Assessing the Factors of Adoption of Agro-chemicals by Plantain Farmers in Ghana Using the ASTI Analytical Framework*

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The Agricultural Science, Technology and Innovation (ASTI) systems' analysis framework was developed by CTA in 2004 to assess the policy environment and how it enhances key actors' competencies and performance in relation to innovativeness as well as the effectiveness of linkages among actors of any subsector in an economy. Recent studies have shown that promotion of agrochemical use for pest control and soil fertility improvement in the plantain subsector in Ghana is yielding positive results. What is not well understood are the factors influencing adoption by farmers, a key actor in the ASTI system. Employing probit estimation, using data from 249 farmers it is observed that being literate, older than 40 years, having higher income from sales, living in villages distant to Accra (capital of Ghana), having access to hi-tech machinery, being migrant and being linked to extension services and financial institutions, have a positive influence on adoption. The functions of farmer-based organisations (FBOs) and non-governmental organisations (NGOs) are yet to make a significant difference. There is a lot that these institutions have to do, especially to bring more young, illiterate, low income and indigene farmers up to be part of the science, technology and innovation system in Ghana.

Keywords: 1nnovation, adoption, agro-chemicals, plantain farmers, probit

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Introduction

Agriculture contributes 39 percent to Ghana's gross domestic product (GDP) which was estimated at GH¢11.6 Billion in 2006 (ISSER 2007). This makes the sector the backbone of the economy and so, the economic and structural transformation of Ghana that should lead to a 6 to 8 percent growth rate and propel it to a middle income country by the year 2015 has been tied to the sector (Ghana Government 2005). Apart from attempts to re-align the macro incentive structure which sought to liberalise Ghana's economy in the mid 1980s, a specific medium term agricultural development plan (MTADP) was launched in 1990 and two rounds of Food and Agricultural Sector Development Policy (FASDEP I&II) have been implemented in the 2000s (Ghana Government 2007). These policy interventions allowed a number of development partners such as Sasakawa Global 2000, Monsanto Company and Gatsby Charitable Foundation to support growth promoting projects in the food crop subsector (Boahene, Dartey, Dogbe, Boadi, Triomphe, Daamgard-Larsen, and Ashburner 2007). One of the important food crops that received significant support is plantain (Musa spp ABB) (see Owusu-Benoah, Anno-Nyako, Egyir, and Banful 2007).

Plantain is the third most important starchy staple after maize and cassava. Its performance (albeit nominal) in area, output, yield and producer price in recent times suggests that it is on its growth path (Figures 1&2). The crop contributes 13 percent to agricultural GDP and (although it is not considered as a traded commodity) its potential for cross border trade has been noted. In 2006, about 261 metric tonnes of fresh plantain exported to the Sahel countries (including Burkina Faso, Mali and Niger) fetched Ghana approximately US$121,510.00 (ISSER 2007).

[FIGURES 1&2 HERE]

Plantain contributes about 770 Kcal/Kg (depending on ripeness and processing) and its supply of micronutrients such as iron and zinc is well known (Babatunde, Omotesho, and Sholotan 2007)[1]. Its contribution then in eliminating hunger and poverty, a pre-requisite for achieving all the other targets of the Millennium Development Goals, cannot be overemphasized (FAO 2005).

The plantain projects promoted integrated crop and pest management (ICPM); they recommend use of improved disease resistant germplasm, organic manures and mulches, insecticides (including nematicides), fungicides, herbicides and inorganic fertiliser (Owusu-Benoah Anno-Nyako, Egyir, and Banful 2007; Ekboir, and Dankyi 2002). This was because farmer indigenous practices alone led to low yields. Yield levels in 1990 were estimated at 5.5 Mt/Ha; with the ICPM projects, it was anticipated that yields could improve to over 9 Mt/Ha by year 2000 and approach the experimental plot level of 30 Mt/Ha in subsequent years. Due to logging for timber and cocoa production, soil fertility in forested areas in Ghana has declined and weed control is becoming more difficult. In addition viral and fungal diseases of plantain such as the black sigatoga, leaf spot, anthracnose and wilt as well as attack by pests such as nematodes and banana weevil eggs abound (Hauser 2006; and Godonou, Green, Oduro, Lomer, and Afreh-Nuamah 2000). Such factors and others that contribute to water deficiency lead to low turgor permitting pseudostem break and result in yield losses (Hauser 2006).

Apart from yield improvements from ICPM the positive income changes that the resulting increased supply offer is important because for small farmers, especially those based in rural areas, the income from off-farm activities that characterize livelihood strategies has not

[1] In Ghana, plantains are consumed at 5 different stages of ripeness. Fully ripe plantains are often deep fried or cooked in various pancake dishes. Green plantains are boiled and eaten in stew or mashed, together with boiled cassava, into a paste called *fufu*. A commercial dehydrated mix of *fufu* has been developed for the convenience of the urban middle-high income residents.

been adequate to meet households' needs (Akinsanmi, and Doppler 2005). In addition, it is observed that households in Ghana depended more (50-66 percent) on home produced root, tuber and plantain than all other food types (Asuming-Brempong 2004). As Ghana's 20 million population grow (estimated at 3 percent), increases in the supply of staple foods would be needed. The widespread use of productivity enhancing technologies would be necessary on plantain farms to ensure increased harvest. The range of such technologies and the extent to which small farmers are aware of and adopt them become an issue. It is also important to understand the factors that influence adoption for a guided change to take place, one that leads to including more of the excluded.

In 2006, a rapid appraisal of the agricultural, science, technology and innovation (ASTI) system related to plantain, showed that over 60 percent of the 57 farmer respondents had adopted for use a combination of fertilisers, herbicides and insecticides on their farms (Owusu-Benoah Anno-Nyako, Egyir, and Banful 2007). The study also showed that gross incomes from sale and age was among factors that were variable (albeit without statistical testing) across those who had adopted agro chemicals and those who had not. Other studies in Africa have shown that the greater influence to apply agrochemicals "would come from those expected to gain any experience in [tomato] production and less from unit changes in length of experience….the person who makes the decision has a strong influence in the increase of application of fungicides" (Lagat, Wangia, Njehia, and Ithinji 2007). These studies point to the fact that certain socio-economic factors influence adoption of agrochemicals. Many biological studies on plantain in Ghana have assessed effectiveness of agrochemicals on root and leaf health, use of disease resistant hybrids (agronomic, physio-chemical and sensory evaluation), and micro propagation, (Dzomeku, Osei-Owusu, Ankomah, Akyeampong, and Darkey 2006; Lamptey, Dzomeku, Anno-Nyako, Banful, and Hughes 2007 and Crouch, Crouch, Madsen, Vuylsteke, and Ortiz 2000); others have described the constraints to agrochemical use and issues in crop protection policy (Dankyi, Dzomeku, Anno-Nyako, Adu-Appiah, and Gyamera-Antwi 2007; Willamson 2003; Ekboir, and Dankyi 2002 and Gerken, Suglo, and Braun 2001). What have not been adequately discussed are the socioeconomic and institutional determinants of adoption of agrochemicals by small scale plantain farmers.

Therefore, the objective of this paper is to find factors that influence small scale plantain farmers' decision to adopt productivity-enhancing technology in Ghana, using agrochemicals as example. The factors in this study included farmer characteristics as well as institutional characteristics. The gap between current plantain yields (9.7Mt/Ha) and the potential (30Mt/Ha) suggest that inadequate knowledge, skills and practices persist or the issue of stakeholder linkages and funds for investment need further attention. The ASTI approach to socio-economic data collection and analysis is towards a better understanding of the policy environment and its links with barriers of poor market infrastructure and prices, illiteracy, low capital, soci-cultural biases and poor technical capabilities that keep the poor outside the circle of progress.

Methodological Approach

It is noted that the ICPM projects involved adoption of scientific knowledge and technical innovation. However, meeting the resource requirements of the ICPM is a major barrier that keeps the poor outside the circle of progress. Those who will strive to meet the requirements expect a high return. It is said that, technical change (that agrochemicals bring about on plantain farms) is induced by price signals in the market provided that prices efficiently reflect changes in the demand and supply of products and factors and that there exists effective interaction among farmers, public research institutions and private agricultural supply [and marketing] firms (Bretschger 2004; Ruttan and Hayami 1998). This is the situation of an effective agricultural science, technology and innovation (ASTI) system. In this system there is the policy environment within which actors of a subsector operate and link up with one another (CTA, 2005). An effective policy environment allows competition and adequate pricing and actors respond by changing habits and practices (innovate) and improve functions and performance. Indeed, studies have shown that innovative measures that do not demonstrate profitability in the short to medium term may be short lived with small and resource poor farmers (Asamlu 2006; Baidu-Forson 1999).

As such it is assumed here that plantain farmers are induced by shifts in relative prices to search for technical alternatives that save the increasingly scarce factors of production, organic fertilizers and pesticides[2]. Therefore in deciding to adopt agrochemicals, it is assumed that plantain farmers weigh the expected utility of wealth from adoption represented as $U^{A}(\pi)$, and the expected utility of wealth from non-adoption represented as $U^{N}(\pi)$ where π represented wealth (net farm returns), and adoption occurs if $U^{A}(\pi) > U^{N}(\pi)$, assuming that a farmer is risk neutral. The parameters of this decision are not observable, but can be represented by a latent variable $U(\pi)=1$ if $U^{A}(\pi) > U^{N}(\pi)$, and $U(\pi)=0$ if $U^{A}(\pi) < U^{N}(\pi)$, We can drop the superscripts for exposition and express the utility of adoption $U(\pi)$ as related to a set of explanatory variables X as:

$$U(\pi) = \mathrm{X}_i^{'}\beta + \varepsilon_i \qquad (1)$$

[2] The organic manures and mulches as well as botanic pesticides are more environmentally friendly. However, markets for these were not available; farmers were taught to manufacture their own if desired. It made such commodities the scarcer alternatives to agrochemicals.

where variables in X include characteristics of the farmer and resource characteristics of the farm, β is a vector of parameters and ε is a random error term. The dependent variable U is binary: U takes value 1 if adoption occurred and value 0 if adoption did not occur. The probability of farmers' adoption of chemicals can be expressed as:

$$Prob(U = 1 \mid X) = \Pr obU^{A}(\pi) > U^{N}(\pi) = \Pr ob(\varepsilon_i > -X_i'\beta) \quad (2)$$

When ε_i has a symmetric distribution, this probability can be expressed as:

$$Prob(\varepsilon_i < \mathbf{X}_i'\boldsymbol{\beta}) = \Phi(\mathbf{X}_i'\boldsymbol{\beta}) \quad (3)$$

where $\Phi(\bullet)$ is a symmetric cumulative density function, assuming that $\Phi(\bullet)$ is a standard normal cumulative distribution function.

The following hypotheses have been drawn to be tested by the model:

(1) Farmers' age, gender and education, immigrant status, locality and farm size may affect the adoption of agrochemicals;

(2) Contact with institutions such as extension services, FBOs and NGOs may lead to easier access of agrochemical input and information and adoption;

(3) Previous experience with agrochemicals and motive for plantain cultivation may increase the probability of adoption;

(4) Household's previous income level from plantain may affect the adoption; and

(5) Availability of markets for credit and the agrochemical inputs may increase the probability of adoption.

Empirical Model

Table 1 presents descriptive statistics of the data comparing the main variables between adopters and non-adopters of agrochemicals in plantain production. Definitions of variables used in the probit model employed are listed in Table 2. Following the extant literature on the impact of socio economic factors on technology adoption (see for example, Lagat, Wangia, Njehia, and Ithinji 2007; Amsalu, and De Graaff 2007; Baidu-Forson 1999), the age of farmer (*AGE*), gender of farmer (*GENDER*), residential status (RES), farm size (*FMSIZE*) and living close to Accra (DISTANCE) are included in the model to test hypothesis (1). To estimate the possible impact of education level (EDUC), motive of farming (MOTIVE) and experiences (YEARS) of plantain farmers on the adoption of agrochemicals, illiteracy, subsistence motive and inexperience are taken as the omitted category. Household contact with technical information agents such as the extension services and agricultural research institutes (EXTN), farmer-based organizations (FBO) and non-governmental organizations (NGO) was used to test impacts on the adoption. The adoption of agrochemicals requires extra investments and incentives so the farmer's gross income from plantain sales from the previous season measured in 2006 (INCOME) was also included in the adoption probability model. Access to the technology and credit are important determinants of technology adoption and therefore variables capturing whether the farmer was had access to financial institutions (FIN) and complementary machinery (HI-TECH) were included. In addition ability to pay for hired labour (LABOUR) and manage cash crops may be an added motivation to adopt agrochemicals.

TABLE 1&2 [HERE]

Data Collection

The collection of data for analysis was based on the five-component ASTI analysis framework developed by the CTA in 2004 (Figure 3). In this framework, the first stage involved, policy review of the plantain subsector[5], followed by an identification and classification of key plantain actors into five categories: market demand, enterprises, diffusion, research and training and infrastructure development (CTA, 2005).

[FIGURE 3 HERE]

The third stage involved collecting socio-economic data indicating key actors' (here farmer) characteristics, competencies and innovativeness while the fourth stage focused on collecting data with regards to functions of other key actors (here traders, research institutes, input dealers, rural banks, NGOs and FBOs). The final stage involved mapping the linkages between farmers and the other key actors.

The method of primary data collection included group discussions at workshops and sample surveys. At initial and final validation meetings of 30 actor representatives in each of four major plantain growing regions, the actor categories, characteristics, functions and linkages were identified. The regions are the Ashanti, Brong-Ahafo, Eastern and Western and the communities visited were villages around Konongo, Kenyasi, Koforidua and Sewhi Wiawso respectively. These regions are the first four among six major plantain growing regions in Ghana (Owusu-Benoah Anno-Nyako, Egyir, and Banful 2007)[6]. Communities in the Eastern region (capital Koforidua) and Ashanti region (capital Kumasi) are closer to Accra, the capital of

[5] See the following documents: Development Plans of Ghana (1961- 1999) and policy documents of the Ministries of Food and Agriculture, Education, Science and Technology, Communication and Trade and Industry.
[6] The two others are Central region (capital Cape Coast) and Volta region (capital, Ho) (see Appendix 1)

Ghana, than the others in the far Northwest. Several types of productivity enhancing technologies have been promoted among farmers in the forest zone, including integrated pest management, new cultivar development and testing, micro-propagation and alley farming. Extension activities on agrochemical use were conducted by research and development agencies such as the Crop Research Institute, the Universities of Ghana and the Ministry of Food and Agriculture using funding from the International Development research centre (IDRC), World Bank, United States Agency for International Development (USAID), Gatsby Charitable Foundation and the government of France (Owusu-Benoah Anno-Nyako, Egyir, and Banful 2007).

Given this, villages in the regions were first stratified based on whether they have had plantain projects or not. Farmers were representatively selected from villages that have had exposure and from villages without exposure to projects. Stratified random sampling was used to identify 249 farmers[9] (agrochemical adopters and non-adopters) in 16 villages across the regions. Gender balance was also incorporated in the sample. The women included consisted of women (single/married) who owned plots. In general, women in Southern Ghana get access to land via their parents since the matrilineal system of inheritance allow females to inherit land or have use rights on family/clan/village land.

Coded structured questionnaires were used as survey instruments. The questionnaires were first pretested with 20 farmers in all four regions during the initial workshops, and then revised to incorporate farmers' suggestions on the dynamics of agrochemicals and other innovations on their farms and in the district. District-level data were collected from group discussions with selected actor representatives during workshops held at the district capitals.

[9] This includes the initial CTA sample of 57 respondents.

Actors were to rate on a scale the relative intensity of specific district factors such as land tenure and access to land, status of soil infertility, incidence of pest/disease intensity, organic manure and botanical pesticide scarcity, importance of non-farm income, availability of input dealers, financial institutions and contact with farmer-based organizations, non-governmental organizations or research or extension services involved in agrochemical research or extension. These factors and other socioeconomic data were also collected individually from farmers. The socioeconomic data included age, education (9 years or more of formal schooling), gender, years of experience in plantain farming, origin (migrant or native), motive for farming (subsistent or commercial), membership of farmer association, and farmers' adoption and use of agro chemicals including fertilizer, herbicide, fungicide and/ or insecticides. During focus group discussions, data were also collected on farmers' perceptions of yield trends under agrochemicals compared to adjacent fields that do not apply agrochemicals.

Results and Discussions

The review of the plantain ASTI system in Ghana suggested that there was a broad agricultural policy and other sectoral policies that supported the development of the plantain subsector. There are specific public-funded institutions for research and extension; private sector markets for input supply, credit and transportation; and non-governmental development partners. The functioning of the key actors was just fair since the roles were well understood yet budgetary constraints limited performance of planned actions. Thus there was some collaboration among the key plantain actors: linkages between farmers and other business actors were fairly strong since it was based on exchange of commercial goods and services and payments. The linkages between farmers and research and diffusion agencies were just fair. The contacts were not as regular as desired and information flows were not always effective. However, the econometric model results showed that the impact on farmers of any new introduction into the plantain system was determined by not only the institutional framework but also the socio-economic characteristics of the farmers.

The probit model was estimated with Whites heteroskedastic consistent estimator. The coefficients, their standard errors, and significance levels are listed in Table 3. Overall the estimated probit model was significant. The Likelihood Ratio was 84.22 ($p<0.000$). The pseudo R^2 was 0.54 and the model correctly predicted 94 percent of the sample. The results from the probit estimation show that certain socio demographic and institutional factors are important in explaining agrochemical adoption among plantain farmers. The results identified a positive and statistically significant influence of age (*AGE*) and education (*EDUC*) on the probability of pesticide adoption. Indeed the age variable suggests older farmers tend to adopt more than younger farmers. This result should also be cast in light of the fact that in the Forest Zone, a large percentage of plantain is intercropped with cocoa and most farmers start managing cocoa in older age when they have inherited farms or accumulated capital. Literate farmers tend to read, participate in relevant fora listen to and find out more for themselves. The probability of adoption given literacy is 81 percent, making this factor the greatest driver of innovation adoption.

The farmer's gender had a negative but statistically insignificant coefficient in the model. It is important to discuss the implications of this result. Contrary to previous studies suggesting gendered patterns in adoption due to women's limited access to resources including land and credit (Adesina et al. 2002; http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T3Y-40GJ04C-6&_user=1067211&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000051237&_v

ersion=1&_urlVersion=0&_userid=1067211&md5=dc0c2023552d0a70eeb4a4b6ca2a3512 - bib15Tonye 1997) the results suggest no significance difference between male and female farmers.

[TABLE 3 HERE]

However, this result is similar to that of Doss, and Moriss (2001) who observed that, the adoption of maize varieties (MVs) and fertilizer is not associated with the gender of maize farmers in Ghana. This may be due to increased efforts by government policy as well as development agents in widening opportunities for hitherto vulnerable groups especially women. Indeed at 11 percent significant level, there is a 6 percent probability that women farmers would adopt agrochemicals rather than men.

The number of years that farmers had been growing plantain was negative and statistically significant, although the percentage change is negligible (0.4%)[7]. The general indication is that individuals with more experience in plantain farming were less likely to adopt agrochemicals perhaps reflecting their experience. New farmers may view the new knowledge and practice as an alternative worth trying. Then, when it worked it was sustained. The results also suggest that farm size (FMSIZE) is negatively correlated with the adoption of chemicals by plantain farmers. This result is quite intuitive as it suggests that farmers faced with limited land intensify production through use of commercial and productivity enhancing inputs. The percentage increase in likelihood is about 15 percent. Interestingly also, those who are considered migrants tended to adopt agrochemical use, probably because they have smaller farm sizes and have commercial motives. Indeed, MOTIVE is positively correlated with adoption of chemicals, though statistically insignificant.

[7] We included a variable YEARS squared but it did not change the results.

That the coefficient on the distance from Greater Accra (DISTANCE) is negative and statistically significant is unexpected. Accra is the capital and largest city in terms of population of consumers, traders and processors. It was expected that farmers located closer (two hundred kilometres) to Accra would take advantage of the available ready market and adopt innovations that lead to volume expansion. The results may seem counterintuitive but should be seen in the light that development agents (with information and credit, among others) target areas away from Accra, which reduces the informational constraints to adoption by farmers away from Accra. Other factors could also be that, farmers near Accra may be less likely to adopt because they have more sources of non-farm occupation (Amsalu, and De Graaff 2006). In addition the supply chains of plantains are managed by long distance wholesale traders who organise packaging and transportation at origin for delivery to all major urban centres, meaning that even long distance farmers with access to these wholesalers can expand production.

An important limitation of adopting chemicals could be the costs of purchasing chemicals. Assessing the effect of this cost in the adoption decision was captured by including the variable net income from plantain in the previous season (*INCOME*) in the adoption decision model. The estimated coefficient indicated that households with higher net incomes from plantain in the previous season had a higher probability of adopting chemicals. This results is consistent with previous studies (Abdulai and Binder, 2006; Moser and Barret, 2003) which suggests that gross income from sale of produce is the major source of funds for most producers; hence the larger it is the more likely farmers can re-invest part in innovations, suggesting the importance of demonstrating profitability of innovative measures (Asamlu 2006; Baidu-Forson 1999). Indeed, the mean yield of adopters was 57 percent higher than that of non-adopters (see table 1); since the market price is one, volume expansion that comes from adopting productivity enhancing technologies is as critical a factor as output price increases. It appears that having other cash crop farm negatively influenced adoption of agro-chemical on plantain; such farmers probably treat plantain as a subsistence activity for household food only and do not consider high yielding innovations.

Having access to spraying machine (HI-TECH) was positive and statistically significant and the result is quite intuitive; the machines are needed for effective application of agrochemicals. The probability of adoption increases by 18 percent. Having access to a formal information especially through links with government extension services as well as access to credit were positive and statistically significant (see also Abdulai and Binder 2006 and Moser and Barrett 2003). Two reasons may explain this result, the first being that farmers with access to information and credit have easier access to agrochemicals (perhaps with option not to pay spot for the input), and such farmers try to be a good example to others. The effect of farmer linkages with extension services and financial institutions suggests that linkages between farmers and holders of capital (including knowledge, money and the agrochemicals) are important. Currently, the policy in Ghana is to decentralise access to research and market information by engaging district level extension services departments; messages are repackaged in local content and diffused among farmers by extension officers. It is shown that with effective linkage with government extension and financial institutions the probability of adopting agro-chemicals will increase by about 16 percent and 11 percent respectively. Plantain farmers may need small loans (up to GH¢300.00) to cover expenses on agrochemicals[8]. The government extension services usually collaborate with NGOs and FBOs. It is thus interesting that the variables NGO and FBO

[8] 1 hectare of plantain farm requires 6 (50kg) bags of fertilizer, 3 litres of herbicide and 3litres of insecticides plus hiring of spraying machine (and a sprayer, for farmers with low competency in spraying). In 2006, fertiliser price (for say 50Kg NPK) was GH¢20.20; herbicide (say 1L Round-up) price was GH¢6.30 and spraying machine (manual) price was GH¢50.00. The spraying fee per hectare (for machine hire and spraying) was GH¢12.00.

were not significant. The NGOs support not only the extension services but also the Environmental Protection Agency that trains input dealers who double as pest control agents. It is supposed that FBOs are easy to organise for training and effective dissemination of technical information. Increased adoption of agrochemicals suggests that the issue of safe handling need priority attention and the functions of NGOs and FBO would need further re-orientation.

Conclusion

The plantain subsector in Ghana can contribute more to food security and economy growth if farmers are motivated to adopt productivity enhancing technologies such as agrochemicals for managing pests and diseases and soil infertility. The objective of this research was to determine factors influencing farmers' decisions to adopt agrochemicals in plantain production in Ghana. The current policy is to apply agrochemicals as a last resort in pest and soil fertility management. The data collection and analysis framework involved an assement of the agricultural science, technology and innovation (ASTI) system of plantain. The policy environment that support markets and allow actors to function and perform through linkages was reviewed. A probit model was constructed, based on a survey, to estimate coefficients in farmer characteristics, resource characteristics of the farm and institutional characteristics on the probability of agrochemical adoption in Ghana.

Most of the econometric research results were similar to other studies in developing countries, while some were different from other studies. Somewhat different from other studies but similar to that of Doss, and Morris (2001), is the fact that there was no statistically significant difference in adoption behavior/pattern between male and female plantain farmers. Like other studies, the results suggest that the age and education of the farmer as well as linkages with capital and information providers, particularly government extension agents had an impact on adoption. This finding was consistent with the results of Abdulai and Binder (2006) and Moser and Barrett (2003).

From the aspects of resource characteristics of the farm, large farms located close to the national capital city Accra were associated with smaller adoption probabilities than small farms located in remoter areas. This reinforces the inputs saving nature of agrochemicals and inclusiveness of remote populations in technical information dissemination. An important limitation of adopting chemicals in plantain could be the cost; farmers who had registered higher net sales from plantain in the previous season had a higher probability of adopting chemicals. These results have strong implications to the extension of productivity enhancing technologies in plantain farmers in rural areas of Ghana. The results reinforce the fact that the efforts by the government of Ghana on modernizing agriculture should include staples such as plantain. Plantain farmer practices towards adoption of productivity enhancing technologies are improving; there is growth in yields and income. The results of the study show that extension service is an effective instrument. If government encourages farmers in remote areas to participate in extension services and provides them with opportunity to get the experience of inputs saving technology, then the technology could be adopted by more farmers. Public investment in rural extension institutions, in conjunction with appropriate actions from non-governmental development agents would have significant effects beyond immediate outcome. It is noted that development agents such as NGOs and FBOs working alone may not have adequate impact.

Policy can focus on three key areas. The first is to target plantain technologies in remote locations that may not have abundant land for expansion and where probability of adoption is high. Second, there is the need to provide extension education that demonstrates risk reduction capacities of no-tillage, soil fertility improvement, and insect/nematode/fungi management techniques. This will make available information capable of stimulating adoption of agrochemical that complements traditional cultural practices on plantain farms. Third, local institutions that hold capital resources, whether governmental or non governmental need to be encouraged and strengthened to intensify linkages with plantain farmers. Such institutions would be depended upon to bring the young, illiterate, low income and indigene farmers up to be part of the science, technology and innovation system in Ghana. Then, the policy environment in enhancing competencies and performance of actors of the plantain system in relation to innovativeness as well as the effectiveness of linkages among them would be fully realized.

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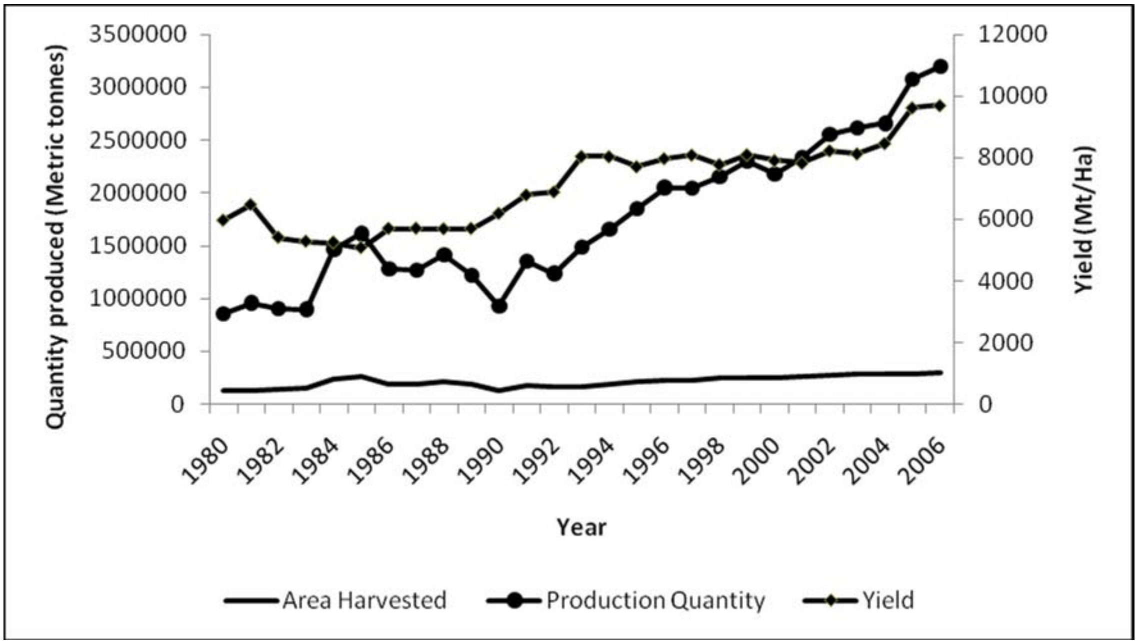
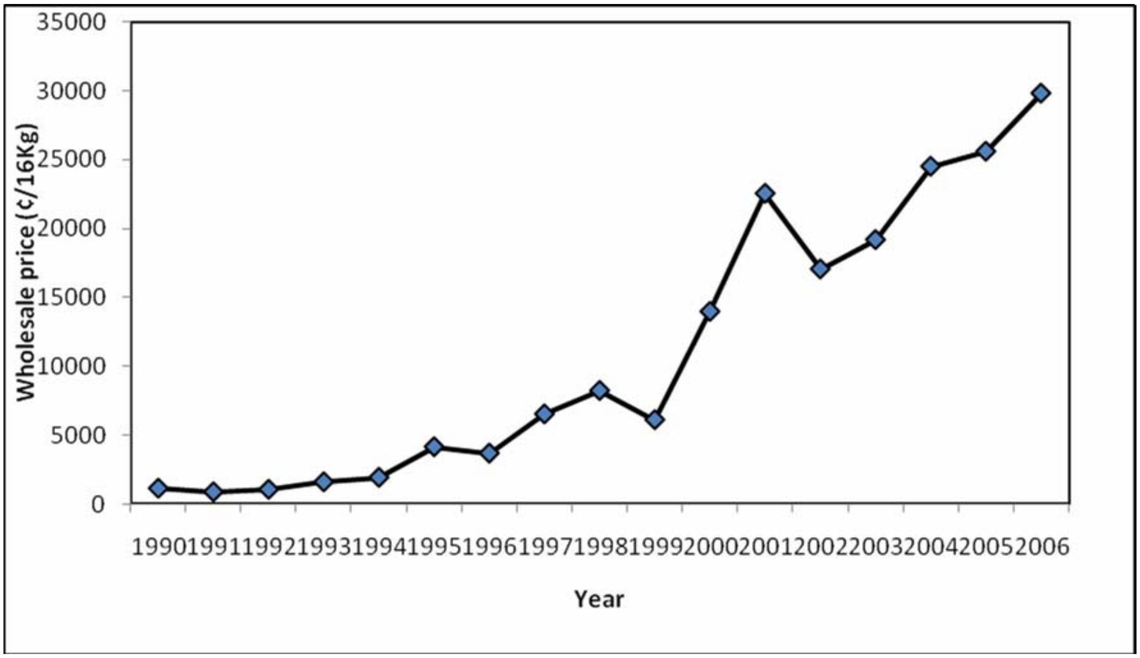
Figure 1
Production, area and yield of plantain, 1980-2006



Source: Raw data from FAOstats

Figure 2
Nominal wholesale price of plantain in Ghana, 1990-2006



Source: Raw data from FAOstats

Figure 3
Stages in the CTA ASTI systems analysis framework

Review of policy framework concerning agriculture

↓

Identification of key actors in the system (farmers; traders; processors; consumers; extension services; research; District Assemblies; financial institutions; input dealers; non-governmental organizations (NGOs))

↓

Assessment of innovations in the habits and practices, competencies and performance of Actors (socio-economic characteristics)

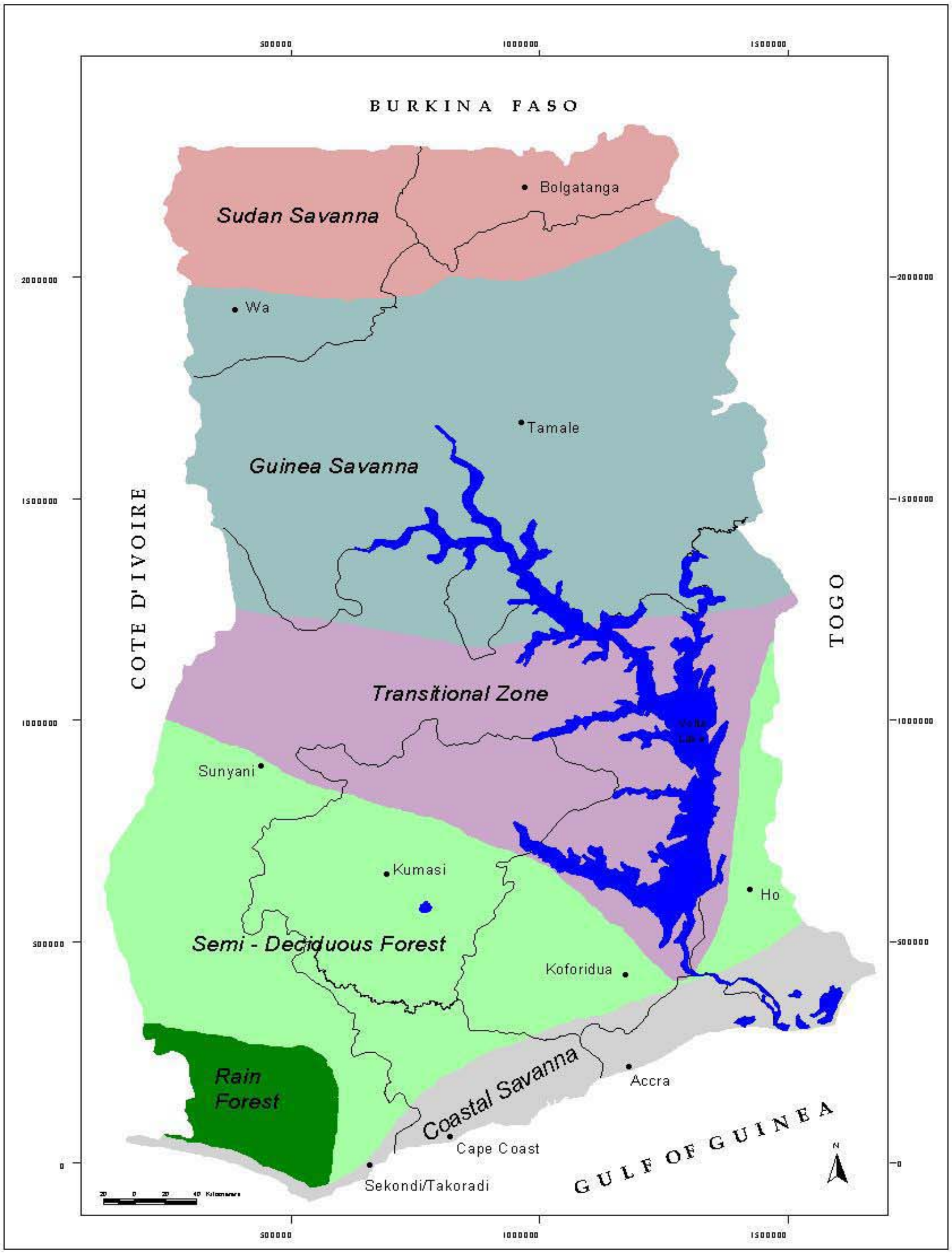
↓

Assessment of effectiveness of key functions of Actors

↓

Mapping of strength of innovative linkage strategies among various actors

Appendix 1
Ghana: Agroecological zones



Source: Benneh & Aggyepong (1990)

Table 1

Comparing adopter/non-adopter characteristics

Variables	Adopters N=159 (64%)	Non-Adopters N=90 (36%)	All N=249 (100%)
Gender			
% male	76	58	71
% female	24	42	29
Mean age	46	45	45.8
Marital status			
%Married	89	87	88
%Not married	11	13	12
Immigrant status			
% Indigene	55	70	60
%Migrant	45	30	40
Geographical location			
%Proximity to Accra	57	37	49
%Distant from Accra	43	63	51
Education			
%Illiterate	3	32	11
% Literate	97	68	89
Mean years in plantain farming	12	17	14
Motive of farming			
%Subsistent	23	13	30
%Commercial	77	87	70
Mean land area (Ha)	0.96	1.03	0.99
Major source of labour			
% Own, Family and friends	26	20	24
% Hired	74	80	76

Table 1 cont'd:

Variables	Adopter N=159	Non-Adopter N=90	All N=249
Mean seasonal gains from sale	569.00	180.00	428.69
Mean yield in 2006 (Mt/Ha)	11.8	7.5	9.7
Access to other machinery			
% Yes	59	4	28
%No	41	96	72
Use of credit			
%Yes	67	19	28
% No	33	81	72
	47.80	32.22	
Mean amount of credit (GH¢)			
Member of Farmer-based organization (FBO)			
%Yes	9	0	6
% No	91	100	94
Major source of information			
%Formal	78	59	81
%Informal	22	41	29
Linkages with:			
MoFA Extension	74	62	70
Farmer-based organization (FBO)	19	6	30
Financial institutions	25	9	19
Input dealers	15	6	12
Research institutions	18	24	15
NGOs	11	13	12
District assembly	33	24	12

Table 2

Sample statistics of variables used in the empirical econometric model

Variable	Mean	Standard Deviation	Minimum	Maximum
GENDER (dummy, gender of farmer)	0.6948	0.4614	0	1
AGE (age of farmer)	45.8072	10.8172	26	78
EDUC (dummy, literacy status)	0.8675	0.3397	0	1
RES (residential status)	0.6024	0.4904	0	1
DISTANCE (proximity to Accra)	0.4940	0.5010	0	1
YEARS (years in plantain farming)	13.9357	10.3614	2	42
FMSIZE (size of farm in Ha)	0.9894	0.6348	0.2	3.24
MOTIVE (key motive for farming)	0.8072	0.3953	0	1
INCOME (value of plantain sales in 2006)	428.6900	595.1100	0	4000
CASH (own cash crop farm)	0.7510	0.4333	0	1
LABOUR (afford hired labour)	0.7630	0.4260	0	1
HI-TECH (access to spraying machine)	0.2271	0.4486	0	1
INPUT (links with input dealers)	0.1165	0.3214	0	1
FIN (relationship with financial inst.)	0.1928	0.3953	0	1
EXTN (formal source of information)	0.7108	0.4543	0	1
FBO (links with formal farmer group)	0.1406	0.3483	0	1
NGO (links with NGOs)	0.1165	0.3214	0	1

Table 3

Results of probit regression of adoption of agrochemicals on plantain farms

Variable	Coefficient	Robust Std error	Marginal effects
Constant	0.631	0.602	-
AGE	1.514*	0.278	0.292
GENDER	-0.453	0.279	-0.058
RES	-2.058*	0.299	-0.273
EDUC	2.625*	0.418	0.766
YEARS	-0.029***	0.015	-0.004
FMSIZE	-0.926**	0.461	-0.135
MOTIVE	0.162	0.482	0.025
DISTANCE	-1.940*	0.371	-0.322
INCOME	6.41e-07*	1.17e-07	9.36e-08
CASH	-1.679*	0.368	0.155
LABOUR	-1.979*	0.332	0.169
HI-TECH	1.854*	0.392	0.180
EXTN	0.851**	0.338	0.157
FIN	1.325*	0.371	0.116
NGO	0.350	0.552	0.042
FBO	-0.699	0.464	-0.142
Number of observations		249	
Percent correctly predicted		92.18	
Wald chi2(16)		187.10	
Prob >chi2		0.000	
Log-pseudo likelihood value		-66.662	
Pseudo R-squared		0.591	

= significant at 1%, **=significant at 5 percent, *=10%*
Note: The Stata software was used in this analysis