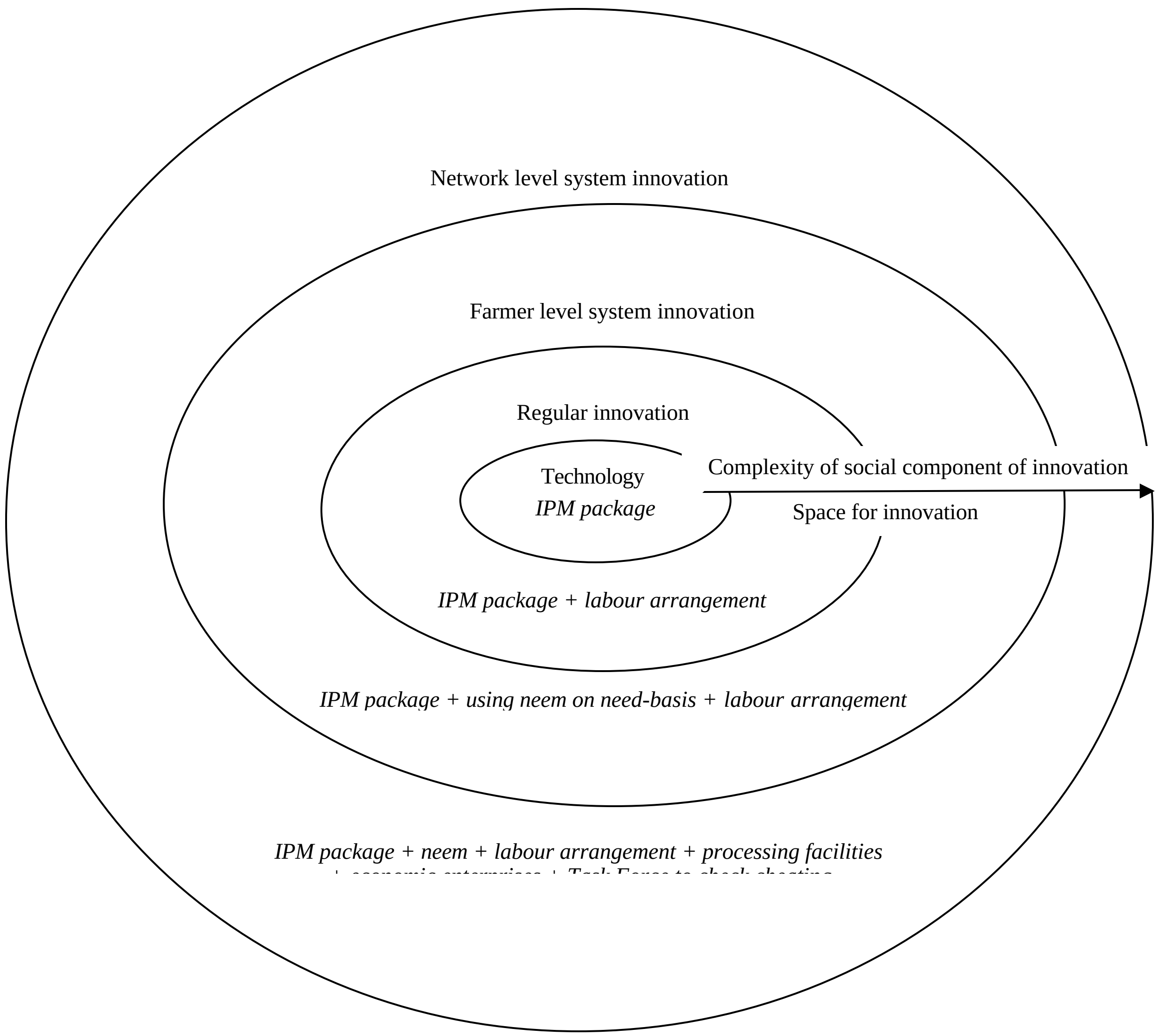

Figure 4.3: Increasing space to accommodate different levels of

In developing different levels of innovations, a modification in the ‘software’ component drives changes in the ‘hardware’ and ‘orgware’ components to respond to the new goals and mindsets.

For instance, in moving from stage one to three, the focus shifted from direct pest management to tackling the constraints that hinder adoption of pest management technologies in an environmentally-friendly manner. This required the acquisition of additional technical components like processing facilities ('hardware'), and collecting pod husk for making soap ('orgware').

4.7.2 Scope of extension services and dissemination of innovations

To develop and disseminate innovations, the role and scope of extension services must be examined critically. In Ghana presently, the focus of agricultural extension is on improving agricultural production performance through dissemination of information on better technologies. This assumes that awareness alone will motivate the farmer to adopt the technologies. However, there is a international debate on the purpose of agricultural extension; whether it should only advance knowledge on how to increase production, or to engage in a broader range of agricultural development tasks such as credit, supplies and marketing (FAO, 2001). In this study, the action researcher – who is at the same time employed as a senior extension officer – has stimulated and facilitated the development of 'orgware' in the form of organising new modes of labour; facilitating the setting-up of a committee to combat cheating in the marketing chain; linking the farmers to Neem producers; and assisting them to establish new micro-enterprises for Neem and soap production. All these were done as an integral 'building blocks' of an innovation that originally started in the realm of pest management. One might argue that the researcher has fallen in the trap of creating artificial conditions for IPM adoption that cannot be sustained in the long-term. While indeed it is too early to assess whether the composite innovation will prove to be durable, we feel that the activities carried out by the action researcher are qualitatively different from creating artificial circumstances with the help of resources from a temporary programme or project. The main role of the action researcher has been to connect people who were not previously connected, to point towards existing resources and opportunities (e.g. a regular grant system, the availability of Neem), and to facilitate joint learning and interaction on the basis of which communities could re-organise themselves vis-a-vis their environment. In essence, the researcher has invested in a social process and capitalised on available organisational capacity and leadership in and outside the community. In principle, the same roles could have been played by other senior extension or research personnel, if only they had considered this their responsibility and mandate to do so. Hence, we make a plea for researchers and extension staff at all levels to broaden their scope and facilitate building networks that can support technology adoption.

Depending on the level and complexity of the social factors constituting an innovation, the issue of dissemination must be dealt with differently. For technology and relatively simple innovations, be they 'regular' or 'system' it is possible to disseminate them through peer education and influence as seen with the regular innovation in this research. They can also be disseminated by extension workers using various participatory extension approaches. However, for system innovations at the network organisational level, dissemination is not feasible. Rather, the innovation has to be (re)designed jointly by researchers, extension workers, and farmers with support from political, administrative and social authorities to fit location-specific conditions as shown in the different components of the innovation in stage 3 at Achiansah and Ntumkum. Designing location-specific innovations can address, to some extent, heterogeneity and diverse interest of farmers. Therefore, the idea of disseminating innovations must give way to one of co-designing innovations that are location-specific and involves creating and sharing knowledge as a collective process. We suggest that, innovations developed with small groups of farmers would not spread rapidly by themselves, even if the results are visible, unless deliberate steps are taken to introduce them to other farmers. Whilst technology and regular innovations may be disseminated through ToT approaches and peer education by farmers, the more complex innovations cannot be transferred as a package using ToT approaches but only as a concept using a process involving all the relevant actors, and the innovation must evolve from the process to suit location-specific needs. It is therefore important to look beyond the ToT approach and the production performance focus of extension and facilitate the building of networks that enable farmers to take advantage of all the resources and opportunities available to them.

4.8 Conclusion

This study supports the view that development of innovations is a multi-dimensional process. Depending on the nature of the problem to be solved, an innovation would combine one or more technologies, social and organisational arrangements like labour, and economic elements such as off-farm enterprises with support from research and extension workers. To develop complete innovations that are relevant to farmers, the role of extension must change from its narrow technology performance focus into a broader one that includes assisting farmers to harness all resources and opportunities that are available to them. In this regard, extension workers have to play a more facilitating role in organizing the elements of an innovation that will make it complete and useable by farmers on a sustainable basis. This new role for extension will require the training of a new 'breed' of 'extension agent' whose focus will not be the dissemination of technology but rather the development of innovations. This will, however, be possible only if officials at high policy level are made to appreciate the new paradigms of innovation development and build both individual and organizational capacity to work in this direction.

The implication of this study for research is that it re-enforces the point that technologies developed by researchers for farmers must have a 'social face' (Chambers, 1983; Chambers & Ghildyal, 1985) by keeping in mind farmers' conditions and have in-built flexibility that allows farmers to adapt them to their conditions. This requires a continuous learning and feedback mechanism between researchers, farmers, extension workers, consumers among others. However, this will only be possible if researchers do not limit their work to their offices, laboratories and research stations but come out to farmers' fields and conduct action research with flexible agenda. This will enable them appreciate the emergent and unpredictable character of innovation development processes where important elements that make it possible for farmers to use available technologies can become clearer.

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Chapter Five
Explaining differential outcomes of participatory innovation development in three cocoa producing villages in Ghana[6]

Abstract

A major problem facing cocoa farmers in Ghana is low yields caused by a combination of socio-economic and biological factors. In a participatory action research project, an integrated pest management (IPM) innovation was developed with farmers in two villages with the objective of assisting them to improve their yields. The innovation was extended to a third village in an attempt to experiment with out-scaling the innovation. Although the interactive process and innovation concepts were similar, the outcomes were different in the three villages. The objective of this paper is to explain the factors responsible for the differential outcomes. Taking the innovation trajectories in the three villages as case studies, a comparative analysis of the processes is made using sensitising concepts from theories of learning and social capital in an attempt to explain the outcomes. The paper concludes that a high level of social capital, particularly in terms of group organisation, trust, and leadership, facilitates the quality of learning required for developing innovations. An effective organisational capacity of farmers also makes it easier for them to 'connect' with relevant networks to take advantage of opportunities that enable them create the necessary linkages between technical, social-organisational and economic

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elements to develop 'complete' innovations that are relevant and easily applicable under their conditions.

Additional keywords: experiential learning, interactive participation, social capital, social learning.

5.1 Introduction

One of the major problems facing cocoa farmers in Ghana is low yields caused by a combination of socio-economic and biological factors. Although many cocoa farmers are aware of the technologies recommended by research to improve yields, they do not adopt most of them (Gerken *et al*, 2001; Humado, 1999) mainly due to socio-economic factors (Dormon *et al.*, 2004; Anon., 1999). A participatory action research approach was used to develop an integrated pest management (IPM) innovation in two villages in the Suhum-Kraboa-Coalter District of the Eastern Region of Ghana with the objective of assisting the farmers to improve their yields. The level of participation (see Pretty *et al.*, 1995) by farmers was generally high, and much effort was made to support experiential learning (Kolb, 1984) during the action research, which was carried out between 2002 and 2005 (Dormon *et al*, 2004; Dormon *et al*, 2006a; Dormon *et al*, 2006b). In 2005, the innovation development process was extended to a third village in the same district.

The trajectories and level of success were quite different in the two villages where the study started and the third village to which the IPM innovation was extended (Dormon *et al*, 2006a; Dormon *et al*, 2006b). In this study, success is viewed in two broad terms: (i) effective implementation of the IPM technical package to reduce the incidence of pests and diseases leading to increased yields, and (ii) effectiveness in addressing constraints to sustainable adoption of the technical package through the development of new social-organisational arrangements as an integral part of a complete innovation.

The objective of this paper is to discover the factors responsible for the differences in the trajectories and outcomes of the pest management innovation in the three villages. Section two describes the study area, the philosophy and general character of the innovation process, as well as the outcomes in the three villages. The third section describes the research methods. Section four explores theoretical notions that may be useful to explain the differential process and outcomes in the three research locations. In section five we describe the innovation development process in the three villages. Section six analyses and discusses the outcomes, while the last section draws conclusions about what explains the different levels of success in the different villages.

5.2 The three villages and outcomes of the innovation development process

5.2.1 The research area

The three villages; Adarkwa, Achiansah and Ntumkum, are located in the Suhum-Kraboa-Coalter District of the Eastern Region. The district is in the forest zone, has an average daily temperature between 24 and 29°C, a relative humidity between 87 and 91%, and annual rainfall between 1270 and 1651 mm (Anon., 2000). Out of a total population of about 170,000, 64% are farmers by occupation (Anon., 2000). About 40% of all farmers in the district cultivate cocoa (Y. Dotse, District Director of Agriculture, pers. com) on an area of 8,720 ha, representing about 20% of total area under crop cultivation (Anon., 2000). In addition to the long history of cocoa production, the implementation of the Eastern Region Cocoa Project in the district between 1970 and 1979 resulted in the rehabilitation of cocoa farms and the training of farmers in improved methods of cocoa production (Amoah, 1998).

In terms of climate and physical factors like vegetation and soils, the three villages have much in common. Also, the farmers in all three villages are second or third generation descendants of migrant farmers who settled in and around Suhum in the early 1920s to cultivate cocoa. All the farmers produce food crops in addition to cocoa and some of the men engage in other income-generating activities like tapping palm wine (a local drink from the oil palm tree) and masonry. For the women, petty trading is common. Generally, spouses who do not own cocoa farms assist their partners on their farms.

Adarkwa is located about 8 km from Suhum, the district capital, while Achiansah is about 20 km away from Suhum. The third village Ntumkum is about 10 km from Suhum and 2 km from Adarkwa.

5.2.2 Philosophy, design and outcomes of the innovation process

In the past, innovations were equated with new technical devices or, in the case of agriculture, with technical solutions to problems. However, this view has changed considerably, and innovations are seen more as packages of new social and technical arrangements and practices in the form of coordination within networks of inter-related actors (Leeuwis & van den Ban, 2004). Consequently, an innovation must be seen as a *novel working whole* (Leeuwis & van den Ban, 2004) consisting of various components. In a similar vein, Smits (2000) defines innovation appropriately as a successful combination of 'hardware' (technology), 'software' (goals and mindsets), and 'orgware' (social-organisational and institutional arrangements). From this perspective, innovation development is a multi-actor process which evolves over time in an unpredictable and uncontrollable manner (Kline & Rosenberg 1986; Leeuwis & van den Ban, 2004) and can therefore be described as an emergent property of a soft system (Röling & Jiggins 1998). The innovation process includes deliberate efforts to create effective linkages between technical arrangements, people and social-organisational arrangements (Leeuwis & van den Ban, 2004) in a co-evolutionary manner (Geels, 2002a; Smits, 2000). Building coherent linkages and networks around an idea or technical device to develop an innovation is referred to as alignment (Rip, 1995) and this process requires the creation of a variety of solutions that are worked on simultaneously and accepting that some ideas will fail to become established (Aarts & van Woerkum, 2002; Geels, 2004).

The innovation development process was facilitated by a team made up of the first author, a Research Assistant and the Agricultural Extension Agent working in a particular village. The facilitation team assisted the farmers to implement IPM practices, collect data and analyse them, discuss emerging results, identify constraints and design strategies to develop a complete innovation. The activities carried out in the innovation development process are presented in three phases (Figure 5.1). In practice, these phases sometimes overlapped and several iterations occurred between the phases.

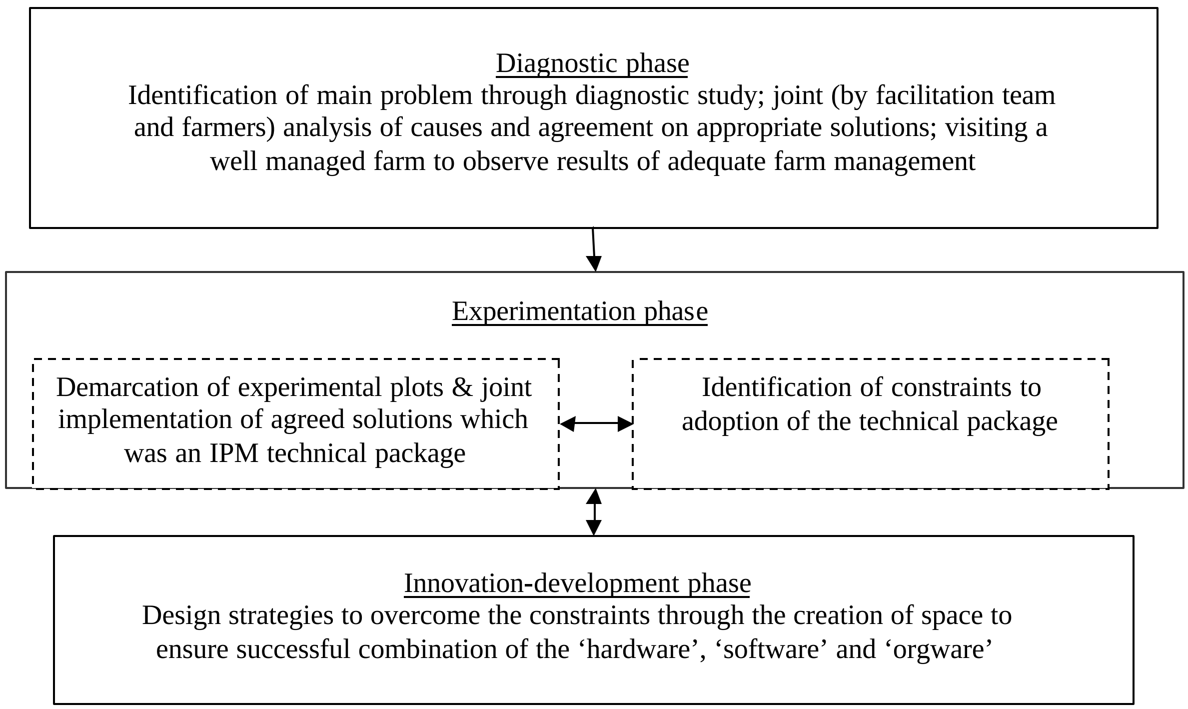

Figure 5.1: The general character of the innovation process in Adarkwa and Achiansah

Diagnostic phase

In Adarkwa the diagnostic phase was open to all the cocoa farmers in the village and was organised through community meetings. In Achiansah, the Agricultural Extension Agent (AEA) helped in selecting two of his farmers' groups; the Victory Farmers Group and the *Gye se wobre* Group, for the study. The Victory Farmers' Group had 16 members all of whom are Akwapims (an ethnic group) and also belong to the same church. The *Gye se wobre* group is made up of 15 farmers all belonging to the Krobo ethnic group, and has a somewhat broader interest in both crop (including cocoa) and livestock production. The AEA had been working with these two groups since 2000. In both villages, low yields were identified as the main problem facing cocoa farmers

(Dormon *et al.,* 2004). The causes of low yields were analysed jointly with the farmers. The farmers in Achiansah emphasised biological causes, while farmers in Adarkwa stressed the importance of socio-economic problems. In both villages cultural practices and the use of a botanical pesticide were identified as strategies to control pests and diseases to improve yields rather than relying on synthetic pesticides. No diagnostic study was carried out at Ntumkum. The leaders of a farmers' group in the village, the Ntumkum Farmers' Association, approached the first author in mid 2004 to discuss the possibility of extending the IPM program from Adarkwa to their village. After a visit to the village, and realising the enthusiasm of the farmers, the program was extended there in early 2005. The inclusion of Ntumkum offered an opportunity to try out some of the lessons learnt in the first two villages.

Experimentation with the technical package

Eight experimental plots (30 x 30m each) were demarcated in Adarkwa, and seven for the Victory Farmers' group in Achiansah. A number of (or all) the agreed pest management practices (which can best be described as an IPM package) were carried out on each plot depending on problems identified on a specific plot. The technologies selected relied on low external inputs to meet the farmers' conditions of low capital, inadequate and expensive credit facilities. Capsids (Heteroptera: Miridae) were controlled by spraying aqueous neem (*Azadirachta indica*) seed extracts (ANSE) on need-basis (if 25% or more of pods harvested had lesions caused by capsid feeding); black pod (*Phytophthora* sp.) by removing all diseased pods and husks and either burning or burying them; mistletoe and epiphytes by cutting them with cutlasses or pruners and controlling weeds three to four times a year.

Six months after implementing the IPM package on the demarcated plots, graphs showing changes in pod damage on each plot was presented at a meeting attended by farmers, extension staff from the Ministry of Food and Agriculture (MoFA), representatives of cocoa Licensed Buying Companies (LBCs), staff of the Cocoa Services Division (CSD), and Quality Control Division (QCD), and the results were discussed. This was repeated in September 2004, June and

October 2005. The graphs provided a visual trend of reduction in pest levels as a complement to farmers' observations in the field. It also offered an opportunity to discuss what accounted for different results on different plots and in different villages. These presentations formed part of the learning process through exchange of experiences from the results on various plots and farmers' fields. It also helped to identify and discuss constraints to the widespread use of the IPM package.

Reduction in pest incidence, measured in terms of the percentage of harvested pods that had 100% good beans, showed a high and consistent trend in Achiansah, (between 70 to 90%) six months after implementing the IPM package. In Adarkwa, however, the reduction was generally lower (between 30 to 80%) and fluctuated over time (Figure 5.2).

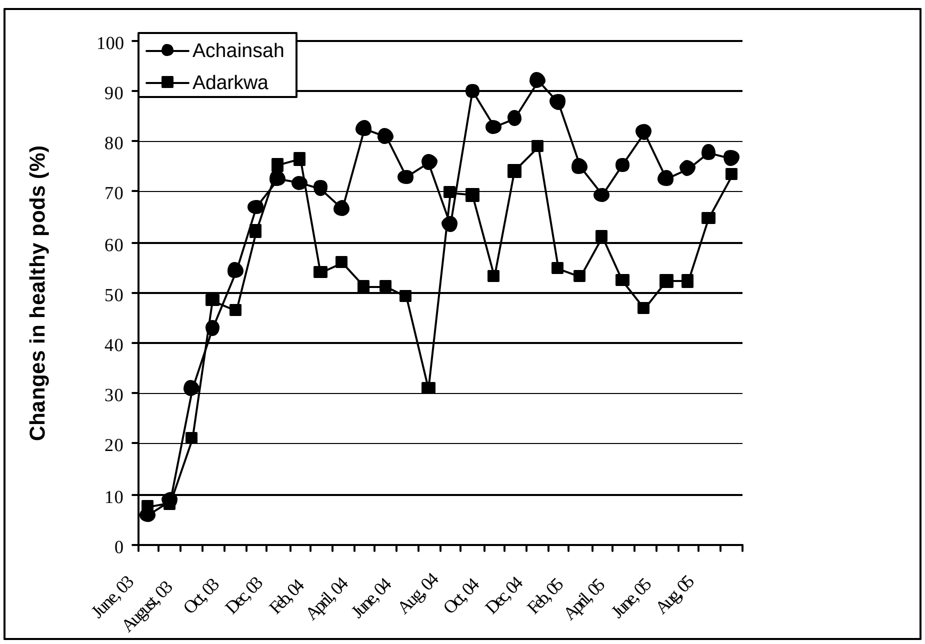

Figure 5.2: Average changes in healthy pods from June 2003 to September 2005 (from Dormon *et al*, 2006a)

Yield data were collected from the IPM plots and compared with yield from control plots which were the farmers' normal practice. However, farmers adopted part of the IPM package on the control plots, which we called farmer-adopted IPM (FA-IPM), and therefore new control plots had to be demarcated, and we called these farmer-practice (FP) plots. The yield increase in Achiansah showed better results than that in Adarkwa (Figure 5.3). Whilst there were significant differences ($p < 0.01$) in yields in both villages by the second year of implementation, in Achiansah the yields from IPM was triple that of the farmers' practice, while in Adarkwa it doubled. Also, whilst there was a significant difference ($p < 0.05$) in yield between farmer-adopted IPM and FP in Achiansah, this was not the case in Adarkwa.

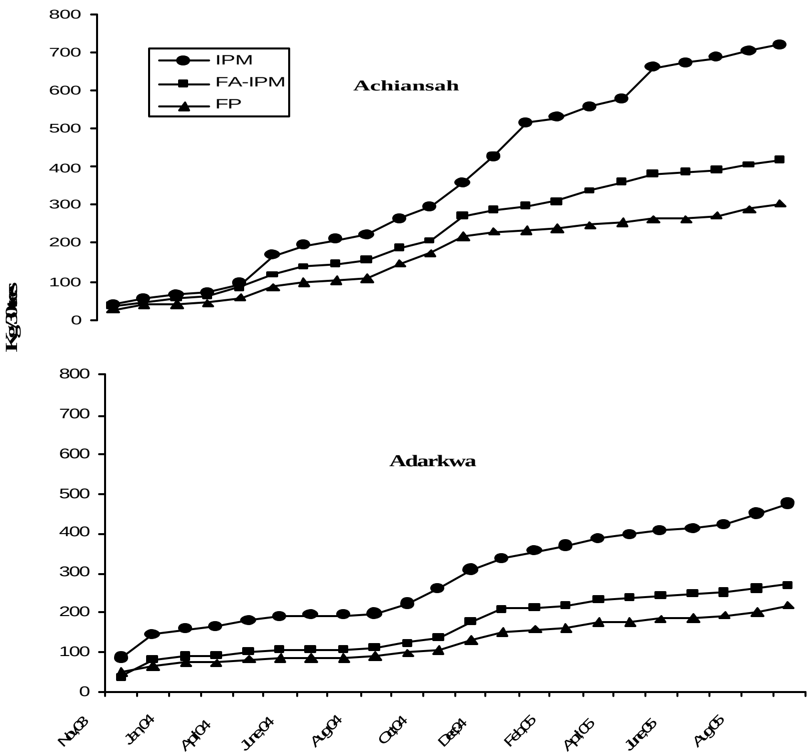

Figure 5.3: Cumulative mean yields from IPM practices and the controls in Achiansah and Adarkwa (from Dormon *et al*, 2006a)

At Ntumkun, only one experimental plot (30 x 30 m) was set up as a learning platform where the IPM technical package was implemented and farmers observed the changes in plant growth, flowering and pod formation, however, quantitative data were not taken.

Innovation-development phase

The innovation-development phase involved identifying strategies to re-design and overcome the constraints by looking for opportunities that enabled the farmers to combine the necessary 'hardware' (technical components like neem processing facilities), 'software' (mindsets and goals) and 'orgware' (social, organisational and economic elements) to realise a complete innovation (Dormon *et al.,* 2006b). The constraints identified include: lack of facilities for processing neem seeds; neem not available in the community; and the package being labour-intensive. To motivate farmers to collect the pod husks (which act as a source of inoculum of the blackpod disease being able to infect healthy pods) from the fields, soap-making was introduced as part of the innovation. Concerning the control of capsids using ANSE, a means to acquire the neem seeds regularly, and a way to procure the equipment to grind them had to be sought.

We identified a Farmer Based Organisation Development Fund (FBODF) as a source of potential support to develop a complete innovation. This Fund supports farmers' groups with innovative ideas about how to improve their productivity. To access resources from this Fund, a farmers' group must identify a constraint and innovative solutions and present it in the form of a project proposal to a district committee. The District Committee assesses the proposal on its feasibility and relevance to the wider community. If the committee approves the proposal, it is sent to a national secretariat for further action.

By the middle of 2005, the farmers in Achiansah had received a grant from the Fund and at the time of writing this paper, had acquired equipment, and also received training in various aspects of group development and entrepreneurial skills to implement their project. From the grant, the group bought equipment for processing the neem seeds and also for processing palm and palm kernel oil. They were using the cocoa pod husk together with the palm oil and kernel oil that they processed to make local soap (Dormon *et al*, 2006b). The nature of the complete innovation developed in Achiansah is presented in Figure 5.4.

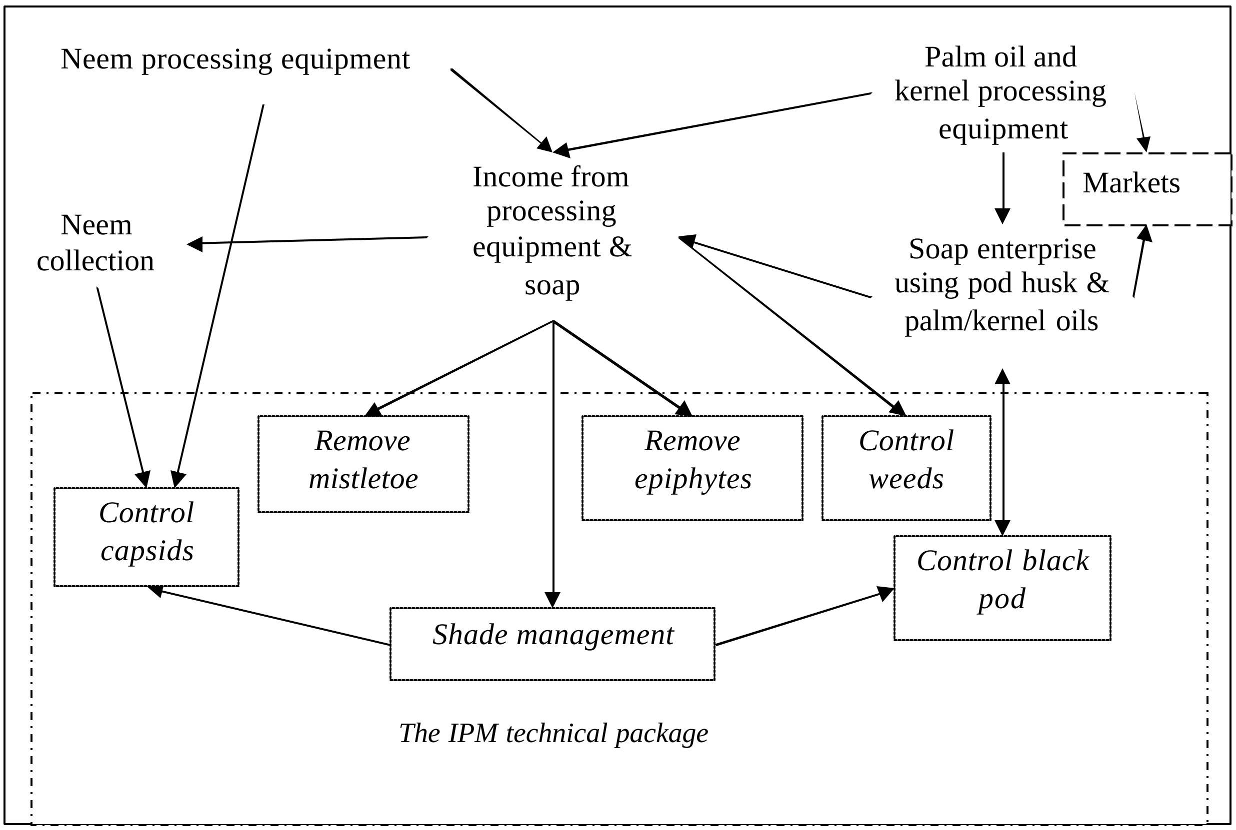

Figure 5.4: Overview of the social-organisational, economic and technical arrangements which formed the 'complete innovation' in Achiansah (from Dormon *et al*, 2006b)

In Adarkwa the processes involved and conditions for accessing grants from this Fund was discussed in January 2005. However, it was not until late in 2005 that the farmers were able to organise themselves adequately to prepare a proposal. It is too early to say how their project will go.

The process in Ntumkun was short and quick. The farmers learnt the impact of the technical package as well as the constraints from the other two villages. At the time of completing the field work in December 2005, the Ntumkum group, like the Achiansah one, had already designed an innovation similar to the Achiansah one and also secured a grant to put this in practice. Their 'complete innovation' is similar to the one described in Figure 5.4 except that they replaced soap making with the rearing of the Grasscutter *Thryonomys swinderianus* (an edible rodent) and edible snails.

The outcomes of various phases of the innovation process in the three villages are summarised in Table 5.1.

Table 5.1: Summary of the outcomes as at December 2005

Phase	Village		
	Adarkwa	Achiansah	Ntumkum
Diagnostic	Focus on social not biological factors	Focus was on biological factors	No diagnostic phase
Experimentation	? Low level of participation by farmers ? Slow learning ? Ineffective implementation ? Yield doubled but with external labour support	? High level of participation by farmers ? Fast and effective learning ? Effective implementation ? Yields tripled without external labour	? Experimentation was limited to one plot and lasted for only six months ? The farmers learnt about success and failure factors from the experiences in the other two villages ? Effective participation and learning
Innovation development	Incomplete as at December 2005	Completed by end of 2005	Almost completed by end of 2005

5.3 Research methodology

The differences observed in the villages were not anticipated from the beginning, but gradually became apparent in the course of the action research. As a consequence, we did not beforehand have a well elaborated theoretical framework and methodological apparatus for studying the processes as they took place. In order to be able to explain the differences between the various processes in retrospect, we pursued several strategies. First, a survey was carried out between September and October 2005 in order to get more reliable information on a number of demographic variables (e.g. age, education levels, etc.) as well as on farm characteristics (e.g. farm size, tenancy arrangement, etc.) that might bear relevance to understanding the differences. Respondents were selected both purposively (these were farmers who took part directly in the experimentation) and randomly (farmers who did not take part directly). Four farmers in Achiansah, and four in Adarkwa, who took part directly in experimentation with the IPM package were interviewed. The number of farmers randomly selected form the three villages was 140, therefore in total, 148 farmers were interviewed. First, house numbers were randomly selected and everyone living in the house and was involved in cocoa production was interviewed with a maximum target of 50 farmers in each village. The data were analysed using the Statistical Programme for Social Sciences (SPSS) for Windows, Version 12.

As a second strategy, we identified several theoretical notions from development and innovation literature that might be relevant to explaining differences at process level. These notions were used as sensitising concepts in analysing the experiences in the three villages. These experiences had been documented in the form of field-notes and research diaries, which were based on various sources of information. As an inherent component of action research, participant observation was an important source of information (Denzin & Lincoln, 2003; Silverman, 2001). In addition, informal discussions were held with individuals and/or groups after field work, sometimes over a drink, with the purpose of clarifying issues that were raised during the period of working on the farms.

During the action research, all observations, progress of implementation and results on various plots were discussed every three months at district meetings where other stakeholders, namely; CSD, MoFA, LBCs, QCD, and the District Assembly (DA) were present. This allowed for triangulation and provided further clarification on observations made in the field and hence added to the validity of our interpretations (Silverman, 2001). All information collected in this manner was re-analyzed and reflected upon ex-post in view of the sensitizing concepts identified.

5.4 Sensitising concepts for explaining process dynamics and outcomes

Building upon literature on agricultural development and innovation, three broad categories of variables were identified as possibly relevant to explaining differential innovation process dynamics and outcomes. These sensitising concepts are in line with the conceptualisation of innovation outlined in section 2. In this regard, we distinguish (i) motivational factors; (ii) social capital; and (iii) nature and quality of learning and facilitation.

5.4.1 Motivational factors

As outlined in section 2, innovation can be seen as a collective achievement based on complementary action in a network of stakeholders. Important social processes in arriving at complementary action include the building of new social networks (Callon, 1986), overcoming conflicting interests, and individual as well as social learning (Leeuwis & Van den Ban, 2004). The latter form of learning involves the process of developing overlapping - or at least complementary - goals, insights, interests and starting-points (Woodhill & Röling, 1998; Röling, 2002) as a basis for 'congruent' action (Grin & van de Graaf, 1996). For individuals or groups of people to engage seriously in such learning, they must be motivated to do so. Some factors that could motivate the engagement in learning include the relative importance of experienced problems and the urgency for finding a solution. People learn when they experience a problem, and depending on the 'priority' of their aspirations and perceived 'magnitude' of a tension between their desired state of affairs and the current situation, they may define a problem as relatively important and serious, or not (Leeuwis & van den Ban, 2004). Also, when people have confidence in the possibility to solve a problem, they are better motivated to engage in learning and they will most likely select the more serious problems that they see as urgent rather than those that can be postponed (Leeuwis & van den Ban, 2004). Another factor that may influence motivation to engage in a learning and negotiation process with others relates to feelings of interdependence (Fisher & Ury, 1981). Willingness to engage in social learning may be reduced if the actors do not feel mutually interdependent on each other for solving a problematic situation. Moreover, learning usually takes place in a social environment in which new ideas may or may not be appreciated. When actors feel the social space for new ideas is limited, learning is likely to be discouraged.

5.4.2 Social capital

When innovations are viewed as emergent properties of a 'soft system' through interactions within networks, the nature of such interactions may influence the innovation processes. Therefore, the concept of social capital could provide some insights into how such interactions influence innovation processes. Social capital comprises relationships of norms and trust embodied in social organisations, horizontal and vertical partnerships between institutions, and human capital comprising leadership, ingenuity, management skills and capacity to innovate (Coleman, 1988; Pretty *et al.*, 2003; Putnam, 1993; Woolcock, 1998). It is difficult to make a clear distinction between human and social capital (Tripp, 2006); whilst human capital resides in individuals, social capital is an indication of relationships in communities rather than a resource of individuals (Putnam, 1993; Woolcock, 2002). Examples of human capital include information acquired through formal education and personal ingenuity, however, information derived from links with other farmers (or community members) in a social network is an example of social capital. Social capital can be distinguished as 'structural' or 'cognitive' forms (Grooteart & van Bastelaer, 2002). Structural forms of social capital include networks of groups and organisations within a defined community whilst trust and norms are examples of cognitive forms (Coleman, 1988; Grooteart & van Bastelaer, 2002; Putnam, 1993). Norms define actions that are considered acceptable or unacceptable whilst trust is an 'emergent property' of a social system (Lyon, 2000), and people may be trusting because of the social norms and networks within which their actions are embedded (Putnam, 1993).

Technologies that rely on low external inputs are usually labour and information intensive and can benefit from strong social relations within a community where farmers are organised to learn new production techniques and strategies (Tripp, 2006). Sharing information is important for low external input technologies because it relies on local resources and therefore needs particular knowledge, skills and organisation (Tripp, 2006). Some factors that affect the flow of agricultural information in some communities include the willingness of farmers to share results of their experiments, whilst interest in other people's fields may be subject to social restrictions because of spiritual beliefs like witchcraft (Sumberg & Okali, 1997).

The concept of social capital is useful in explaining interactions and cooperation (or non cooperation) in a community regarding activities in developing innovations, however, indicators of social capital are largely surrogate and indirect (Bebbington, 1999), and one has to be cautious when using it in examining agricultural development (Tripp, 2006). In this study, certain elements of social capital are considered in analysing the innovation process and its outcomes. These include the characteristics of farmers' 'groups' (group heterogeneity and cohesion, trust, and leadership) and the mobilisation of networks during the innovation process.

5.4.3 Nature and quality of learning and facilitation

The change from the regular research recommendation of pest management for cocoa (using a calendar-based spraying regime of synthetic pesticides) to an integrated pest management approach (using neem on need basis and cultural practices) is an innovation that could re-direct cocoa production to a more 'ecologically sound' path. This kind of shift requires a complex learning process which can take a number of years (Röling & Jiggins, 1998). Farmer experimentation is also a catalyser for innovation by playing a central role in the learning process

(Hagman & Chuma, 2002; Defoer, 2002). Somers (1998) argues that for farmers to improve their knowledge through experimentation, the quality of the learning process is important.

Innovations can be categorised into regular and system innovations (Abernathy & Clark, 1985; Geels, 2002a; Kemp *et al.*, 2001; Leeuwis & van den Ban, 2004) and the types of learning that are required for each category differ. Regular innovations do not challenge the main technological and social-organisational characteristic of the farming system, therefore, single loop learning, which typically involves learning to do the same things better within the basic cognitive assumptions and principles that underlie current practices (Argyris & Schön, 1996) may be adequate. Systems innovations, however, require and incorporate a fundamental reorganisation of social relationships, technical principles and rules (Abernathy & Clark, 1985; Geels, 2002a, 2002b) and hence go beyond doing the same things better. Such innovations require a reconsideration of the principles and basic assumptions underlying existing practices, seeking new ways of doing things, and consequently, 'double loop learning' (Argyris & Schön, 1996).

The nature and quality of learning (what was learnt and how, individual and group learning, social learning, interpretation of technical results, willingness to try out new ideas) could help to explain the differential outcomes. The occurrence of learning, in turn, can be influenced by facilitation efforts. Facilitation is the deliberate use of communicative strategies and methods to enhance social learning and negotiation in a multi-stakeholder setting (Leeuwis & van den Ban, 2004). Facilitation involves a number of activities geared towards creating 'platforms' that provide insights, explicate tacit knowledge, manage conflict, create productive group dynamics, and bring about coordinated action (Leeuwis & van den Ban, 2004). Effective facilitation of experiential learning by farmers requires adequate participatory and group approaches in extension (Röling & van der Fliert, 1994; Percy, 2005), whereas, according to Hagman & Chuma (2002), good facilitation skills are more important than participatory tools or learning aids.

5.5 Results: observations regarding the innovation process in the three villages

The survey carried out in the research area between September and October 2005 did not reveal many differences between the villages that could be meaningfully interpreted to explain the differential outcomes. No significant differences (at $p < 0.05$ using a chi square test) were found between farmers in the three villages regarding their level of education, age, farm size and prevailing tenancy arrangements. Two significant ($p < 0.01$ using a Chi square test) differences were found: Adarkwa and Ntumkum have relatively older farms compared with Achiansah (Table 5.2); and there are more land owners in Adarkwa (52% of respondents) than in Achiansah (32%) and Ntumkum (25%).

Table 5.2: Data are indicated in percentages of the total number of respondents (n=148).

Village	Age of farms (years)					?^{2}	df	P
	< 10	11-20	21-30	31-40	> 40			
Achiansah (n=46)	28%	41%	22%	2%	7%	38	8	,000
Ntumkum(n=47)	6%	15%	13%	47%	19%			
Adarkwa(n=40)	15%	15%	15%	33%	23%			

The fact that farms (i.e. cocoa trees) in Achiansah tend to be younger than elsewhere could, in principle, help to explain why technical results in Achiansah were better than in Adarkwa since younger trees might have a better production potential and greater resilience than older trees. However, even if this were true, it would only be part of the explanation. In Ntumkum (where no technical measurements were taken) the innovation process was much faster than in Adarkwa although farm ages are similar. Concerning land tenure, it is difficult to understand how greater landownership in Adarkwa might have negatively affected the innovation process; other studies suggest that landownership and/or land security would stimulate rather than be an obstacle to innovation (Adjei-Nsiah *et al.*, 2004; 2006). In all, the survey results did not lead to satisfactory explanations of the observed differences. Hence, in this section we describe in more detail some critical events regarding the innovation trajectories in the three villages.

5.5.1 The process in Achiansah

In Achiansah, there were farmers' groups in the village and the Victory Farmers' Group, which had been working with the extension agent in the village since 2000, was selected as collaborators in this action research. The members of the group belonged to the same church and the majority (about 80 %) were from the same ethnic group. The Pastor of the local church was the chairman of the group; he commanded a lot of respect and used the church as a rallying point for members.

During the diagnostic phase, all group members were very active in the process of identifying problems and analysing the causes. The main problem relating to cocoa production was identified as low yields. During analysis of the causes, both socio-economic and biological factors were listed, however, the focus of their analysis was on the biological factors; incidence of pests and diseases, particularly blackpod, capsids, epiphytes and parasitic plants.

To control the pests and disease, the following solutions were agreed upon during the planning: control weeds three to four times a year, remove mistletoes and epiphytes, manage the level of shade to ensure optimum light conditions, remove blackpod-infested pods, and apply aqueous neem seed extracts on need-basis to control capsids. These practices constituted an integrated pest management package and this was implemented on seven experimental plots in four farms which served as learning platforms. Implementation of the IPM package on the plots and the learning process was facilitated by the first author, a research assistant and the extension agent working in the village. During a visit to a well managed farm the farmers used what they saw there as reference, and wanted to improve their farms to that standard. The IPM package resulted in a high reduction in pest and disease incidence and when the farmers observed that diseased pods were found mainly at the boundaries of the plots with adjoining fields and not in the middle, they became eager to implement the IPM package on the rest of the farms including the control plots.

There was a high level of participation in field activities by members of the group, including some on whose farms experimental plots were not established. On their own, the farmers on whose farms experimental plots were demarcated organised reciprocal labour arrangements to implement the IPM practices when they realised that it was labour-intensive and difficult to implement individually. During group work in the fields, farmers were observed to engage in extensive discussions and debates on a variety of issues, which led to considerable progress in learning with regard to both technical and social issues. The effective implementation of the IPM package did not result only in reduction of pest and disease damage but also yield was triple that of the controls.

At a point, some farmers in the community, who were not members of the group, saw the tagged trees and the high number of pods on them, they begun wondering if it was only the IPM package that was responsible for the change with some suspecting that the red bands had spiritual influence. However, when it was explained to them in church by the Pastor, that the results were entirely due to the IPM measures, they became more at ease and interested in learning about the practices. The farmers involved in the experiments were also willing to share their knowledge and experiences with others in the community and were made peer educators for about 40 farmers who expressed interest in learning about the IPM practices.

The farmers here were quick to identify constraints, brainstorm, and suggest solutions. For instance they realised that when the facilitators leave they will have difficulties in getting neem seeds to continue using the IPM package and therefore started planting some neem seedlings in their compounds. When they realised that it was possible, with a good proposal, to obtain funds to overcome the constraints to adopt the IPM package, they set out new goals and by the end of 2005 had developed a complete innovation. By this stage the group had become stronger and membership had also increased from 16 to 24 with more farmers expressing interest to join.

5.5.2 The process in Adarkwa

The whole action research on which this paper is based started in Adarkwa in September 2002. Right from the start, the farmers made reference to the Eastern Region Cocoa Project (ERCP) and hoped that our research would follow the same approach, that is, to provide inputs and labour to rehabilitate and maintain their farms. During implementation of ERCP, all inputs and labour was provided by the project and old trees on cocoa farms were cut and replaced with hybrid varieties, maintained for at least three years and handed over to the owners when the trees had started bearing. The costs incurred were later deducted by instalments from the sale of cocoa to the Produce Buying Company (PBC), which at the time was the sole agency, mandated to buy the crop from farmers.

Since there was no farmers' group in the village, all cocoa farmers were invited to participate in the diagnostic phase, which involved problem identification and analysis of the causes. The farmers identified low yields as the main problem they face with cocoa production. In prioritising the causes of low yields, the socio-economic factors were considered more important than the biological ones. They ranked low producer prices paid to farmers as the most important cause of low yields followed by the lack of electricity. Whilst the former affects farmers' earnings directly and their ability and/or willingness to invest in maintaining their cocoa farms, the latter leads to out-migration of the youth from the village to the cities thereby creating labour shortages and high costs of labour. This affects cocoa production because all the crop management practices like weeding, removal of mistletoes and other cultural practices required for proper plant health and improved yields depend on manual labour.

During the planning stage, the Chief of the village expressed his views on how to overcome the problem of low yields when the farmers were asked to suggest solutions based on the analysis of the causes identified. He said "*we know the problem of low yields and we also know what to do, we simply do not have the means to do it, the best solution is for you or the extension service to work in the same way as the cocoa project*". Generally the farmers agreed with the chief's statements and complemented it with their own opinions that since the cocoa project ended in 1979 there have not been any meaningful extension service. The farmers had little trust that government officials are interested or willing to solve their problems, and saw the LBCs in particular as cheats.

After it was explained that this research was not in a position to follow the example of the ERCP, we proceeded to identify strategies to overcome the causes of low yields . In the case of the producer price, we were fortunate because it was increased by almost 50 % at the same time we were discussing the causes. With electricity, we considered many options but settled on organising a fund raising program as the community's show of self-help and as a way of influencing the District Assembly to support the project. This is in line with a government policy to extend electricity to communities who are able to raise money to cover the cost of the electricity poles. The Member of Parliament and District Chief Executive, among other government officials were to be invited to this fund raising program. A committee was therefore set up to plan the event. Unfortunately, the chief of the village died before this event could be organised and the customs and traditions of the area did not permit such gatherings until all customary rights had been completed and a new chief had been installed.

To address labour constraints, we discussed the possibility of organising reciprocal labour but most farmers were not interested because according to them, such arrangements in the past did not work because some people were not honest and failed to work on others' farms after work was done on theirs. Much later, we found out that group labour was also complicated by strong beliefs in super natural forces which made some farmers extremely hesitant to work on specific farms whilst some farmers did not like particular individuals coming to their farms.

To overcome the effect of pests and disease on yields, farmers agreed on the following solutions: control weed three to four times in a year, remove mistletoes, adequate management of shade, and remove blackpod-infested pods. However, the control of capsids was to be left to government's mass spraying exercise. Later, we decided to experiment with ANSE on need-basis instead of relying on the mass spraying program. The use of ANSE and the cultural practices listed constituted an integrated pest management package which we implemented on eight experimental plots in four farms that were to serve as learning platforms for all farmers. Implementation of the IPM package on the plots and the learning process was facilitated by the first author, a research assistant and the extension agent working in the village.

For the farmers to learn the principles of IPM and observe results, the facilitators suggested to the four farmers on whose farms experimental plots were established, to work as a team on each plot and every farmer in the village was encouraged to join them in this learning exercise. However, the four farmers preferred to work as individuals on their farms rather than in a group in spite of efforts to get them to work as a group. Another effort was made to get other farmers involved. To do this, a meeting was organised with all the farmers in the community and each farmer was given the opportunity to choose one of the farms with experimental plots as their learning platform and a timetable for harvesting pods was discussed to enable them to plan and be present at least during the harvesting. It is during harvesting that observations on changes in pests and disease levels, both on the plots and adjacent fields, were discussed. Out of 26 farmers who attended this meeting, four were farmers on whose farms plots were demarcated, twenty chose one farm on which they preferred to work and two did not opt for any farm. A minimum of three and maximum of seven people opted to work on particular farms. However, only few (less than 30 %) of the farmers occasionally joined the activities that were planned and the rest never participated.

Yields increased significantly only on IPM plots where the research team relied on some amount of hired labour to supplement the individual farmers' labour to implement the IPM package. One of the farmers involved in the experiments extended the practices to parts of his farm and had relatively good yields. With the income from his cocoa sales in 2004, he re-roofed his house. Other farmers in the community became curious about how productive his farm had become to support such investment and began to show some interest in learning about the IPM practices.

Although the farmers in this village recognised the constraints (labour-intensive, unavailability of neem in the village and facilities for processing neem) to adopting the IPM package, they did not take any action to overcome them. The innovation-development phase began only after they realised that the farmers in Achiansah had designed strategies to overcome the constraints and received a grant to purchase equipment for processing neem and also start other economic activities. They realised at this point that their individualistic way of working was leading nowhere and started discussing the need for collaboration. They started coming together and within three months formed a group with 22 members. In order to strengthen the group, the District Cooperative Officer was invited to take the group through various aspects of group development and management: to prepare a constitution and bye-laws; how to manage group funds; effective leadership; conflict management, among others. Eight of the farmers in the new group formed a reciprocal labour sub-group to help each other to implement the IPM technical package on their farms.

Learning seemed to improve with better organisation, more collaboration, joint activities, and exchange of ideas. The farmers seemed to have discovered the need for urgent action through collaboration amongst themselves and sought advice from the Achiansah farmers and with the assistance of the extension agent and the Cooperative Officer, they prepared a proposal with a plan of how to overcome the constraints relating to the IPM package. Although they designed a 'complete innovation' at this point, it is too early to say how successful they will be with its implementation. Even though a group was formed eventually, effective leadership and self-directedness remained weak in Adarkwa. Every stage of the innovation development process had to be facilitated by outsiders and the facilitators had a more difficult task compared with the other two villages.

5.5.3 The process in Ntumkum

At Ntumkum, there was a well organised farmers' group that had already existed for about 10 years and they made the request for an extension of the program to their village. The process here was therefore different from the other two villages. The innovation process was shortened with no diagnostic phase. The experimentation phase was also limited to six months using one demonstration plot which served as a platform for learning and understanding the IPM principles. The farmers participated in meetings where results of the experiments, constraints and strategies to overcome them had been discussed with farmers from the other two villages together with other stakeholders. A field visit was also organised for them to observe the outcomes in Adarkwa and Achiansah. This visit was also used as an opportunity to compare their own observations on their demonstration plot with the participating farmers in the two villages.

From what they learnt from the other two villages, they quickly organised their own reciprocal labour arrangement to implement the technical package after the demonstration plot was established. Within six months they were already designing strategies to overcome the constraints to sustainable adoption of the IPM technical package. They re-packaged the innovation from Achiansah following the same principles but modified some elements; for instance, instead of making soap with the pod husk, they preferred to rear snails and grasscutters to provide additional source of income to support investment in cocoa production.

5.6 Comparative analysis and discussions

In this section, we examine the three innovation trajectories against the background of the sensitising concepts that could help to explain differences in process dynamics and outcomes. In doing so, we point to several relationships between motivational factors, social capital and the nature and quality of learning and facilitation.

5.6.1 Motivational factors and learning

An important difference between causes of low yield identified by farmers in the three villages is the focus by the Achiansah and Ntumkum farmers on biological causes, while in Adarkwa they emphasized socio-economic factors. This raised different expectations from this action research. The different expectations seemed to have influenced their motivation to learn and implement the IPM package.

The farmers in Adarkwa expected this project to solve their infrastructural problems (as evidenced from the priorities identified in the diagnostic phase) hence they were less motivated to learn and tackle the biological factors and this subsequently affected the effectiveness of implementation of the IPM practices. The learning process and quality in Adarkwa was inferior to what occurred in both Achiansah and Ntumkum mainly because it did not directly address their priority needs and problem perceptions. Whilst the proposed strategy to tackle the electricity problem had stalled, there seemed to be no sense of urgency to solve the problem of low yields through IPM. Consequently, there was not much interest in the IPM activity and hence no joint action and little exchange of experiences, knowledge, and ideas. The Adarkwa farmers, however, gained some motivation to organise themselves after they were confronted with the results and benefits that the other two villages were deriving from being organised. In a sense, they felt more confident about the possibility to achieve good results by learning from the experiences of the other two villages, and this eventually influenced their motivation to act.

In Achiansah, the farmers prioritised biological causes instead of the social factors from the outset, which meant that they felt a greater urgency to deal with them. This was reflected in the enthusiasm with which they worked as a team to implement the IPM package and actively sought solutions to constraints that they encountered. The use of reciprocal labour, for example, greatly enhanced the effectiveness with which they implemented the IPM package. The Ntumkum farmers also joined the program with the objective of improving their yields through the IPM package. The expectations of farmers in these two villages were the focus of the action research and the farmers were therefore better motivated to learn and implement them than those in Adarkwa.

In Achiansah and Ntumkum, unlike Adarkwa, there was a sense of urgency to improve yields through the IPM practices and the farmers in these groups also realised that the IPM package was feasible only if they could overcome constraints like neem processing and access to other production resources such as labour and adequate capital. The innovation process was particularly quick in Ntumkum as the group of farmers was not only aware of the nature of the problem, but also had the benefit of seeing proposed solutions work elsewhere. Although they knew that there were constraints to adopting this package, they also knew that the constraints could be overcome, having learnt from the Achiansah farmers. They were therefore confident about the prospects of successfully adopting the package.

5.6.2 Influence of social capital on learning and innovation

In Achiansah and Ntumkum, the cohesiveness of the existing groups made it easy for them to participate effectively in experimentation and development of the innovation. The groups in these two villages both had good leadership and the dynamics within them were conducive for effective participation in group work. Such group activities typically went along with a lot of informal talking, exchange of information and ideas as well as sharing of knowledge and experience. This facilitated learning and the arrival at shared understandings and objectives. One of the constraints to adopt the IPM package by farmers was that it is labour-intensive. In Achiansah, the early realisation of this constraint and the willingness of the farmers to use reciprocal labour made them overcome this constraint. This can be attributed to the strong social relations within the farmers' group and willingness to collaborate. Their willingness to collaborate can be partly attributed to considerable levels of trust within the group. The situation in Ntumkum was similar to Achiansah. The willingness of the Ntumkum farmers to collaborate and work as a group, the trust among the farmers, and effective leadership made them overcome the constraints within a short time. In contrast, the farmers in Adarkwa, preferred to work individually because there was little trust amongst them and hence attempts to organise reciprocal labour was not successful in the first two years. The lack of trust seemed to result mainly from past experiences with other joint activities, where some members of the community were seen to have acted in a dishonest manner, as well as superstition.

There was strong leadership in the two groups at Achiansah and Ntumkum and this may partly account for their ability to take initiatives to maintain trust and also explore solutions to constraints they encountered. In Achiansah for example, when non-participating farmers raised questions about the 'magic' role of red ribbons in improving yields on tagged trees, the Pastor immediately intervened with an explanation. Similarly, in Ntumkum the leaders of the farmers' group made the request for their members to be trained in IPM practices and also took initiatives to seek assistance from the Achiansah farmers and the extension agent to design their own 'complete innovation'.

In the absence of a farmers' group in Adarkwa, there was little collaboration among the farmers and it took more than two years for them to begin organising themselves to work as a group. During most of the research there was no clear leadership and the farmers hardly took initiatives. With the Adarkwa farmers, feelings of interdependence were lacking and there was little collaboration and exchange of information and ideas. The group emerged slowly after they realised that they would not be able to implement the IPM package effectively without collaboration and support from each other. This was especially so, when they realised that within a very short time the Ntumkum group had understood the IPM principles, had identified the constraints to implementation, and had prepared strategies to overcome them.

5.6.3 Relationship between facilitation, learning and innovation.

In developing the IPM innovation in this study, double loop learning was required because the farmers had to explore options for improving cocoa yields by learning the basic principles of reducing pest and disease incidence using low external inputs. Such strategies are based on fundamentally different principles than the existing pest and disease management technologies recommended by research, which are prescriptions relying mostly on external inputs. Although the general character and principles of the innovation development process in the three villages were similar, on hindsight, a number of distinguishing features can be identified in the facilitation that could have influenced the learning process in the different villages. For instance, facilitation of the innovation process was slowed down in Adarkwa in the second year because the facilitators felt that the farmers there were not adequately organised to manage a complete innovation and this could have affected the rate of learning.

In both Achiansah and Adarkwa, there was single loop learning at the beginning of the experimentation phase. However, by the second year the farmers in Achiansah moved on to double loop learning, e.g. by coming to grips with reciprocal forms of labour organisation and the working towards new supportive economic activities in response to constraints encountered. In contrast, the Adarkwa farmers remained unable to deal effectively with such issues, and the facilitators were unable to hasten the pace at which they moved to double loop. At Ntumkum, facilitation was easy and effective because of the farmers' eagerness to learn and overcome constraints within a short time. The Ntumkum farmers moved very quickly to double loop learning probably because the facilitators were influenced by their enthusiasm to succeed and therefore put in a lot of effort in supporting them.

In Achiansah, the farmers were always taking initiatives and because they worked as a group, there were lively discussions during field activities and the farmers were also willing to extend their knowledge to other members of the community, and hence, from the second year, more time was devoted to facilitating the process there. Although the facilitators focused a lot of attention in Achiansah and Ntumkum in 2005, this was driven, to some extent, by the farmers' interest and willingness to learn and implement the IPM and also their desire to overcome the constraints associated with its adoption. In that sense, the facilitation was influenced by the farmers' motivation and willingness to learn and this in turn influenced learning, the innovation process and its outcomes.

5.7 Conclusion

Our findings suggest that the three sensitising concepts used in analysing the case studies in this paper are inter-related in the way they influence innovation development. Figure 5.5 represents our hypothesis with regard to these inter-relationships.

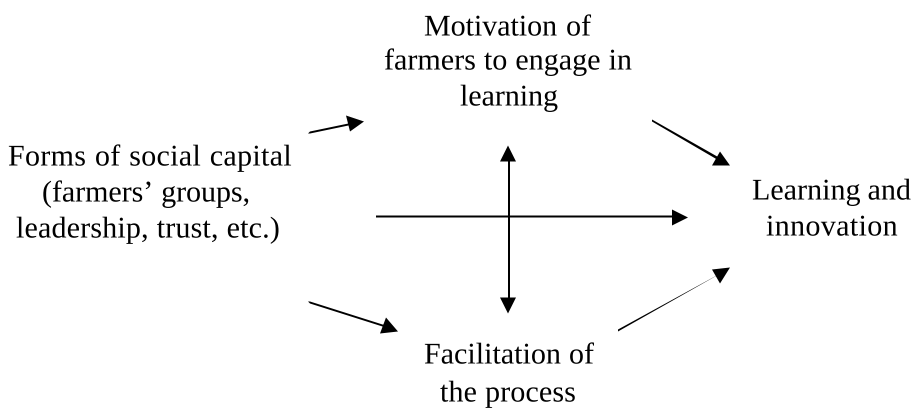

Figure 5.5: Hypothesised inter-relationship between social capital, motivation, and facilitation in influencing learning and innovation development (all influences are in a positive direction)

The effective organisation of farmers' groups, which is a form of social capital, can be seen as the driving force for other factors that influences a participatory innovation development process and their outcomes. When farmers are organised as a group, they participate more effectively in experimentation and this enhances the quality of experiential learning required to innovate. Farmers with effective organisational capacity and good leadership are also better placed to influence their communities to engage in network building and overcome situations of tension and conflict. Such organisational capacity also makes farmers more confident to take up the challenge to develop innovations, and quickens the process of building the necessary networks for innovation.

In any agricultural intervention program, it is important to work on farmers' priority problems. Farmers are then better motivated to participate in experimentation aimed at solving such problems. However, priority problems may sometimes fall outside the mandate of certain organizations, such as agricultural research or a particular agency. However, ignoring such priorities may lead to perceptions by farmers that external intervention programs are not interested in providing 'meaningful support'. This leads to lack of interest and motivation of the target group to collaborate and/or cooperate. Such low interest and cooperation from a community, in turn, affects the effectiveness with which a team can facilitate any change process in such circumstances. This raises questions about what to do in such circumstances. Our view is that, a creative link must be found between the community's interest and an external agent's mandate so that the latter can assist in solving the community or farmers' priority problems. However, where such links cannot be found, it will be better to work mainly in areas where an agency's mandate can address the priority problems of farmers or communities. At the same time, there is a clear need for enhancing mechanisms and opportunities for inter-sectoral co-operation. Even if 'lack of electricity' may be formally outside the scope and mandate of agricultural research and extension, it certainly does have major implications for agriculture. When confronted with such issues, therefore, agricultural officers would benefit from having access routes to colleagues who can act in other sectors, instead of simply ignoring the issue.

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Chapter Six
The need for a national innovation system for the cocoa sector in Ghana

6.1 Introduction

This chapter tries to capture the main lessons learnt from this research and place them in the wider institutional context in Ghana. The overall objectives of this thesis are to: (i) explore alternative pest and disease management strategies that refrain as much as possible from the use of synthetic pesticides for cocoa production; (ii) explore alternative approaches to research and extension which can facilitate the development of innovations that can be used widely by farmers, and (iii) to explore how such approaches can be institutionalised. The approach used in this research is in response to the low adoption of research recommendations for cocoa production in Ghana. Because awareness of research recommendations for cocoa production among farmers is generally high (Humado, 1999) and adoption levels low (Gerken et al, 2001), this could imply that either research recommendations did not address farmers' needs, do not suit farmers' socio-economic circumstances, or that the extension system is not effective. To overcome these problems, the approach adopted in this action research did not only involve farmers in identifying and analysing problems they face with cocoa production and suggesting solutions, but also combined the research and the extension functions in an interactive participatory manner.

We conducted a diagnostic study in which farmers in the research area identified low yields as the main problem facing cocoa production (Dormon *et al,* 2004). Then we tried to find suitable solutions by tackling the factors contributing to the problem. In chapter three, it was shown that an integrated pest management approach, using aqueous neem seed extracts on need basis to control capsids, together with a number of cultural practices particularly to control blackpod disease, can triple yields when implemented effectively. The technology proposed is less harmful to human health and the environment than the use of synthetic insecticides and fungicides applied on a calendar base. Besides being less harmful, it is an economically feasible option. However, there are a number of constraints that makes it difficult, if not impossible, for farmers to adopt the IPM package. The constraints were, on the one hand, the labour-intensive nature of the technologies, and, on the other, the unavailability of neem in the community. As shown in chapter four, however, these constraints can be overcome by developing a complete innovation which combines 'hardware' (neem processing), 'software' (changed mindsets and goals), and 'orgware' (reciprocal labour; arranging for the collection and transportation of neem, etc).

In chapter five, we explain that the success of developing complete innovations in collaboration with farmers depends largely on the farmers' ability to organise themselves effectively. The whole innovation development process, from problem identification, experimentation, and alignment of the technical and social components, require collective learning and network building with other actors. However, the effectiveness of this approach depends on whether the problem being addressed is a priority of the community or the farmers who are targeted as end-users.

Overall, this research has shown that it is possible to develop innovations with farmers using an interactive process, however, a remaining challenge is to utilise the outcomes (the IPM innovation) and the approach on a wider scale. The objective of the current chapter, therefore, is to provide some thoughts and insights into what measures could be taken to institutionalise a research and extension system that can go beyond technology generation and transfer into one that can support farmers to develop innovations that meet their needs.

In section two of this chapter, the lessons learnt during this action research are presented, along with those on our (limited) experiences in scaling out innovations like the IPM package developed in this study. The section also argues for the need of scaling-up the research approach by institutionalizing the guiding principles into the existing research and extension system. Section three examines the prevailing research and extension system for the cocoa sector with the help of ideas and concepts derived from Agricultural Knowledge and Information Systems thinking. It does so on the basis of a survey carried out in the three research villages in late 2005 as well as on analysis of interviews with researchers, staff of the Ministry of Food and Agriculture (MoFA), the Ghana Cocoa Board (COCOBOD) and Licensed Buying Companies (LBCs). The fourth section advocates the need for a national innovation system that is well coordinated and involves all the relevant stakeholders to develop innovations that are suitable to the end-users. Section five draws conclusions and recommendations from this thesis.

6.2 Reflection on the approach, outcomes and challenges

In this section, a number of lessons from this research are drawn. They include lessons about the nature of innovations and the processes and conditions under which they can be developed. Insights on how the concept and principles of an innovation can be scaled out to other farmers within or in neighbouring communities from where they have been developed are also presented, along with conclusions on how to meet both farmers' objectives and the requirements for publishing results.

6.2.1 Need for continuous diagnosis

This action research was conducted in three phases: diagnostic study, experimentation, and innovation development. The diagnostic study provided an opportunity for the researchers to identify priorities for research together with farmers and other stakeholders. The initial idea of the diagnostic phase was to identify researchable problems that are relevant to farmers' conditions. However, during the experimentation phase it was realised that diagnosis has to be a continuous and flexible process as new information emerged and goals changed. A diagnostic study may identify problems which are very difficult for a researcher to solve, especially when they are of a social and infrastructural nature like the lack of electricity (Dormon *et al*, 2004). Nevertheless, it is an important first step in understanding the community and the nature of problems that farmers consider as priorities.

6.2.2 Need to work on all the elements of an innovation simultaneously

Although technologies that improve crop yields in a profitable manner may be developed by researchers, these may only represent the hardware component of an innovation. Our research shows that lack of social-organisational arrangements and capital (or credit) will constrain the adoption of otherwise promising technologies. To make them useful and relevant to farmers, technologies must be aligned with social, economic and organisational arrangements that make them complete innovations. This implies opening up new social space for technological change, and not just the development of technology that is ‘appropriate’ under current social conditions. Our research also indicated that when farmers are better organised, they can much better enhance the process of developing complete innovations. We realise that to develop complete innovations, networks have to be built among various actors. However, support in these areas was largely missing in the research area. It seems that this is the case because actors in the research and extension system feel they do not have the mandate to venture into areas outside their core business, which they perceive as being technology development and transfer. In many ways this is a mindset problem based on outdated innovation theoretical insights, and not a reflection of a lack of real opportunities for collaboration. For instance, MoFA has established the Farmer Based Organization Development Fund (FBODF) that supports farmer innovation especially in areas that add value to their produce (through processing and marketing), and capacity building in the form of technical and entrepreneurial training. We assisted the farmers in this action research to take advantage of this facility to acquire equipment and receive training to develop and use a complete innovation. Many extension staff have however, failed to assist farmers’ groups to link technology and other socio-economic arrangements through this funding source.

6.2.3 Scaling out innovations

An IPM package should not remain an ‘island of good practice’, where only few farmers adopt it. Cocoa farms in Ghana are usually small (85% < 4 ha in the research area) and close to each other, and pests and diseases can easily spread from one farm to another. For instance, the capsid (*Distantiella theobroma*) can migrate more than 1 km (Leston, 1973) and blackpod disease spores can easily be dispersed by wind. Therefore, it is important that a whole community engage in IPM practices. Our experience in Ntumkum has shown that this is possible. The dissemination (or out-scaling) of the IPM innovation was quick and effective without having to go through the whole development process. However, it is important that farmers fully understand the nature of the problem and the ideas behind the various technical and social-organisational arrangements constituting the innovation. What should be scaled out is not only the package but also the concept, along with some process support. This could be done by bringing new groups to share in the experience of those who have gone through the whole innovation development process to learn and understand the success and failure factors, as well as the benefits. This was achieved this in Ntumkum by organising field trips for the farmers to visit Adarkwa and Achiansah to see for themselves the results of the IPM practices compared with controls.

6.2.4 Advantages of using a multi-disciplinary team

Because of the nature of innovations and the development process, both natural and social science insights were required. The CoS project (under which this research was conducted), adopted a multidisciplinary approach to research, and this was a guiding principle for the action research reported in this thesis. This requires a research team consisting of both natural and social scientists to ensure that both the technical and social-organisational elements of an innovation are worked on simultaneously in the innovation process. This also requires a relatively high level of education by the facilitation team. In this research, the facilitation team comprised a PhD researcher with social science and economics background, a research assistant with a masters' degree in entomology, and extension agents with an agricultural college certificate in two of the villages and one with a diploma in the third. The facilitation team was also supported by a multidisciplinary team of supervisors from the University of Ghana and Wageningen University.

One advantage of the multidisciplinary approach used in this research is that it enabled the successful integration of the research-extension-innovation development functions in a holistic manner. This required close collaboration between research, extension, farmers, and other stakeholders in an interactive process. This is not provided by a linear process of technology generation and dissemination and therefore, the present system of research and extension in Ghana would require transformations to take on similar tasks.

6.2.5 Challenges for academic research

As an academic exercise, this research faced a number of challenges that had to be overcome or taken into consideration. For instance, academic research requires scientific rigour: solid methodology, and accurate measurements, and for natural sciences, replicability is also important. In our study, this was difficult to attain as farmers' objectives are to get quick practical results. Although farmers do experiment, and are knowledgeable about many aspects of their farming operations, they often do not use control plots, and rarely involve formal measurement or multiple sites to satisfy statistical demands of replication (Okali *et al.,* 1994). Therefore, in this research, which involved experimental and control plots, the farmers were not interested in keeping the control plots as such, once they had seen the benefits of the IPM practices on the experimental plots. Farmers on whose farms we established control plots were particularly vulnerable because they were eager to benefit from the practices on the IPM plots rather than the control plot being used for comparison. On the one hand, this complicated an objective assessment of the real benefit of the IPM practices, but on the other, it proved that farmers were able to asses the benefits qualitatively. The farmers argued that once they were convinced of the effectiveness of the IPM practices they did not need any statistical proof. One way in which we could have addressed this issue would have been to pay them some compensation for lost revenue as a result of using part of their farm as a control. However, we solved this partially by demarcating new control plots on other farms. The IPM practices were carried out on 20 IPM plots, 20 changed into farmer-adopted IPM (FA-IPM) plots, and 20 were new control plots. Of the 60 plots, only 36 were eventually used in the analysis because in the 24 others, farmers intervened too much so the results were no longer reliable. From the experience in this research, it seems that this type of action research is appropriate in developing technologies and innovations that are both useful to farmers and the results are publishable as well, but precautions should be taken about how to deal with control plots.

6.2.6 Institutionalization of the research approach

An important principle in this research was that the end-product would be relevant and suitable to farmers' conditions and this was achieved, to some extent, on a small scale in the first two villages. In the third village the technology had to be slightly adapted to achieve this. The experience shows that with groups that recognise opportunities and relevance of an innovation, scaling out the principles and concepts behind the innovation to them can be quick and effective. For this to be done on a wider scale, however, the research approach that made this possible should be scaled-up (institutionalized) into the present research and extension system.

The major challenge is how this institutionalization could be achieved. An important aspect would be to include all the relevant stakeholders in the research process, and especially allow farmers to influence scientists' research agenda in line with the philosophy of 'democratizing science' (Funtowicz & Ravetz, 1993) instead of farmers remaining passive recipients of technology in a linear fashion. To introduce the research approach as an alternative to the linear model of research and extension currently in practice, farmers, extension workers, and other stakeholders must be involved as partners in research. The rest of this chapter will focus on assessing the current research and extension system, and reflecting on how it may be changed.

6.3 The need to look at the present research and extension system for the cocoa sector

From the lessons we have learnt in this research, we can conclude that to develop innovations that meet the needs of smallholder cocoa farmers, we need a continuous process of problem diagnosis, and work simultaneously on both the technical and social aspects of identified problems and their causes, as well as on existing opportunities. We have also seen that to achieve the kind of results obtained in this research, we need to look at research and extension as a continuum rather than as totally separate functions. Furthermore, we have learned that innovations can be scaled out to other farmers if we focus on the principles and idea behind them rather than on a predetermined package. What we have not been able to do in this research is attempt scaling up the approach used. Scaling up is necessary if similar innovations are to be developed by the national research and extension system.

To determine how this research approach could be scaled up, we first need to examine how the approach can fit into the prevailing research-extension system. To do this, we examine the technology generation and dissemination system for cocoa production using concepts from Agricultural Knowledge and Information System (AKIS) thinking. The objective of this examination is to identify weaknesses and opportunities in the present system as a basis for making recommendations on how it could be improved.

6.3.1 The concept of agricultural knowledge and information system

The concept of knowledge systems was originally developed by Nagel (1980) with inspiration from American Land Grant Colleges which brought agricultural research, education and extension together in one framework (Lionberger & Wong, 1983; Swanson & Claar, 1984; Leeuwis, 2004). This concept was developed further and operationalized by Röling & Engel (1991; 1992) who wrote about Agricultural Knowledge and Information Systems (AKIS). A major idea underlying this mode of thinking is, that – in order to improve the performance of research, extension and education - it is important to analyse and think about these entities and functions as being part of a (potential) system in which farmers and other sector parties are important actors as well. Under the influence of general soft systems thinkers (e.g. Checkland, 1981) Röling and others realised that the notion of AKIS might not only be useful for agriculture, but also for other 'human activity systems' (e.g. natural resource management, industry, etc.) which led them to speak of 'KIS' rather than AKIS. According to Röling a KIS can be defined as:

> "the articulated set of actors, networks and/or organizations, expected or managed to work synergically to support knowledge processes which improve the correspondence between knowledge and environment, and/or the control provided through technology use in a given domain of human activity" (Röling, 1992:48).

Along similar lines others speak of 'innovation systems' rather than KIS and AKIS (e.g. Hall, 2002, 2005; Smits & Kuhlmann, 2004).

The idea that organisations may work 'synergistically' stems from general systems thinking, and conveys the thought that a system as a whole has emergent properties that none of the parts has. Thus, an AKIS (or innovation system) would be able to achieve more in contributing to societal problem solving than a loose set of actors. According to AKIS and soft systems thinkers (Röling & Engel, 1990; Checkland, 1981) an important prerequisite of a well functioning system is that its members look at themselves as being part of 'a system' and have (or develop) shared meanings and interpretations about the problems that need to be addressed, the goals to be achieved as well as about the processes through which this may be pursued.

In an AKIS, agricultural research and extension are necessary, but by themselves, insufficient elements in the complex innovation-oriented institutional environment (Anderson, 1997; Berdegue & Escobar, 2001; Biggs, 1990; Biggs & Clay, 1981). It is therefore important to look beyond research and extension and identify other actors who contribute to knowledge generation and dissemination. The AKIS concept can be used to identify how various actors like scientist, extensionist, farmers, input suppliers, banks etc are linked in creating and sharing knowledge and information. It can also be used analytically to guide interventions to ensure that actors interact in ways that give rise to desired emergent properties such as innovations (Röling & Wagemakers, 1998).

To understand the system of technology and information flow for cocoa production, the kinds of interaction at the interface between technology generation and dissemination among various actors must be analysed. In the context of technology generation and/or dissemination, an interface is not simply a linkage mechanism but rather the 'force field' between two institutions (Röling, 1988). For similar reasons as Röling's, Long (1989, 2001) uses the term 'social interface' to avoid the image of two surfaces simply coming together. A social interface is defined as "critical points of intersection between different social fields, domains or 'lifeworlds', where social discontinuities based upon differences in values and social interest, are most likely to be found" (Long 2001:177).

In this chapter, we will limit our scope of analysis to the shared meanings, linkages and interactions at the interface between various actors, especially research, extension and farmers to understand how this is functioning.

6.3.2 Methodology

Our methodology for assessing the current system is inspired by the AKIS and innovation systems perspective. In view of time constraints we have not made a fully fledged analysis of the system, but rather focussed on getting a better view of existing linkages between sub-systems like research, extension, farmers, and some other important parties in the sector. We first examined the main features of what could be identified as the knowledge and information system for the cocoa sector with an emphasis on its recent history. To gain further insights and better understanding of how various actors perceive the functioning of the present 'cocoa knowledge and information system', we carried out an exploratory survey between September and October 2005. In this survey, we interviewed farmers in the three research villages; Achiansah, Adarkwa, and Ntumkum, as well as researchers from CRIG, District Directors of Agriculture (DDAs), Agricultural Extension Agents (AEAs), officials of Licensed Buying Companies (LBCs), and staff of COCOBOD.

Farmers

To assess farmers' perception of the research extension system, questionnaires were administered to 148 farmers in the three study villages. The respondents were selected both purposively (these were farmers who took part directly in the experimentation) and randomly (farmers who did not take part directly). Four farmers in Achiansah, and four in Adarkwa, who took part directly in experimentation with the IPM package were interviewed. The number of farmers randomly selected from the three villages was 140. First, house numbers were randomly selected and everyone living in the house and was involved in cocoa production was interviewed with a maximum target of 50 farmers in each village. There were both open-ended and closed questions. The questions were geared towards getting information about: the level of interaction with extension staff and researchers; awareness of research recommendations; main sources of information; adoption of recommendations; assessment of various aspects of the cocoa sector; view on the re-organisation of the research and extension system; government direct intervention through the mass-spraying and 'hi-tech' programmes; and their membership of farmers' organisations.

Researchers

Twenty questionnaires, with both closed and open-ended questions, were distributed to researchers at CRIG out of which 11 were filled and returned. The questions dealt with the strategy researchers follow in identifying problems, the stakeholders they involve in conducting research, and their links with extension workers and farmers. The questions centred around: the methods they use in identifying, analysing research problems, and carrying out research; their interaction with extension staff and farmers; assessment of the feedback mechanism in the present research-extension system and farmers; government direct intervention through the mass-spraying and the 'hi-tech' programmes; and their views on the re-organisation of the research and extension system.

District Directors of Agriculture

A similar questionnaire like the one for the researchers was administered to District Directors of Agriculture (DDAs) in the 11 highest cocoa producing districts of the Eastern Region. The questions focused on: their interaction with researchers; assessment of the feedback mechanism with researchers; views on the impact of the re-organisation of the research and extension system on technology dissemination and farmers' adoption; and government direct intervention through the mass-spraying and the 'hi-tech' programmes.

Agricultural Extension Agents

Sixteen Agricultural Extension Agents (AEAs) from the Suhum-Kraboa-Coalter District were interviewed. The questions tried to get information about: the methods they use in identifying and analysing farmers' problems; the frequency of their interaction with farmers; use of demonstrations as an extension method; assessment of the feedback mechanism with researchers; and their level of knowledge about cocoa.

COCOBOD staff

Eleven staff members of COCOBOD from the national and district levels were interviewed - five from the Quality Control Division (QCD) and six from the Cocoa Swollen Shoot Virus Disease Control (CSSVD) Unit. The questions focused on issues relating to: quality of cocoa beans; cheating by Purchasing Clerks (PCs) of LBCs; impression about the present linkages between the various actors in the cocoa sector; and government direct intervention through the mass-spraying and the 'hi-tech' programmes

Licensed Buying Companies

To gain insights from the LBCs, a total of 23 officials were interviewed from the national and district levels, as well as purchasing points. Six persons were interviewed at national level, five at the district and twelve PCs in the three villages. The questions were mainly open-ended and focused on issues relating to: quality of beans after the liberalization of the internal marketing; provision of extension service and any form of credit; and their impressions about government's direct intervention through the mass-spraying and the 'hi-tech' programmes.

6.3.3 Analysis of field data from survey and interviews

All the questionnaires contained both closed and open-ended questions. The closed questions and some of the open-ended ones were coded, entered into separate data sheets, and analysed using the Statistical Programme for Social Sciences (SPSS) for Windows, Version 12. Most of the answers to open ended questions were not analysed in the same way but, were sorted, coded and used to give meaning to the quantitative findings.

6.4 Important influences and recent history of the Cocoa sector

This section identifies a number of actors in the cocoa sector that are relevant from an AKIS perspective, and also provides some insight in policies and influences that have shaped the sector.

6.4.1 Re-organisation of the research and extension system in 2000

For many years, all aspects of cocoa production; (research, extension and marketing) were managed by various agencies operating under the Ghana Cocoa Board (COCOBOD) with ministerial oversight by the Ministry of Finance (MoF). The Cocoa Research Institute of Ghana (CRIG) is responsible for research into all aspects of cocoa production. Before 2000, CRIG's operational strategy was to identify problems of cocoa production through close collaboration with the Cocoa Services Division (CSD) and other related organisations, and undertake mainly applied and adaptive research and transfer the technologies generated through CSD to farmers (Anon. 1998).

The responsibility for cocoa extension, however, was shifted from the Cocoa Services Division to the Ministry of Food and Agriculture (MoFA) in 2000 as part of a new cocoa sector development strategy that also involved the liberalisation of the internal marketing of the produce. The objective of this transfer to MoFA was to ensure effective and efficient delivery of extension services to all farmers (Anon., 1999a). Consequently, after the re-organisation, cocoa research and extension are managed by different ministries – extension by MoFA and research by MoF. To ensure effective collaboration between research and extension, and to establish an effective feed back mechanism between farmers, research, and extension, the Cocoa Extension Merger Implementation Committee, which developed the modalities for transferring cocoa extension to MoFA, recommended that CRIG should become a member of the Research Extension-Farmer Liaison Committees (RELCs) (Anon., 1999b). However, from our observations in the research area, it does not appear that CRIG has become a member of the RELCs.

The RELCs were established jointly by the Directorate of Agricultural Extension Services (DAES) and the Council for Scientific and Industrial Research (CSIR) in 1994 to: bridge the gap between research, extension, farmers and agribusiness to make research and extension more demand-driven; encourage active participation; enhance interaction; and bring decision-making on technology development and dissemination closer to farmers and agribusiness (Anon., 2002). The merger committee also suggested that CRIG undertakes on-farm adaptive trials in collaboration with MoFA extension staff to ensure effective and efficient transfer of technology to cocoa farmers.

There is, however, a running debate between MoFA, COCOBOD and other stakeholders as to whether MoFA has been up to the task of carrying out cocoa extension effectively and efficiently and whether the links between research and extension has not been weakened by the re-organisation. Under the present system, CRIG is expected to link up directly with MoFA's extension service for the 'transfer' of research recommendations to farmers.

6.4.2 Liberalization of the internal marketing of cocoa

Until 1992 the Produce Buying Company (PBC) another agency under COCOBOD, purchased cocoa from farmers as the sole buying agency. From 1993 private Licensed Buying Companies (LBCs) were permitted to participate in a multiple buying regime as part of re-organisation of the cocoa sector. In 2004, 22 companies had obtained the required licence to operate. The objective is to introduce competition and improve the operational and financial performance of the internal marketing system. Although the government continues to set the producer price, it only serves as a *floor* price and LBCs can pay higher prices to farmers. The LBCs play an important role in ensuring quality by inspecting the beans brought in by farmers before purchasing.

6.4.3 Role of farmers' organisation

Self-help organisations in which individuals come together to pursue common goals can have a spill-over effect on the communities in which they are organised and help to motivate other members in the community to participate in activities of common interest through the pooling of resources (Anon., 1990). We have seen from this research that farmers' organisations can play an influential role in developing innovations. Although there had been a strong farmers' cooperative movement in the past, especially by cocoa farmers, this has virtually collapsed. The co-operative movement in Ghana evolved around cocoa when the Cocoa Growers Association was formed in Atasomanso, a village in the Ashanti Region, in 1922 with the objective of improving quality and assisting members to sell their produce at a good price through combined sale (Anon., 1990). Between 1922 and 1923, 36 fermentaries were established and all members of the Association fermented their beans there using boxes. Through collective action with the objective of producing quality beans, the cooperative movement spread to other cocoa producing areas in the Eastern Region and by 1934, there were a total of 414 societies with about 8791 members (Anon., 1990).

Due to political interference, however, the cooperative movement suffered many set-backs under various governments. For instance, in 1961, and again in 1977, the governments in power at the time confiscated the assets of the Ghana Cooperative Marketing Association (GCMA) and farmers lost their investment in shares. With this historical background, efforts to revive agricultural cooperatives have faced difficulties because many farmers are not interested in joining farmers' cooperatives. Presently, the Cocoa, Coffee and Sheanut Farmers' Association (CCSFA) is the umbrella body for cocoa farmers but it does not seem to have any organisational structures at the base. In the three villages where this research was conducted, for instance, none of the farmers belonged to this Association although the leaders at the national level continue to represent all cocoa farmers.

The Ministry of Food and Agriculture recognises the role of farmers' organisations as effective partners in the extension system. For at least the last 15 years, the policy of the extension services of MoFA has been that AEAs should develop and work with farmers' groups. The establishment of the FBODF in 2002 was to build the capacity of such groups without necessarily encouraging them to become cooperative societies.

6.5 Main features of linkages in the cocoa knowledge and information system

In this section we present the main findings from the survey that was carried out among various actors with the purpose of gaining insight in the nature and quality of linkages in the current knowledge and information system.

6.5.1 Involvement of various actors at different stages in the research process

Analysis of the answers from researchers indicate that most of them identified problems for research from reports and literature, and only a third of them did so through interaction with farmers (Table 6.1). Eighty-eight percent of respondents did not see any differences in the methods of identifying problems for research presently and before 2000.

Most researchers indicated that problems identified were mainly analysed and solutions suggested by themselves together with other researchers; farmers and AEAs play only a minor role (Table 6.1). In both pre and post 2000, 80% of the respondents indicated that they involved colleague researchers, 30% farmers and 10% AEAs in various stages of the research process.

Table 6.1. Percentage of researchers that qualifies other actors as important during different research stages

Research process	Reported involvement (%) (n=11)				
	Farmers	From reports or literature	AEAs	Other researchers	Technicians
Identifying problems	36	91	18	-	-
Analysing problem	20	-	10	90	10
Suggesting solutions	30	-	10	80	10

About 55% of the research conducted at CRIG involved field trials, and 83% of respondents had carried out such trials on farmers' fields. However, only 33% had involved farmers directly, and AEAs were involved in about 50% of the trials. Ninety percent of farmers interviewed had never had any contact with researchers, and 97% reported that they had never seen a CRIG trial or demonstration.

Most farmers are not involved in the planning of research and extension activities. Over 93% of farmers interviewed had never participated in any planning meeting organised by CRIG or MoFA.

6.5.2 Main sources of information for various technologies used by farmers

The sources of information reported as being the most important by farmers are MoFA and fellow farmers whilst the least mentioned are CRIG and input dealers (Table 6.2). For specific sources of information on various aspects of cocoa production, see Table 6.3.

Table 6.2. Sources of information mentioned by farmers

Main source of information	Percentage (n=148)
CSD	10
CRIG	1
LBCs	16
MoFA extension service	61
Input dealers	1
Others (mainly fellow farmers)	42

Table 6.3. Reported awareness and sources of information used by farmers for various technologies (%), (n=148)

Source, awareness and adoption	Hybrid varieties	Source of hybrid seedlings	Report swollen shoot disease	Control capsid using pesticides	Control black pod using fungicides	Control black pod using cultural practices	Control mistletoes	Weed control	Remove chupons	Using fertiliser	Manage shade to reduce capsid	Control shade to reduce black pod	Proper fermen-tation of beans
Awareness	100	95	61	99	86	100	100	88	99	98	100	99	99
Source													
MoFA	64	66	65	59	62	64	65	70	66	64	66	66	52
CSD	5	6	18	5	5	3	3	3	2	2	1	3	4
LBCs	5	4	3	2	1	1	3	1	3	18	4	4	28
CRIG	0	1	0	0	0	0	0	0	0	0	0	0	0
Others	25	23	15	34	32	33	29	27	29	17	28	28	16

6.5.3 Linkages between research, extension and dissemination of research findings

Contact between researchers and MoFA staff is generally low: 43% of the researchers had no contact, and 29% had contact once a year. Most (70%) researchers at CRIG were not aware of the RELCs and only 9% had taken part in any RELC activity. Eighty percent of the DDAs also said there was no forum where they can provide feedback to researchers, and 63% had no contact at all with researchers. Ninety percent had not met or interacted with researchers from CRIG during any RELC activity and none was aware of any research activity by CRIG that involved staff of MoFA. Similarly, 87% of the AEAs had never had any contact with researchers from CRIG. However, half of the respondents from CRIG said they used workshops organised by MoFA as the main channel of getting research findings to AEAs, 25% rely on personal communication, and another 25% through official reports.

All the researchers said there was no formal mechanism to get feedback from farmers about research recommendations. They all felt that it has become more difficult after 2000 to get feedback from extension and felt that dissemination of research recommendations to farmers has worsened. However, most District Directors of Agriculture (DDAs), hold a contrary view (Table 6.4). Most of the DDAs indicated that dissemination had improved; only a few said that it had worsened. Most farmers interviewed in the survey shared the views of the DDAs that extension had improved whereas about a quarter of them felt it was either the same or had worsened (Table 6.4). Half of the AEAs felt that extension had improved, a third said it was the same, and about a quarter said this had worsened since 2000.

In spite of the large number of farmers who felt that extension had improved, 64% of them wanted cocoa extension to be returned to COCOBOD. Probing further to understand this seeming contradiction revealed that farmers' judgement on improved extension service was directly related to the free mass-spraying of their farms. Their call for a return of extension to COCOBOD was to ensure that this program continued since it is COCOBOD rather than MoFA, which has the financial capacity to continue spraying their farms for free. Although 80% of the AEAs were of the opinion that extension had either improved or remained the same since 2000, 60% of them wanted this function to be sent back to COCOBOD. They argued that taking on extension has resulted in an increased workload for the same 'meagre' salary whilst COCOBOD staff are paid well from the cocoa revenue. Because of the low salary they have no motivation to work on cocoa. Regarding the levels of adoption of research recommendation by farmers, the researchers and DDAs differed in their perception. Whilst most researchers were of the view that it had worsened since 2000, most DDAs thought this has not changed (Table 6.4). Likewise, while a third of the DDAs believed that dissemination had improved all the researchers interviewed believe it had worsened.

Table 6.4. Perception of researchers, DDAs, AEAs, and farmers on the impact of shifting cocoa extension to MoFA on dissemination and adoption of technologies

Assessment	Researchers (%) (n=11)	DDAs (%) (n=9)	AEAs (%) (n=15)	Farmers (%) (n=148)
Dissemination				
Improved	0	67	47	62
Worsened	100	11	20	16
Remains the same	0	22	33	22
Adoption				
Improved	0	29	-	-
Worsened	67	14	-	-
Remains the same	33	57	-	-

6.5.4 Capacity of AEAs to deliver cocoa extension effectively

Most (67%) DDAs are of the opinion that the AEAs have adequate technical knowledge on cocoa production to provide extension services to farmers. Although 80% of the AEA respondents said their main source of information and knowledge on cocoa technologies was from staff training organised by MoFA, almost 80% said such training was held only once a year or less often. In response to a question about their level of confidence to advice cocoa farmers, 57% were moderately confident, 36% very confident and 7% were not confident to carry out this task.

On extension coverage, 50% of the AEAs said they reached less than 30% of the cocoa farmers in their operational areas, 21% reached between 30 and 50%, 14% said they covered between 51 and 70% and the remaining 14% AEAs reportedly reached 70% or more. On average, 64% contacted (visited) cocoa farmers monthly, 27% quarterly, and 7% yearly. An assessment of using demonstrations as an extension method showed that 60% of the AEAs had never used this method, and the remaining 40% who had done so did this only for fertilizer application under the "hi-tech' program in collaboration with researchers from CRIG.

6.5.5 Role of LBCs in providing services

Responses from officials of LBCs at all levels indicate that 77% provide some form of extension services informally to cocoa farmers. This covered mainly the proper fermentation processes to ensure the quality of beans, and on a minor scale, they advice farmers on general agronomic practices. Sixty eight percent provide some form of credit, 46% cash, and 41% inputs and logistics like cutlasses and Wellington boots. This role is important because the banks are reluctant to grant credit to farmers. Their role in the knowledge system, beyond buying cocoa from farmers, therefore needs to be recognized and encouraged. The LBCs however had no linkages with the extension services or research and are not also part of the RELCs.

6.5.6 Membership of farmers' organizations

Most farmers do not belong to any farmer group. Out of 148 farmers interviewed in the three research villages, 36% belonged to at least one farmer group or organisation and the rest did not belong to any group (Figure 6.1).

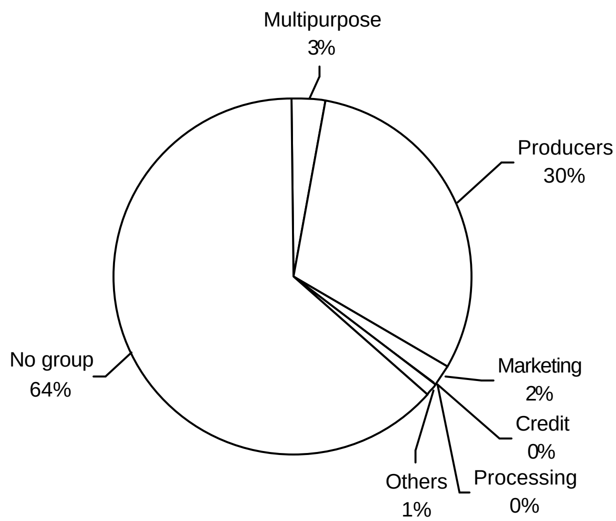

Figure 6.1: Membership of farmers' organization as indicated by farmers in three villages (Achiansah, Adarkwa and Ntumkum) in Ghana (source: data from survey in September to October 2005), (n=148)

The main reason given by most farmers (62%) in the three villages who do not belong to any group was that they had no time for group activities, 15% did not like the leadership of the groups in the villages, 7% had been disappointed in the past, 12% said there was none in their community and only 4 % said they did not need any assistance from groups.

6.5.7 COCOBOD led interventions

Two direct interventions by government to increase production levels are the cocoa diseases and pest control (CODAPEC) program (mass spraying) and provision of inputs to farmers on credit under the cocoa 'hi-tech' program. Over 70% of researchers, DDAs, farmers and officials of LBCs believe that the mass-spraying has contributed to increases in cocoa production (Table 6.5).

With the exception of farmers (28% indicate a positive contribution) most of the other actors believed that the 'hi-tech' program too has also contributed to the increases (Table 6.5). Most farmers believe that an increase in the number of times they weed their farms (which is a condition for getting their farms sprayed) has contributed as much as the mass-spraying itself to increases in production. However, most researchers and DDAs do not share this view.

Table 6.5. Perception of various actors on the reasons for increased cocoa production in the last three years

Reasons for increased production	Researchers (%) (n=11)	DDAs (%) (n=10)	Farmers (%) (n=148)	COCOBOD (%) (n=11)	LBCs (%) (n=23)
Mass spraying	90	78	73	55	91
'Hi-tech'	90	68	28	55	73
Improved weeding	20	33	72	46	59
Others[1]	80	78	18	36	41

[1] Improved producer price, improved extension services, etc.

Whereas the number of farmers benefiting from the mass-spraying exercise was reported as increasing over the years, that from the 'hi-tech' program was decreasing (Figure 6.2).

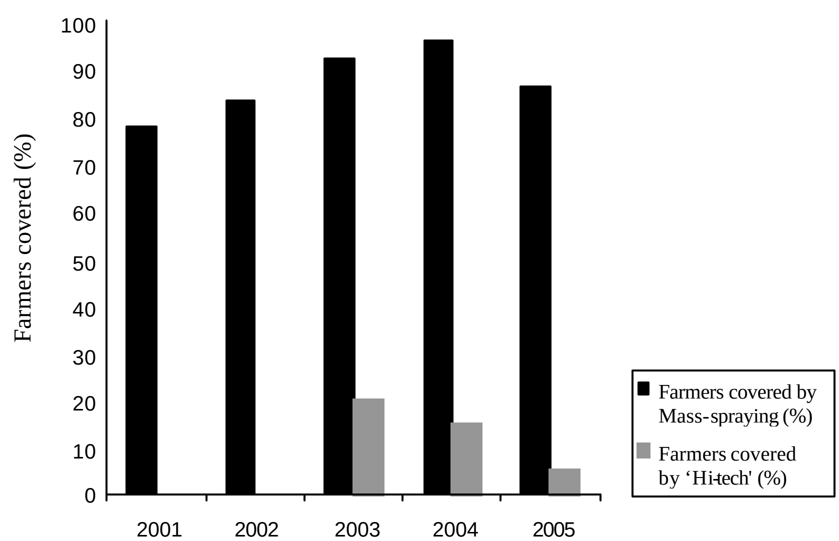

Figure 6.2: Coverage by the two direct government interventions in the cocoa sector from 2001 to 2005 (Source: data from survey in September to October 2005), (n=148)

At the time of the interviews, the mass-spraying exercise for 2005 was still ongoing and it is likely that a higher percentage of farmers will be reached than what is reported here.

6.6 Discussion

When interpreting and integrating the findings presented in the previous section against the background of an AKIS perspective, some features stand out.

6.6.1 Weak interaction between research extension and farmers

The general impression from the interviews with researchers and DDAs shows that the interface between research and extension is characterised by a lack of communication and weak collaboration at all stages of the research process: from problem identification, analysis, experimentation, dissemination, and feedback. The research agenda is set almost exclusively by researchers with little involvement of the other actors. Solutions to problems identified focus on developing technologies for onward transfer to farmers, however, with the weak feedback mechanism between research, extension and farmers, there is a discontinuity between technology 'generators' and 'end-users'. In the researchers' 'lifeworld', finding technical solutions to problems of cocoa production remains their prime objective.

By adopting direct interventions through CODAPEC and the "Hi-tech' program (both designed by CRIG), the government seems to share similar views as the researchers. Whereas all the actors recognise the contribution of the mass spraying exercise to increased production, the farmers disagree with the other actors as far as the contribution of the hi-tech program is concerned. This might be due to the relatively small number of farmers - which also keeps declining every year - who have access to the inputs under this program. This is partly because the inputs are not free and failure to repay credit from a previous year disqualifies a farmer from accessing the credit the following year.

6.6.2 The questionable value of mass-spraying in the long term

A striking feature of farmers' responses is that, possibly in the absence of other visible activities, they seem to associate research and extension primarily with mass-spraying. In the eyes of the farmers, this is the only thing that is 'going right'.

As a short term intervention, this can be described as a success if one looks only at the resultant increases in production from about 390,000 mt in 2001 to 736,000 by 2004. However, confounding factors should be taken into account: weeding is required to be eligible for the programme; and higher cocoa prices could have motivated farmers to harvest more and pay more attention to the crop. Another problem with this programme is the effectiveness of the spraying as it is calendar based and not need based, and often, less than the recommended four times is sprayed and also because spraying gangs are paid based on area covered, they rush through the farms. It also does not seem a feasible option to continue with such an exercise in the long-term. An added risk is that this will discourage farmers' innovation because they may become over-dependent on the government for pest and disease control to the extent that when this stop, there will be little innovation for farmers to use on their own.

The unwillingness of farmers in Adarkwa (chapter 5) to focus on solving biological causes of low yields that they had identified can be attributed to them being used to the fact that problems are solved for them. For instance, the cocoa project that was implemented in the 1970s provided all inputs and labour. Such a strategy of providing operational services to farmers may not be sustainable in the long run and may hinder farmers to develop capacity and take responsibility for pest and disease management and other important domains.

6.6.3 Farmers' representation and role in AKIS

The majority of farmers in the study area are not organised and the few farmers groups and associations are very weak. However, without proper organisation, it is difficult for farmers to play a serious role in the AKIS. Taking the RELC as an example, there are farmers' representatives but the question is, who do these 'farmer representatives' actually represent if they were not nominated by farmers? Also, at the national level, the CCSFA represents cocoa farmers on the committee that recommends the producer price of cocoa to government but they have no members on the ground; at least that was our observation in the study area.

Without proper representation, the actual needs of farmers may escape the attention of the other actors in the AKIS who could have played a role in meeting those needs.

We have also seen in this research that in developing innovations, it is easier when farmers are organised because this makes it possible for them to connect with other actors in the innovation system. However where these farmers' groups existed, they were found to be very weak. For instance the Achiansah group, even though quite organised still required a lot of training, especially in entrepreneurial skills to manage a complete innovation that links economic activities with pest and disease management. Our experience should be considered as an opportunity for research, extension and farmers to begin a different process. This requires a change of mindset from one of helplessness when they encounter constraints to the use of technologies, to actively engaging in a search for opportunities and partners in the AKIS to overcome such constraints. This can start with the 30% of farmers belonging to producer organisations whose objectives include learning new technologies and practices.

6.6.3 Role of Licensed Buying Companies

From the results, it seems that the LBCs play a more important role in the knowledge system than generally acknowledged with over 70% providing some form of extension service to farmers. With almost a third of the farmers relying on LBCs as the main source of advice on proper fermentation of beans, they certainly play an important role in the production of quality beans. In the area of fertilizer use, they are second only to MoFA as the source of information used by farmers.

An important constraint to adoption of technology by smallholder farmers is the lack of access to credit. During the action research, we invited banks (as important actors) operating in Suhum to join in stakeholder meetings but all the attempts were not successful because they were not interested in providing loans to farmers. With almost two-thirds of the LBCs providing some form of credit (either cash or in the form of inputs) to farmers, they fill an important gap that has been left by the credit institutions.

6.7 The need for a national innovation system

Before discussing the need for, and how to scale up the research approach, it is useful to summarise the weaknesses and opportunities in the present system. From the results and discussions, there are very weak linkages between research, extension and farmers whilst the role of actors like LBCs in technology generation and dissemination is not acknowledged despite the important role they play. Although the need for a strong research-extension linkage is recognized, CRIG has not been part of the RELCs as expected; however, the existence of this committee provides a quick entry point for CRIG into the broader agricultural knowledge and information system.

Farmers' organisation can facilitate innovation development processes but most farmers do not belong to any such group and the existing ones are weak, however, the establishment of the FBODF, and similar grant or credit programs, provides opportunities for linking technology with other economic activities to develop innovations that are relevant to the farm family's livelihood. Another opportunity for research to develop technologies that are relevant to farmers' needs is the establishment of a competitive research grant by the Council for Scientific and Industrial Research (CSIR) under the Agricultural Services sub-Sector Investment Project (AgSSIP) implemented by MoFA. This grant is linked to the RELCs and focuses on financing research into problems identified by farmers and especially those that emanate from RELCs.

From the above, it can be concluded that there are bits and pieces of funds, grants, or institutional mechanisms that could support the cocoa innovation system but there is a large room for improvement. In other words, the current AKIS or innovation system functions sub-optimally, and in fact does not show many system-like features. There is little evidence of synergy, shared goals and visions on how to collaborate, while the main shared understanding remains the outdated linear model of technology generation and transfer. This means that national strategies are needed to improve the collaboration and synergy among actors, so that an effective cocoa innovation system can emerge. A well-functioning national innovation system can be described in terms of a systemic, interactive and evolutionary process whereby networks of organisations, together with the institutions and policies that affect their innovative behaviour and performance, bring new products and processes into economic and social use (Edquist, 1997; Freeman, 1987; Hall, 2005; Lundval, 1992). Hall (2005) argues that what is important for developing countries is to develop innovation capacity rather than science and technology. Whilst it is important to develop research capacity, failure to develop complimentary competencies and structures to put research knowledge into use remains a major concern in the science and technology debate (Hall, 2002; Chataway *et al.*, 2005). The latter requires responsiveness of science to economic sectors and society as a whole. Whereas the work of research organisations is important, it is equally important for them to integrate and interact with other sources of knowledge in a country or a defined sector and the process required goes beyond calls for scientist to work with farmers. Hall (2005) argues that this should involve the development of a web of interactions through which knowledge is shared and exchanged in different arenas such as task, sector, state or region. Capacity development in an innovation system requires skills and competencies in both scientific and non-scientific kinds, linkages between producers and users of knowledge, relationships, an institutional setting conducive to knowledge sharing, interactive learning, and a policy environment that is sensitive to the need for creating conditions that make productive use of knowledge rather than focusing on the creation of such knowledge (Hall, 2005).

Starting from the co-evolutionary development of innovation practice, theory and policy, Smits & Kuhlmann (2004) lists five functions that play a critical role in the management of present-day innovation processes: (i) management of interfaces, (ii) (de-) construction and organising of systems, (iii) providing platforms for learning and experimenting, (iv) providing an infrastructure for strategic intelligence, and (v) stimulating demand articulation, strategy and vision development. The ideas from Hall (2005), Smits & Kuhlmann (2004) and AKIS (Röling, 1992; Engel, 1995) are in line with general systems theory, and the need for establishing a national innovation system for the cocoa sector in Ghana. Such a system must have the capacity to spearhead the process of developing innovations that suit the majority of farmers who are smallholders.

An important question, of course, is how such a system might come about. In many ways, establishing such a system is a radical innovation process in itself. And as we have learned from this thesis, such innovations cannot be usefully designed as blueprints from above, but need to a considerable extent be designed and agreed upon in an interactive fashion by actors in the network themselves. Recent experiences with re-organising research and extension in the cocoa sector too suggest that drawing new organizational charts and taking structural measures does not necessarily lead to desired results. A fundamental insight from soft systems thinking is that is not just structure that matters, but rather that actors in the system become aware of the idea that they can potentially act as a system, that they analyse and recognize obstacles that prevent them from doing so, and start to act or experiment with new ways of operating on the basis of shared meanings and objectives. This implies that relevant actors in the innovation system need to go through a similar kind of experiential learning process (be it at the institutional level) as the one that the farmers in this research went through when developing the IPM innovation. Thus, the establishment of a national innovation system must be done through a carefully facilitated and flexible process. The Rapid Appraisal of Agricultural Knowledge Systems (RAAKS) methodology developed by Engel (1995) offers the necessary diagnostic concepts and tools for such a learning exercise at the inter-organisational level. RAAKS can be used to: make a strategic diagnosis of a system's performance, constraints and opportunities; identify opportunities for intervention aimed at improving collective innovative capacity; create awareness among relevant actors about existing constraints and opportunities; and identify people who may act effectively to remove impairments and make use of opportunities (Engel, 1995). An overview of the RAAKS concepts and tools are presented in Box 1.

Box 1: Overview of RAAKS phases and windows, incorporating the main analytical concepts and questions asked during the process

Phase A: Problem definition and system identification:

A1: Redefining the objective of the appraisal: Who's problem is it anyway? What is it about?

A2: Identifying relevant actors: Who is involved, or should be? What is it about in their eyes?

A3: Tracing diversity in mission statements: Who pursues what, why? Who perceives what 'problem'?

A4: Environmental diagnosis: Natural, economical and socio-cultural factors to be taken into account.

A5: A first approximation: Clarifying the problem situation; who is relevant, why, how?

Phase B: Constraint and opportunity analysis:	
B1:	Impact analysis: Volitions cause assessments to differ; what is the outcome in practice?
B2:	Actor analysis: Not all actors are equally relevant for, or interested in each type of innovation!
B3:	Knowledge network analysis: Studying interactive communication for innovation.
B4:	Integration analysis: Studying linkages and resource coalitions.
B5:	Task analysis: What should be done to innovate and who does it?
B6:	Coordination analysis: studying leadership and orchestration.
B7:	Communication analysis: Cultural barriers in the way of effective communication for innovation.
B8:	Understanding the social organization of innovation: How does it work? Or, does it?
Phase C: Policy articulation/intervention planning	
C1:	Knowledge management: What can be done to enhance innovative performance?
C2:	Actor potential analysis: Who can, and is willing to do what?
C3:	Strategic commitments: Who will do what? Who will participate in carrying out the activities?

Source: Engel 1995:265, Box 7: RAAKS windows: appreciating a situation and the social organization of innovation from different angles.

In addition to the RAAKS windows above, Engel and Salomon (1997) have developed for each window, specific exercises, procedures and forms of visualisation. These tools can be used in analysing the present knowledge and information system for the cocoa sector and the actors can negotiate what needs to be done and how it has to be done in order to institutionalise a well functioning national innovation system.

With these concepts and tools, as well as the insights into innovation development and process contained in this thesis, MoFA (which is responsible for cocoa extension) and COCOBOD (responsible for all other aspects of cocoa production and marketing), should take the initiative to start the process of establishing an effective innovation system.

The process to establish such a system should start by putting together a team to manage the process. The team should be made up of senior members of staff from CRIG, MoFA, COCOBOD head office, LBCs, farmers' organizations, District Assemblies and any other organization that can be identified as having the mandate or potential to play a role in the knowledge system. The members of the team must be exposed to the new modes of thinking about innovation in order to appreciate the task and what to focus on. The task of the team should be to analyse the present state of the AKIS and suggest 'experiments' for new ways of operating by the various actors in the system. This should be based on an identified shared mission and vision of the innovation system. It is also important to identify factors that could bring about resistance from some actors and how to deal with them.

Some key issues that the team may consider when making recommendations on how to operationalise the system include: establish guidelines that spell out rules and norms for all actors; strategies on how to stimulate demand from end-users of innovation; a continuous system of monitoring and evaluating the attainment of goals and objectives; and strategies to build the capacity and competencies of all stakeholders to enable them play their respective roles effectively.

6.8 Conclusion

This thesis concludes with a reflection on the following question: has the problem of low yields identified by farmers in the study area persisted due to a lack of technology, or is it because farmers refuse to use the available technology? It is probably neither of the two. With the exception of using neem, the rest of the technologies in the IPM technical package discussed in this thesis were existing technologies that most of the farmers were aware of but did not use. In the classical adoption discourse, these farmers would be labeled as laggards and conservatives. This labeling is from an old paradigm of adoption and diffusion theory but unfortunately, many researchers and extension workers still adhere to it. With this mode of thinking, researchers, extension officers, and policy makers fail to realize that what is important is to develop innovations rather than technology. Unless the focus is changed, farmers will continue to ignore research recommendations.

The research has also shown that the present research-extension system is not only weak but also, that it is not designed (or does not operate) in a way that can support the development of innovations that are relevant to farmers. The way forward for research and extension to make an impact on farmers' livelihood is to strengthen farmers' organisations, to involve all stakeholders in defining research problems, and work together in finding solutions that meet their needs. This can only be done by focusing on the development of innovations rather than technology. However, this would require changes in the mindsets of researchers and extensionist. The best way to achieve this is to interactively design and institutionalise a national innovation system that connects all the relevant actors in the cocoa sector. We therefore propose that steps should be taken by the government to start an interactive learning process with relevant actors in the cocoa sector with the objective of analysing the current system and designing new arrangements on the basis of experiments and lessons learned elsewhere. The outcomes can be institutionalised and form the contours of an effective national innovation system with a supportive policy environment.

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Summary

Ghana is a major producer of cocoa in the world and relies heavily on the crop for foreign exchange revenue. However, production levels declined from the mid 1960s reaching the lowest level in 1983. The decline in production was a result of decreasing areas under cultivation, and low yields. Pests and diseases are inadequately controlled, and the use of synthetic pesticides, applied on calendar basis, is recommended However, due to the high cost of pesticides and low producer prices, farmers are not motivated to use the synthetic pesticides. Moreover, the sole reliance on synthetic pesticides may affect human health through inappropriate handling, causes environmental problems, and leads to resurgence of pests as natural enemies are destroyed.

The objectives of this thesis were to explore: (i) more sustainable pest and disease management strategies; (ii) research and extension approaches which can facilitate the development of innovations that can be used widely by farmers; and (iii) how such approaches could be institutionalised. Theoretical inspiration and concepts orienting the thesis were derived from general systems theory, soft systems thinking, innovation theory, integrated pest management (IPM) concepts and theories about learning and social capital. The research was carried out in an action research mode, and as part of it, both quantitative and qualitative methods were used in collecting and analysing data. Quantitative data were collected from experimental plots to evaluate the effectiveness of IPM practices in improving yield. They were also collected through a survey that was geared at gathering information about the demographic structure of the study area, and to gain insight in the perceptions of various actors about the existing research and extension system. Qualitative data were collected through participant observation, informal interviews and open-ended questionnaires.

Based on the idea that current research and extension messages might insufficiently address farmers' problems, a diagnostic study was carried out to better understand farmers' views on the problems of cocoa production (chapter 2). The study was conducted in three villages in the Suhum-Kraboa-Coalter District of the Eastern Region of Ghana. The diagnostic study identified low productivity as the main problem and the causes were classified into socio-economic and biological factors. The biological factors include the incidence of insect pests and diseases, most of which have received extensive research attention in Ghana, and

epiphytes, which have been neglected. The socio-economic causes were indirect and include the low producer price, and the lack of amenities including electricity, which leads to migration of the youth to the cities resulting in labour shortages and high labour costs. From the diagnostic study, it was concluded that the biological and socio-economic causes of low productivity were inter-related in such a manner that tackling them separately would not help to overcome the problems.

Experiments were carried out with farmers to find suitable solutions by tackling the factors contributing to low yields (chapter 3). An IPM package was composed and experimented with on farmers' fields with their active participation. The package included the use of aqueous neem (*Azadirachta indica* A. Juss.) seed extracts to control insect pests and cultural practices to control diseases, weeds and parasitic plants. These measures improved yields significantly and increased profitability. In Achiansah, yields from IPM plots were three times that of the farmers' normal practice (1,881 compared to 650 kg ha^{-1}) by the end of the second year and in Adarkwa, they were double (1,482 compared to 715 kg ha^{-1}). During the same period economic returns on the additional investment in the IPM plots reached 307 and 261% in Achiansah and Adarkwa respectively.

There were many constraints to adoption of the package by farmers because the practices are labour-intensive and the neem is not available in the community. Although the IPM package relied on minimum use of external inputs, it still required some capital, therefore resource-poor farmers could only adopt them if the necessary economic, social, and organisational 'space' would be enlarged. Chapter 4 reports on how these constraints were tackled, and how, as a result, the technical package was transformed into a complete innovation. Such a complete innovation consisted of a successful combination of the necessary 'hardware' (neem processing), 'software' (changed mindsets and goals) and 'orgware' (reciprocal labour; arranging for the collection and transportation of neem etc). In developing the complete innovation, it appeared useful to distinguish between regular and systems innovations. On the basis of the findings, we suggest that regular innovations can be realised at farmers' level and may be facilitated through extension agents, while system innovations require co-designing with other stakeholders to suit network-specific circumstances. Therefore, the role of extension agents, which currently emphasise technology transfer, require learning to include facilitation of social and economic network building around such technological packages. They also need to be involved in extending the principles underlying a particular innovation to other farmers.

The outcomes and processes for developing the innovations in two villages (Adarkwa and Achiansah), as well as out-scaling the process to a third village (Ntumkum) were quite different. A study was therefore carried out to explain the factors responsible for the differential processes and outcomes (chapter 5). Taking the innovation trajectories in the three villages as case studies, a comparative analysis of the processes was made using sensitising concepts from theories of learning and social capital. It was concluded that the differences could be explained by the level of social capital, particularly in terms of group organisation, trust, and leadership, which influences the quality of learning required for developing innovations. An effective organisational capacity of farmers will facilitate learning and also make it easier for them to 'connect' with relevant networks. In this way it enables them create the necessary linkages between technical, social-organisational and economic elements to develop 'complete' innovations that are relevant and easily applicable under their conditions.

Overall, this research had shown that it is possible to develop innovations with farmers using an interactive process. A remaining challenge, however, is to utilise the outcomes and the approach on a wider scale. The objective of the final chapter of this thesis, therefore, was to provide some thoughts and insights into what measures could be taken to institutionalise a research and extension system that goes beyond technology generation and transfer into one that can support a widespread development of innovations that are suitable to farmers' conditions. To this end the last chapter in the thesis examines the prevailing research and extension system for the cocoa sector with the help of ideas and concepts derived from Agricultural Knowledge and Information Systems' (AKIS) thinking. The results from a survey carried out in the three research villages and among various actors in the cocoa sector suggest that present research and extension linkages are weak and are unlikely to support the development and uptake of appropriate technologies. Furthermore, that the current system is not well equipped for developing complete innovations. Using insights from AKIS and concepts from innovation theory, the final chapter discusses the need to establish a national system of innovation that is well co-ordinated and involves all the relevant stakeholders to facilitate the development of innovations that are suitable to the end-users. It is suggested that arriving at such a system requires an action learning process similar to that which the farmers went through, but this time in the domain of organisations that play or may play a role in supporting agricultural innovation.

Samenvatting

Ghana is een belangrijke producent van cacao in de wereld en is erg afhankelijk van het gewas voor deviezenopbrengsten. Desondanks daalde het productieniveau vanaf het midden van de jaren '60, waarbij het laagste niveau in 1983 werd bereikt. De daling in productie was het resultaat van verminderd teeltoppervlak en lage opbrengsten per hectare, veroorzaakt door plagen, ziekten en toepassing van ontoereikende bestrijdingsmaatregelen. Voor de beheersing van plagen en ziekten wordt het gebruik van synthetische pesticiden op kalenderbasis geadviseerd. Ook kunnen voor het onderdrukken van ziekten een aantal teelttechnische beheersingsmaatregelen worden uitgevoerd. Echter, wegens de hoge kosten van pesticiden en de lage prijzen voor cacaobonen, zijn boeren niet gemotiveerd om synthetische bestrijdingsmiddelen te gebruiken. Voorts kan de uitsluitende afhankelijkheid van synthetische pesticiden de volksgezondheid schaden alsmede het milieu aantasten door slecht en ongecontroleerd gebruik.

De doelstellingen van dit onderzoek waren: (i) het onderzoeken van alternatieve, duurzame ziekte - en plaagbestrijdingsstrategieën die niet zijn gebaseerd op het gebruik van synthetische pesticiden; (ii) het verkennen van alternatieve benaderingen van onderzoek en voorlichting die de ontwikkeling van breed toepasbare innovaties kan vergemakkelijken; en (iii) verkennen hoe dergelijke benaderingen zouden kunnen worden geïnstitutionaliseerd. De theoretische inspiratie en de concepten die de basis vormden van deze thesis werden afgeleid uit algemene systeemtheorie, Soft Systems Theory, innovatie theorie, literatuur over geïntegreerde plaagbestrijding (IPM) en theorieën over leren en sociaal kapitaal. Er werd gekozen voor een actie-onderzoek benadering, waarbij zowel kwantitatieve als kwalitatieve methoden werden gebruikt bij het verzamelen en analyseren van gegevens. Om de doeltreffendheid van geïntegreerde ziekte- en plaagbestrijding voor het verhogen van de opbrengst te evalueren werden kwantitatieve gegevens vergaard uit experimentele percelen. Ook werd een kwantitatief survey gehouden om gegevens te verzamelen over de demografische structuur van het onderzoeksgebied, en om inzicht te krijgen in de percepties van actoren ten aanzien van het onderzoek- en voorlichtingssysteem.

Kwalitatieve gegevens werden verzameld door participatieve observatie, informele gesprekken en open vragenlijsten.

Gebaseerd op het idee dat het huidige aanbod van onderzoek en voorlichting niet toereikend is om de problemen van boeren aan te pakken, werd een diagnostische studie uitgevoerd om de perspectieven van boeren op problemen in de cacaoteelt beter te begrijpen (hoofdstuk 2). De studie werd uitgevoerd in drie dorpen in het Suhum-Kraboa-Coalter district van de Eastern Region provincie in Ghana. De studie identificeerde lage productiviteit als belangrijkste probleem, waarbij de oorzaken werden geclassificeerd in sociaal-economische en biologische factoren. De biologische factoren omvatten het vóórkomen van de plaaginsecten en ziekten die meestal al in teelttechnisch onderzoek in Ghana betrokken worden, en epifyten, die tot nu weinig aandacht kregen. De sociaal-economische oorzaken waren indirect en omvatten de lage prijs voor cacao, en het gebrek aan voorzieningen, waaronder de afwezigheid van elektriciteit, wat leidt tot het wegtrekken van de jeugd naar de steden en daarmee tot een tekort aan arbeidskrachten en hoge loonkosten. Vanuit deze bevindingen is geconcludeerd dat de biologische en sociaal-economische oorzaken van lage productiviteit zodanig met elkaar verbonden waren dat het aanpakken van hen afzonderlijk niet zou helpen om de problemen te overwinnen.

Nadat de boeren in het onderzoeksgebied lage opbrengsten als belangrijkste probleem in de cacaoproductie hadden geïdentificeerd, werden in samenwerking met de boeren experimenten uitgevoerd om geschikte oplossingen te vinden voor de problemen (hoofdstuk 3). Om de opbrengsten te verhogen met behulp van relatief milieuvriendelijke maatregelen, werd een IPM maatregelen pakket samengesteld en getest op akkers met actieve participatie van de boerengemeenschap. Het pakket omvatte het gebruik van een extract op basis van water en gemalen zaden van de neemboom (*Indica Azadirachta* A. Juss.) om plaaginsecten te bestrijden, alsmede teelttechnische maatregelen om ziekten, onkruid en parasiterende planten te beheersen. Het verbeterde de opbrengsten significant en leek ook voordeliger dan de gangbare toepassingen. In Achiansah waren de opbrengsten van IPM percelen drie keer hoger dan die van de boerenvelden onder gangbaar bestrijdingsregime (1.881 tegenover 650 kg Ha^{-1}). Tegen het einde van het tweede jaar waren de opbrengsten in Adarkwa verdubbeld (1.482 tegenover 715 kg Ha^{-1}). Het economische rendement van de extra investering in de IPM percelen was tegen het eind van het tweede jaar 307% en 261% in respectievelijk Achiansah en Adarkwa.

Er waren vele obstakels voor het implementeren van het IPM pakket door boeren omdat de maatregelen arbeidsintensief zijn en neemzaden niet beschikbaar zijn in de gemeenschap. Hoewel het IPM pakket uitging van een minimumgebruik aan externe inputs, vereiste het nog steeds een startvermogen. Daardoor konden onbemiddelde boeren het pakket slechts toepassen wanneer de noodzakelijke economische, sociale, en organisatorische ruimte daartoe werd vergroot. Hoofdstuk 4 beschrijft hoe deze obstakels werden aangepakt, en hoe daardoor het technische pakket in een volledige innovatie werd omgezet. Deze volledige innovatie bestond uit een succesvolle combinatie van de noodzakelijke ‘hardware’ (verwerking van neemzaden), ‘software’ (veranderde denkrichtingen en doelstellingen) en ‘orgware’ (uitwisseling van arbeid; organisatie voor de inzameling en het vervoer van neemzaden, enz.). Bij het ontwikkelen van de volledige innovatie bleek het nuttig om onderscheid te maken tussen reguliere innovaties en systeeminnovaties. Op basis van de bevindingen stellen wij dat reguliere innovaties op boerenniveau kunnen worden gerealiseerd en door voorlichtingsdiensten kunnen worden overgedragen en verspreid, terwijl systeeminnovaties samen met andere stakeholders moeten worden ontworpen om binnen netwerkspecifieke omstandigheden te passen. De rol van voorlichtingsdiensten, die zich momenteel toeleggen op de overdracht van technologie, zal moeten worden verbreed in de richting van het bouwen van sociale en economische netwerken rondom technologische pakketten, althans, wanneer men wil bijdragen aan het ontwikkelen en overdragen van complete innovaties en/of onderliggende principes.

De resultaten en de processen van innovatie ontwikkeling in de twee dorpen (Adarkwa en Achiansah), evenals de uitbreiding van het proces naar een derde dorp (Ntumkum) waren nogal verschillend. Daarom werd er een studie uitgevoerd om te verklaren welke factoren verantwoordelijk zijn voor de geobserveerde verschillen in proces en resultaat (hoofdstuk 5). De innovatietrajecten in de drie dorpen als case studies beschouwend, werd een vergelijkende analyse van de processen gemaakt waarbij ‘sensitizing concepts’ uit theorieën over leren en sociaal kapitaal werden gebruikt. Er werd geconcludeerd dat de verschillen samenhangen met uiteenlopende niveaus van sociaal kapitaal, en met name het organisatorisch vermogen van de groep, het onderlinge vertrouwen en leiderschap. Deze factoren beïnvloedden de kwaliteit van het leren dat nodig is voor het ontwikkelen van innovaties. Een effectief organisatorisch vermogen van boeren faciliteert het leerproces en zal ook het leggen van connecties met relevante netwerken vergemakkelijken. Op deze wijze stelt het hen in staat de noodzakelijke verbindingen tussen technische, sociaal-organisatorische en economische elementen te leggen, en daarmee om ‘volledige’ innovaties te ontwikkelen die relevant en gemakkelijk toepasbaar zijn in de specifieke context.

Al met al heeft dit onderzoek aangetoond dat het mogelijk is om innovaties met boeren te ontwikkelen via een interactief proces. Een resterende uitdaging echter is, om de resultaten en de benadering op bredere schaal toe te passen. De doelstelling van het laatste hoofdstuk van deze dissertatie is om ideeën aan te reiken over welke maatregelen zouden kunnen worden genomen om een onderzoek- en voorlichtingssysteem te institutionaliseren dat verder gaat dan de klassieke technologie ontwikkeling en overdracht, en dat in staat is om de ontwikkeling van complete en toepasbare innovaties op grotere schaal te ondersteunen. Daartoe analyseert het laatste hoofdstuk van het onderzoek het bestaande onderzoek- en voorlichtingssysteem voor de cacaosector met behulp van ideeën en concepten afgeleid van het denken over ‘Agrarische Kennis en Informatie Systemen’ (AKIS). De resultaten van een onderzoek dat in de drie onderzoeksdorpen en onder diverse actoren in de cacaosector werd uitgevoerd, suggereren dat de huidige verbindingen tussen onderzoek, voorlichting en boeren zwak zijn, en dat het onwaarschijnlijk is dat deze de ontwikkeling en de verspreiding van geschikte technologieën kunnen ondersteunen. Verder is het niet aannemelijk dat het huidige systeem goed is uitgerust voor het ontwikkelen van volledige innovaties. Op basis van AKIS concepten en innovatie theorie bespreekt het laatste hoofdstuk de noodzaak om een nationaal systeem van innovatie op te zetten dat goed wordt gecoördineerd en waarbij alle relevante stakeholders betrokken zijn om de ontwikkeling van innovaties te faciliteren die toepasbaar zijn voor de eindgebruikers. Er wordt voorgesteld dat het realiseren van een dergelijk systeem een interactief leerproces vereist, dat lijkt op het proces dat de boeren doormaakten, maar dit keer tussen organisaties die een rol spelen of kunnen spelen in het ondersteunen van innovatie in de landbouw.

The Convergence of Sciences Programme [7]

Background

This thesis is the outcome of a project within the programme "*Convergence of Sciences: inclusive technology innovation processes for better integrated crop and soil management*" (CoS). This programme takes off from the observation that West African farmers derive sub-optimal benefit from formal agricultural science. One important reason for the limited contribution of science to poverty alleviation is the conventional, often tacit, linear perspective on the role of science in innovation, i.e. that scientists first discover or reveal objectively true knowledge, applied scientists transform it into the best technical means to increase productivity and resource efficiency, extension then delivers these technical means to the 'ultimate users', and farmers adopt and diffuse the 'innovations'.

In order to find more efficient and effective models for agricultural technology development the CoS programme analysed participatory innovation processes. Efficient and effective are defined in terms of the inclusion of stakeholders in the research project, and of situating the research in the context of the needs and the opportunities of farmers. In this way stakeholders become the owners of the research process. Innovation is considered the emergent property of an interaction among different stakeholders in agricultural development. Depending on the situation, stakeholders might be village women engaged in a local experiment, but they might also comprise stakeholders such as researchers, farmers, (agri)-businessmen and local government agents.

To make science more beneficial for the rural poor, the CoS programme believes that convergence is needed in three dimensions: between natural and social scientists, between societal stakeholders (including farmers), and between institutions. Assumptions made by CoS are that for research to make an impact in sub-Saharan Africa: most farmers have very small windows of opportunities, farmers are innovative, indigenous knowledge is important,

[7] Hounkonnou, D., D.K. Kossou, T.W. Kuyper, C. Leeuwis, P. Richards, N.G. Röling, O.Sakyi-Dawson, and A. van Huis, 2006. Convergence of sciences: the management of agricultural research for small-scale farmers in Benin and Ghana. *Wageningen Journal of Life Sciences (NJAS)*, 53(3/4): 343-367.

there is a high pressure on natural resources, the market for selling surplus is limited, farmers have little political clout, government preys on farmers for revenue, and institutional and policy support is lacking. To allow '*ex-ante* impact assessment' and ensure that agricultural research is designed to suit the opportunities, conditions and preferences of resource-poor farmers, CoS pioneered a new context-method-outcome configuration[8] using methods of technography and diagnostic studies.

Technographic and diagnostic studies

The technographic studies explored the innovation landscape for six major crops. They were carried out by mixed teams of Beninese and Ghanaian PhD supervisors. The studies looked at the technological histories, markets, institutions, framework conditions, configurations of stakeholders, and other background factors. The main objective of these studies was to try and grasp the context for innovation in the countries in question, including appreciation of limiting as well as enabling factors.

The diagnostic studies were carried out by PhD students from Benin and Ghana. They focused in on groups of farmers in chosen localities, in response to the innovation opportunities defined during the technographic studies. The diagnostic studies tried to identify the type of agricultural research - targeting mechanisms - that would be needed to ensure that outcomes would be grounded in the opportunities and needs of these farmers. Firstly, that not only meant that research needed to be technically sound, but also that its outcomes would work in the context of the small farmers, taking into account issues such as the market, input provision, and transport availability. Secondly, the outcomes also needed to be appropriate in the context of local farming systems determined by issues such as land tenure, labour availability, and gender. Thirdly, farmers also need to be potentially interested in the outcomes taking into account their perceived opportunities, livelihood strategies, cultural inclinations, etc.

The diagnostic studies led to the CoS researchers facilitating communities of practice of farmers, researchers, scientists from national research institutes, local administrators and local

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[8] See R. Pawson and N. Tilley, 1997. *Realistic evaluation*. London: Sage Publications.

chiefs. The research was designed and conducted with farmer members of the local research groups. Their active involvement led to experiments being added, adapted or revised. It also made the researchers aware of the context in which the research was conducted. A full account of the diagnostic studies can be found in a special issue of NJAS[9].

Experimental work with farmers

After completing the diagnostic studies, the PhD students engaged in experiments with farmers on integrated pest and weed management, soil fertility, and crop genetic diversity, in each case also taking into account the institutional constraints to livelihoods. They focused on both experimental content and the design of agricultural research for development relevance. Experiments were designed and conducted together with groups of farmers, and involving all stakeholders relevant for the study. The aim was to focus on actual mechanisms of material transformation – control of pests, enhancement of soil fertility, buffering of seed systems – of direct relevance to poverty alleviation among poor or excluded farming groups. The ninth PhD student carried out comparative 'research on research' in order to formulate an interactive framework for agricultural science.

Project organization

All students were supervised by both natural and social scientists from the Netherlands and their home countries. In each country, the national coordinator was assisted by a working group from the various institutions that implemented the programme. A project steering committee of directors of the most relevant research and development organizations advised the programme. The CoS programme had a Scientific Coordination Committee of three persons, including the international coordinator from Wageningen University.

CoS had two main donors: the Interdisciplinary Research and Education Fund (INREF) of the Wageningen University in the Netherlands and the Directorate General for International Cooperation (DGIS), Ministry of Foreign Affairs of the Netherlands. Other sponsors were the FAO Global IPM Facility (FAO/GIF), the Netherlands Organization for Scientific Research

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[9] Struik, P.C., and J.F. Wienk (Eds.), 2005. Diagnostic studies: a research phase in the Convergence of Sciences programme. *Wageningen Journal of Life Sciences (NJAS)*, 52 (3/4): 209-448.

(NWO), the Wageningen Graduate School Production Ecology and Resource Conservation (PE&RC), the Technical Centre for Agricultural and Rural Cooperation (CTA or ACP-EU), and the Netherlands organization for international cooperation in higher education (NUFFIC). The total funds available to the project were about € 2.2 million.

About the author

Emmanuel Dormon was born in Accra, Ghana on 21st April 1965. He attended the Achimota Secondary School in Accra from 1979 to 1986 where he obtained both his 'Ordinary' and 'Advanced' level certificates of the West African Examination Council. From 1987 to 1991 he attended the University of Science and Technology in Kumasi, Ghana where he graduated with a BSc. (Hons) degree in agricultural science (economics option). After graduation, he worked with the Extension Department of the Ministry of Food and Agriculture in Ghana, mainly in monitoring and evaluation of extension programs.

In September 2000 he was awarded a scholarship under the Netherlands Fellowship program to pursue a Master of Science program in Management of Agricultural Knowledge Systems in Wageningen University. Soon after graduation in January 2003, he was offered a PhD position in the Convergence of Science Project jointly implemented by the Wageningen University, the University of Ghana and the Université d'Abomey-Calavi in Benin with funding mainly from the Interdisciplinary Research and Education Fund (INREF) of the Wageningen University in the Netherlands and the Directorate General for International Cooperation (DGIS), Ministry of Foreign Affairs of the Netherlands.

Currently, he is working as a Senior Agricultural Officer in the Ministry of Food and Agriculture and coordinates a program aimed at facilitating the development of farmers' organizations. He is particularly interested in how smallholder farmers, through their organizations, can develop innovations that will enable them add value along their product chains as a means of improving their income and livelihoods.