Pesticide Use Practices, Productivity and Farmers' Health:

The Case of Cotton-Rice Systems in Côte d'Ivoire, West Africa

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To

THE LORD JESUS CHRIST - for turning my life around for the better

My PARENTS - for their vision

DEOLA, TOFUNMI, and SOOTO - for their sacrificial love

Preface

Growing concern about the widening food insecurity and hunger in the world has led to various approaches to intensify food production systems and raise productivity. Aside from increased use of chemical fertilizers, farmers are increasingly encouraged to also apply pesticides to control pests. Often painted as the panacea by many for pest problems, pesticides have been pushed to poor farmers with various policy incentives. Until recently, policy makers paid little attention to the negative effects of pesticide use as long as the productivity enhancing effects were visible.

However, overuse of pesticides leads to both direct and indirect costs for farmers and the society. Indirect costs include negative externalities such as effects on human health, degradation of the environment, loss of bio-diversity, irreversible changes in the natural ecosystems, leading to even greater future costs for controlling pests. The divergence between the private and social costs of pesticide use, arising from market failure, missing markets, and externalities, have led many to question the real benefits of pesticide use. Productivity effects of pesticide use may indeed be overvalued, as studies rarely take into consideration these direct and indirect costs on the environment and farmer health. This study uses a holistic economic and bio-medical approach to critically evaluate the productivity and health effects of pesticide use by cotton growing farmers in northern region of Côte d'Ivoire.

Rapid shifts in cropping systems can have serious consequences on the pest distribution and their dynamics within the ecosystems. As farmers move from mixed cropping systems to more intensified mono-cropping systems; tendency is for the level of pest population to rise. Increased pest populations from such system intensification leads researchers and extension workers to recommend 'immediate solutions' - often increased use of pesticides.

This study shows that with cotton intensification, farmers have moved to a permanent system of mono-cropped cotton with historically high levels of dependence and use of pesticides. However, while cropping intensification can lead to increase in yields today, reliance on pesticides can lead to increased future costs of control if such levels of use leads to breakdown in the ecological balance between the pests and their predators. Experience with the major outbreak of the brown planthopper in rice systems in Asia in the 1970's showed that overuse of pesticides can cause destruction of natural enemy populations, pest resistance, development of biotypes and outbreak of pests. Cursory evidence from this study reveals that cotton intensification is already leading to the development of pest resistance for cotton pests, further reinforcing farmers reliance on pesticides. There is clear need for the development of integrated pest management for cotton-based systems across West Africa. Lessons can be learnt from the highly successful experience of the ‘farmer field schools’ in South East Asia that led to major reductions in the levels of use of pesticides among farmers.

The author argues convincingly that the cotton parastatal company (CIDT) has over the years systematically discouraged farmers from the use of other pest management practices. It has achieved this via the use of pro-pesticide extension systems, and use of credit, input and output pricing arrangements that encourages farmers to buy pesticides to achieve higher cotton yields. Farmers in the cotton zone are thus bound to use pesticides, even when the economics of its use is very questionable. The study also reveals that these pro-pesticide policy arrangements have led to erosion of the indigenous pest management practices among the farmers. Farmers are not exposed to integrated pest management (IPM) approaches. Thus, they systematically over-estimate the damage from pests and overuse pesticides. This ‘information gap’ needs to be closed. This can be done by providing information provision on alternative pest control methods to farmers, supported by farmer training (perhaps through farmer field schools) to improve their understanding of pest population, their dynamics and how to manage them in an ecologically sound manner.

The study shows that there is already evidence of declining returns to the use of pesticides within the cotton system. Estimates from production function analysis shows that fertilizer, herbicides, insecticides and labor were the major factors affecting yield of cotton. However, the inelastic production elasticity for insecticides suggests that the marginal productivity of use of insecticide is less than the marginal cost of the input, which should suggest that farmers should be using less. In the absence of such information to farmers, extension agents continue to encourage further pesticide use. An important finding in this study is that the marginal productivity of insecticide use is higher in areas with longer history of pesticide use, than in areas with short history of use. This suggests that the systems in the former may already be experiencing degradation of the biological ecosystem, further widening the gap between the yields obtained without pesticides and that obtained with pesticide use.

The effects of pesticides on farmers health are extremely important, yet they are under reported in national statistics on pesticide use, due to overly biased focus on the productivity effects of pesticides. Non consideration of the health costs (both direct and indirect), when combined with lack of consideration of other negative environmental externality effects leads to over-estimates of the benefits from pesticide use. This study provides the first of such estimates for cotton growers in Cote d'Ivoire, using a bio-medical approach that examines the direct health costs due to exposure to pesticides. Findings point out that households in areas with longer experience in pesticide use have significantly greater exposure to pesticide effects. The likelihood of falling sick was much higher for farmers with exposure than those non-exposed. These results suggest that efforts are needed to inform policy decision-makers of the productivity-reducing effects of pesticide use due to morbidity effects on labor. These effects are even likely to be higher today with the advent of HIV-AIDS pandemic and its impacts on agriculture via labor morbidity. Long term chronic effects of pesticide use on farmers health are very important to take into consideration in the design of agricultural and public health policies. Efforts to reduce pesticide use must therefore take an intersectoral and holistic approach.

One of gaps in this book is the non-consideration of the role of multiple pest resistance in reducing farmers dependency on pesticides. While several studies have been done in Africa on the rates of returns to variety development research, very little research has yet examined the social rates of returns to technical change from multiple-pest resistance. The use of varieties with multiple pest resistance will significantly lower pesticide use and effects on farmers health, while raising (and stabilizing) yields. Rapid advances in biotechnology holds the promise for the development of cotton varieties that produce their own natural pesticides with the incorporation of genes of *Bacillus thuringiensis* Berliner gene (*Bt*-Cotton). Policy makers need to look into how to promote such application of modern science to solve the current problems of overuse of pesticides by cotton farmers and arrest its negative effects on farmers health.

This study clearly advances the discussion on how to develop informed policy decisions on the use of pesticides for smallholder farmers in the cotton zone of Côte d'Ivoire. The approach used focused mainly on detailed farm-level production and health data. The study's findings have implications for all the cotton-based farming systems in West Africa where cotton companies continue to systematically promote pesticides.

Future studies can build on this work to examine effects of sectoral and macroeconomic policies on the private and social benefits from the use of alternative pest control technologies, including integrated pest management. The author of this study has provided very interesting and illuminating evidence that suggests the need for such policy analysis. The book will be very valuable for academics, researchers, extension workers, health sector officials, and policy makers and donors, interested in finding environmentally viable and cost-effective strategies for controlling pests on farmers fields.

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The Rockefeller Foundation

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Olu AJAYI

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Executive Summary

Due to several policies that promote pesticide use, the crop protection strategy in many African and developing countries relies essentially on pesticides. In some countries and especially in the cash crop sector, the adoption of less chemical-dependent crop protection methods takes place on a relatively lower scale. In Côte d'Ivoire, the 100% subsidy on pesticides in the past and the on-going credit-financing of chemicals are part of the economic policies that have led to a very rapid rate of increase in pesticide use particularly in the cotton sub-sector.

Despite that rapid increase in pesticide use in Côte d'Ivoire, no study has been undertaken to evaluate the productivity of pesticides or their effects on the natural biological resource base of the production system. The misuse of pesticides by farmers (as documented in previous studies) indicates that farmers' health may be at risk, but the extent of this risk among Ivorian farm households remains largely unknown. In addition, farmers' knowledge and perception of pesticides, the extent of deviation of field level pesticide practices from recommendations, and the underlying reasons for such deviations have not been well understood. These three problems underline the main objectives of this study.

A total of 165 households and 193 cotton fields were selected from the cotton-rice region, using the technique of stratified random sampling. Data include agro-economic and health economic information that were collected weekly. Structured questionnaire on farm household's knowledge, attitude and practices (KAP) were administered on all collaborating households. In addition, bio-medical blood tests and laboratory residue analysis were carried out. The data were analyzed using alternative specification of the "damage function" models and logit models.

The study is organized into ten chapters. Chapter **one** introduces the study. The underlining problem and the objectives of the study are stated. The **second** chapter synthesizes the results obtained from previous studies on pesticide productivity. The synthesis identifies that the change in the natural resource base of an ecosystem is one of the missing links to explain the productivity paradox (high estimates) that were obtained in earlier efforts on pesticide productivity measurements. The synthesis is followed by a discussion on the conceptual and theoretical framework for filling in some of the missing gaps in pesticide productivity estimation. In chapter **three**, an overview of the general economic development of Côte d'Ivoire is discussed with special reference to

economic and agricultural policies on crop protection that have been adopted by Côte d'Ivoire. This study reveals that various price and non-price policies play vital roles in the evolution of agriculture – and the crop protection sector in particular — in northern Côte d'Ivoire. The historical antecedents and the type of policies that were adopted in the crop protection sector inadvertently affected the outcomes of agricultural practices among farm households in the later period. The antecedent policies have also determined the dominant crop protection practices in the country.

Chapter **four** focuses on the research methodology of the study. The details of the multi-stage sampling technique that was used to select farmers are given. The type of data that were collected and the methodology of data collection are also provided in the chapter. In chapter **five,** the geographical, socio-cultural and the agricultural economy of the study area are presented. The results show that there is a strong integral reciprocal relationship and interdependence between the households and the farms. The former provides almost 90% of all the labor required to carry out field operations in the latter. Over the years, there has been a structural change in the farming enterprise in northern Côte d'Ivoire. Of particular importance is cotton that was a mere secondary crop (grown in association with other crops) about four decades ago, but has now emerged to be the most important crop (grown as a monocrop) in the present farming structure within the study area. Presently, cotton and rice crops alone make up 62% of the total cultivated crop field area.

In chapter **six**, the empirical information on farmers' knowledge, attitudes and practices (including indigenous practices) regarding pesticides and crop protection are analyzed. The potential opportunities and constraints to incorporate non chemical-based methods into crop protection technologies in the study region are highlighted. The study reveals that farmers respond to economic policies in making decisions on pesticide use. Opportunities for the adoption of IPM technology currently do exist in the region. But while technical feasibility/superiority of non-chemical crop protection methods (over pesticides) are necessary conditions, they are not sufficient to persuade farmers to use this 'new' methods. Appropriate economic policy and the favorable relationship between inputs and output prices are two of the complementary factors that should be taken into consideration in order to improve the crop protection strategy in northern Côte d'Ivoire. Part of this improvement may include the possible adoption of alternative (non chemical-based) crop protection practices that impose less negative health effects on farmers.

In chapter **seven**, the analytical procedures and the empirical models to compute pesticide productivity are specified. The productivity coefficients and marginal value products for pesticides in different production ecosystems are computed. The results show that in the geographical zones where pesticide use has a longer history, cotton production is comparatively *less* responsive (has a lower elasticity) to the application of insecticides (in terms of the quantity and the monetary value). The results reveal that the marginal value product of insecticides is greater than unity for the Cobb-Douglas model and the alternative damage function specifications (except Weibull model) that were suggested by LICHTENBERG and ZILBERMAN (1986). Given a strictly economic interpretation, the results imply that farmers should increase the amount of pesticides above what they are currently using. This implies that changing the functional specification of the production models *alone* does not explain all the paradoxons observed in the economic studies of pesticide productivity. However, the productivity estimates become more plausible for economic interpretation if the degradation of natural biological (capital) resources in relation to pesticides is taken into account. Special attention must be paid to the net effect of pesticides on the renewable and non-renewable biological capital resources in the interpretation of the productivity estimates of pesticides.

Chapter **eight** contains an empirical analysis of the pesticide-related human health symptoms in the study area. A framework to identify health costs of pesticide symptoms is presented. This is followed by a discussion of the methodology used to impute economic costs on the health symptoms that have been identified. The results clearly indicate that there are health problems associated with the use of pesticides in the study area. The health symptoms have multi-dimensional cost implications on the farm households ranging from expenses that are obvious and are directly associated with pesticide use to other costs that are indirectly linked to pesticides. The costs may also be grouped as ‘damage acceptance’, ‘preventive’, ‘mitigation’ and ‘unknown’ costs. Some of the costs were evaluated but others were only identified qualitatively. The economic value of the pesticide-related health costs that were evaluated was 2160 CFA per household and season. The amount of actual expenses that households incur on pesticide-related health symptoms is influenced by information about and the perception of pesticide symptoms among the farming community. Farmers in the study area tend to consider only fatal cases and acute health symptoms of pesticides, but discount the chronic health effects of the chemicals used. The probability to fall sick is four times higher among pesticide applicators than among non applicators living in the same household. But only in 2% of the actual pesticide-related health symptoms cases do the victim consult health centers for formal health assistance. In general, farm households *appear* to be aware of the possible health effects linked to pesticides but, when they have to make the choice between incurring (indirect) health costs and the use of farm inputs, farmers tend to give higher consideration to the latter. With the aid of logit models, the factors that influence the willingness of households to invest in health are identified. The relationship between exposure to pesticides and actual health expenses incurred by farm households is presented. Finally, the chapter ends with a discussion on the farm households' decision-making on pesticide-related symptoms. Chapter **nine** summarizes the findings of this study while chapter **ten** concludes on the technical and policy implications of the study results. Further areas of research relevant to this type of study are also suggested.

Zusammenfassung

Wie in vielen anderen Entwicklungsländern wird auch in Afrika der Einsatz von chemischen Pflanzenschutzmitteln (PSM) durch die staatliche Pflanzenschutzpolitik stärker gefördert als nicht-chemische Maßnahmen des Pflanzenschutzes. Côte d’Ivoire ist ein typisches Beispiel. Durch langjährige subventionierte Abgabe und teilweise sogar kostenlose Verteilung von Pestiziden hat der Einsatz von PSM besonders in der Baumwollproduktion sehr stark zugenommen. Unter allen Ländern Westafrikas ist Côte d'Ivoire heute das Land mit dem höchsten Intensitätsniveau an PSM im Baumwollanbau. Trotz der seit vielen Jahren andauernden Unterstützung des Pestizideinsatzes und des starken Anstiegs der Verbrauchsmengen wurde bisher in Côte d'Ivoire keine Untersuchung zur Produktivität von Pestiziden durchgeführt. Es gibt keine Information darüber, welche Auswirkungen die Anwendung von Pflanzenschutzmitteln auf die natürlichen Ressourcen und die Gesundheit der Anwender hat. Darüber hinaus ist das ökonomisch optimale Einsatzniveau von PSM nicht bekannt.

Die häufig zu beobachtende Mißachtung von Anwendungsvorschriften und die Tatsache, daß Schutzmaßnahmen bei der Ausbringung von PSM selten vorgenommen werden, läßt vermuten, daß der Einsatz von PSM im Baumwollanbau in Côte d'Ivoire die Gesundheit der Anwender ernsthaft gefährdet.

In der vorliegenden Arbeit wird der Versuch unternommen, die Grenzproduktivität des Insektizideinsatzes im Baumwollanau in Abhängigkeit vom Intensitätsniveau und der Dauer der Pestizidanwendung abzuschätzen. Das Ziel der Berechnungen besteht darin, festzustellen, ob der Einsatz von Pestiziden bereits zu einem Verlust an natürlichen Ressourcen geführt hat und ob damit Folgen für die menschliche Gesundheit verbunden sind, die zu meßbaren Kosten für die bäuerlichen Haushalte geführt haben.

Mit Hilfe einer stratifizierten Stichprobe wurden in der Baumwollzone von Côte d'Ivoire 165 Haushalte ausgewählt, wobei in einem Untersuchungsgebiet Pestizide bereits langjährig angewendet werden, während diese im anderen Gebiet erst seit relativ kurzer Zeit zum Einsatz kommen. Neben sozioökonomischen Daten der ausgewählten Betriebe wurden auf insgesamt 193 Baumwollfeldern agrarökonomische Daten erfaßt. Die Daten wurden bei wiederholten Besuchen auf wöchentlicher Basis erhoben. Weiterhin wurden biomedizinische Blutuntersuchungen und Laboruntersuchungen der Kleidung der

Pestizidanwender zur Rückstandsanalyse durchgeführt. Die Daten wurden mit Methoden der deskriptiven Statistik und der Produktionsfunktionsanalyse sowie mit logistischen Regressionsmodellen ausgewertet.

Die Ergebnisse zur Abschätzung der Grenzproduktivität des PSM-Einsatzes unter Verwendung der Cobb-Douglas-Funktion sowie von Ansätzen mit Einbeziehung einer Schadensfunktion zeigen, daß erstere immer zu höheren Grenzproduktivitäten führt. Beide Funktionsansätze zeigen jedoch, daß das derzeitige Einsatzniveau bei Insektiziden noch unterhalb des kurzfristigen Optimums liegt. Im Vergleich der beiden Anbaugebiete weisen sämtliche Modellspezifikationen allerdings eine geringere Produktionselastizität, aber eine höhere Grenzproduktivität für den langjährigen PSM-Einsatz aus.

Bei den Berechnungen zu den Gesundheitskosten konnte gezeigt werden, daß Personen, die Pestizide ausbringen, ein im Vergleich zu anderen Haushaltsmitgliedern vier Mal höheres Risiko eingehen zu erkranken . Die medizinischen Untersuchungen und Labortests bestätigen dabei den Zusammenhang zwischen Pestizideinsatz und Kontamination. Allerdings wird nur in 2 % der Fälle schulmedizinische Hilfe in Anspruch genommen. Wenngleich die tatsächliche Höhe der pestizidbedingten Gesundheitskosten nicht endgültig geklärt werden konnte, so zeigen die Untersuchungen jene Faktoren auf, welche die Zahlungsbereitschaft der Bauern für Maßnahmen zum Schutz gegen Pestizidvergiftungen beeinflussen. Weiterhin konnte der Zusammenhang zwischen Gesundheitsrisiken durch PSM, dem Entscheidungsverhalten von Landwirten und den pestizidbedingten Gesundheitskosten herausgearbeitet werden. Die Ergebnisse deuten auch darauf hin, daß die amtliche Statistik die Häufigkeit von Pflanzenschutzmittelvergiftungen unterschätzt.

Zum Schluß der Arbeit werden Schlußfolgerungen im Hinblick auf mögliche ökonomisch-technische und agrarpolitische Lösungsansätze gezogen.

Resumé

Dans plusieurs pays en voie de développement et particulièrement en Afrique, les politiques de la protection des végétaux favorisent beaucoup plus l'utilisation de pesticides que d'autres méthodes alternatives qui utilisent moins de pesticides. En conséquence, la stratégie de la protection des végétaux dans ces pays, en particulier pour les cultures de rente, est basée largement sur les pesticides, tandis que l'adoption des méthodes alternatives est minimale. La Côte d'Ivoire représente une étude de cas. La distribution des pesticides aux paysans dans ce pays était gratuite (cette à dire, subventionnée à 100%). Cela et la politique actuelle de la fourniture des pesticides à crédit aux paysans font partie des politiques économiques qui mènent à un taux de croissance très rapide de l'utilisation de pesticides dans le secteur agricole, surtout dans la filière de coton. La Côte d'Ivoire a évolué très rapidement et devenue un important consommateur des pesticides en Afrique.

Cependant, malgré de nombreuses années de soutien politique à l'utilisation des pesticides et ce qui a occasionnée une croissance de produits chimiques consommés dans le pays, aucune étude n'a été entreprise afin d'évaluer la productivité de pesticides. Il reste à savoir si la quantité de pesticide utilisée actuellement dans les parcelles est rentable ou si le niveau d'optimum économique a été dépassé. Aussi, il y a peu d'information concernant l'effet des pesticides sur les ressources naturelles et biologiques. Par ailleurs, dû aux cas d'abus de pesticides par les paysans et étant donné qu'ils ne portent pas de vêtements de protection appropriés au moment de manipulation des pesticides, la santé des paysans pourrait être à risque. Mais, le niveau de ce risque n'est pas encore bien connu. En plus, la connaissance des pesticides par les paysans, la différence entre les pratiques réelles des paysans et les recommandations officielles, et les raisons expliquant cette différence ne sont par encore bien étudiés.

Afin de mieux approchent ces problèmes, une étude a été entreprise, et trois objectifs principaux y sont assignés. Premièrement, estimer le produit marginal (*marginal product*) d'insecticides dans des systèmes de production ayant différents niveaux d'intensification de production - et de période de l'utilisation de pesticides, afin de déterminer si le pesticide implique un coût sur les ressources naturelles. Deuxièmement, déterminer s'il y a des problèmes de santé humaine liés à l'utilisation de pesticides dans les ménages agricoles, identifier ces types de problèmes, et les quantifier en estimant la valeur économique. Le troisième objectif est d'analyser la situation actuelle sur la connaissance, les

pratiques et les perceptions des paysans concernant les pesticides, ainsi que leurs implications pour l'adoption d' autres stratégies de protection des végétaux au niveau de paysan.

Par une méthode d'échantillonnage aléatoire stratifiée, 165 ménages ont été sélectionnés dans la zone de coton et riz où le pesticide est utilisé respectivement pendant une longue et une courte période. La plus grande quantité de pesticides utilisée dans le pays est consommée dans cette zone. Des données démographiques ont été recueillis des ménages choisis, et des donnés agro-économiques sont collectées auprès 193 champs cultivés par ces ménages. Les données agro-économiques sont recueillies en effectuant plusieurs visites. De plus, des analyses biomédicales de sangs et des analyses de laboratoires sur des vêtements portés ont été effectuées pour des applicateurs de pesticides. Les données ont été saisies en utilisant plusieurs modèles spécifications alternatives de productions de "damage function", et des modèles régressions de logit.

Les résultats obtenus de Cobb-Douglas ainsi que des spécifications alternatives de modèles "damage function" montrent que la valeur de production marginale (*Marginal Value Product*) des insecticides est plus grande que l'unité. Mais, pour tous les modèles, la valeur de production marginale des insecticide est plus grande pour la région où les pesticides ont été utilisés pour une longue période. En addition, l'élasticité de la production de coton aux insecticides est inférieur dans la région où les pesticides ont été utilisés pendant une longue période, i.e. la production de coton est comparativement *moins sensible* aux insecticides dans la région plus exposée aux pesticides. Ensemble, les deux derniers résultats pourraient être une indicateur d'effet progressif de l'utilisation des insecticides sur les ressources biologiques et naturelles dans les systèmes de production. Concernant la productivité d'insecticide, cette étude conclue que le changement de la spécification des modèles seulement, ne peut pas expliquer tout le paradoxe constaté dans les études économique de la productivité de pesticides au niveau des champs. Néanmoins, par l'intégration des facteurs de la dégradation des ressources naturelles et biologiques dans des modèles, l'estimation de la productivité de pesticides devient comparativement plus plausible.

Les résultats de l'étude montrent qu' il y a des problèmes de santé humaine dans les ménages agricoles dû à l'utilisation de pesticides. Les applicateurs de pesticides sont exposé aux risques d'empoisonnement aigu. Les personnes qui manipulent les pesticides subissent des cas de maladies qui est en moyenne quatre fois plus élevés que d'autres membres de même ménage. Les résultats des analyses biomédicales et de laboratoire ont établis une relation de "causes à effets" entre l'utilisation de pesticides et les symptômes des maladies. Les coûts de la santé humaine liés aux pesticides sont de multiple dimensions pour les ménages. Bien que les paysans reconnaissent que le pesticide pose un important problème à la santé humaine, généralement ils perçoivent des problèmes/symptômes comme des risques courants à l'utilisation des pesticides. Il y a une lacune d'information de la part des paysans quant aux coûts réels de pesticides. Ils se rendent aux centres médicaux pour des consultations et des assistances formelles seulement dans 2% des cas de maladies/symptômes liés aux pesticides. Donc, les chiffres officiels des cas d'empoisonnement de pesticides sont probablement des sous-estimations. A cause de la lacune d'information concernant les coûts réels de santé humaine liés aux pesticides, les paysans donnent en général la priorité aux coûts directs de la production agricole (e.g. prix d'achat de pesticides, de main-d'oeuvre, des intrants, etc.) plutôt que le coût de la santé humaine de pesticides en faisant leurs décisions. Le frais qu'ils sont prêt à dépenser pour des raisons de la santé humaine est peu.

Les paysans répondent très sensiblement aux politiques économiques en vigueur concernant le pesticide. Des potentiels existent pour l'adoption de la lutte intégrée (Integrated Pest Management, IPM) dans la région de l'étude. Mais la politique actuelle de livraison de pesticides aux paysans à crédit donne l'avantage pour les pesticides, et renforce les technologies de protection des végétaux à base chimique plutôt que celui de l'IPM. L'étude montre aussi que la faisabilité/supériorité technique des méthodes alternatives de protection des végétaux sur le pesticides est une condition nécessaire, mais pas suffisante à inciter les paysans à adopter ces méthodes alternatives. Au delà de la supériorité technique, la promotion des méthodes de protection des végétaux qui réduisent les problèmes de la santé humaine liés aux pesticides exige la combinaison de deux facteurs importants: programme d'information pour l'amélioration de la connaissance des paysans (e.g. par la formation) et des politiques appropriées.

L'étude conclut en donnant des recommandations pour améliorer la situation actuelle de protection des végétaux et de la production de coton en Côte d'Ivoire. Les perpectives pour des future recherches ont été suggérées.

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ACHE	Acetylcholinesterase Enzyme
ADRAO	Association pour le Développement de la Riziculture en Afrique de l'Ouest *(West African Rice Development Association)*
ai	active ingredient
ANADER	Agence Nationale d'Appui au Développement Rural (*National Agency for Support of Rural Development*).
CFA	Communauté Financière Africaine (French-speaking African Financial Community)
CIDT	Compagne Ivorienne pour le Développement des Textiles et Fibres (*Ivorian company for textiles and fiber products development*)
FCFA	Francs de la Communauté Financière Africaine (The Franc of the French-speaking African Financial Community)
DM	Deutsche Mark
DPVQ	Direction de la Protection des Végétaux et de la Qualité (*Directorate of Plant Protection and Quality*)
DRS	Défense et Restauration des Sols *(Soil protection and Rehabilitation dept of CIDT).*
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographical Information Systems
GVC	Groupement à Vocation Cooperative *(Farmers' cooperatives groups)*
ha	hectare
IDESSA	Institut des Savanes, Bouaké (*Savanna Research Institute, Bouaké*)
	Current name: Centre Nationale de la Recherche Agronomique (*National Agricultural Research Center*)
IPM	Integrated Pest Management
KAP	Knowledge, Attitude and Practices
LD50	Lethal Dose 50
LH (LE)	Long History Region (Long Exposure Region)
NGO	Non Government Organization
USD / US$	Unites States Dollar
WARDA	West African Rice Development Association, Bouake, Côte d'Ivoire
SAS	Statistical Analytical System
SH (SE)	Short History Region (Short Exposure Region)
WHO	World Health Organization of the United Nations

1 Introduction

1.1 Background

In many African countries, economic and agricultural policies promote the use of pesticides compared to non-chemical-based pest control measures. In the cash crop sector in particular, the adoption of less chemical-dependent crop protection methods by the farming community takes place on a relatively lower scale[1]. Though the quantity of pesticide use per unit cropped area in Africa is low compared to Asia and the Western world, the *rate* of increase of use of agro-chemicals in Africa in recent times is among the highest in the world. FARAH (1994: p. 13) estimated that between 1988 and 1993, pesticide use in Africa increased at a rate of 200% compared to only a 20% increase for the same period in all developed and developing countries together. Pesticide use has increased rapidly over the past ten years in South Africa (LONDON and ROTHER, 1998: p.30). In Nigeria, the annual increase in sales of pesticides was between 5-10% per annum (SAGODOYIN,1993).

Côte d'Ivoire represents a case with a very rapid rate of increase in the quantity of pesticide use in the agricultural sector, and particularly in the cotton sub-sector. The rapid increase is largely due to the policy in which farmers were given free pesticides (100% subsidy) on a standard dose basis for every hectare of cotton cultivated. From the mid 1960s when this policy began, as the area grown to cotton increased, pesticide use also increased commensurately. As a result, the rural economy of northern Côte d'Ivoire became increasingly dominated by cotton. The nation also emerged as one of the major pesticide consuming nations in Africa, and it utilizes the largest amount of insecticides for cotton production in the West African sub-region. The trend in cotton production (and implicitly the trend of pesticide use) in northern Côte d'Ivoire is presented in Figure 1.1[2].

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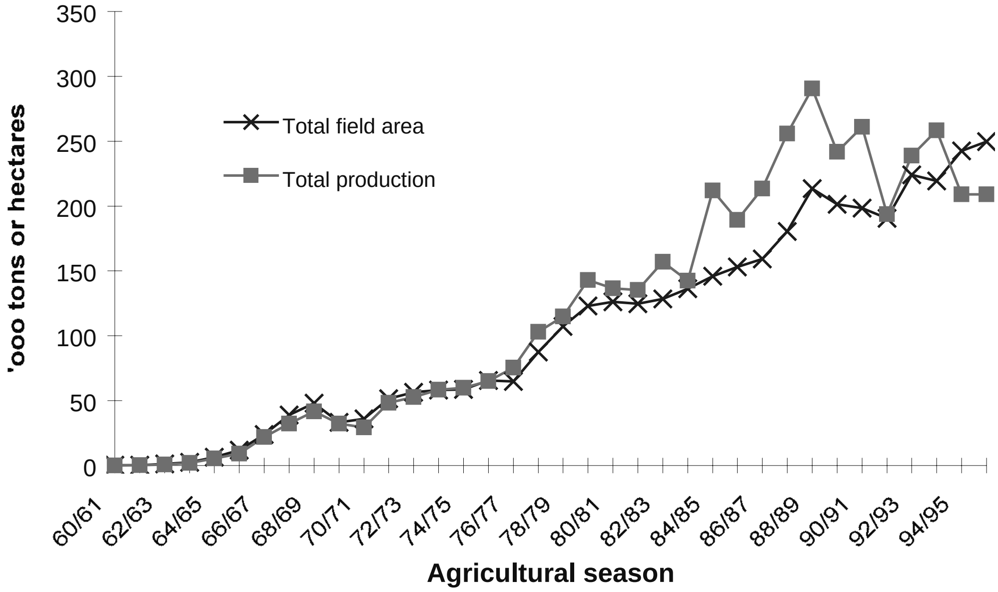
[1] This happens sometimes even when the less-chemical dependent methods have proven to be technically feasible or sometimes superior. An example for Côte d'Ivoire is presented in Chapter six of this study.

[2] Due to the policy of giving out a standard dose of insecticides free of charge to cotton farmers in Côte d'Ivoire , the *official figures* of the crop area that is grown to cotton provides a very good information on the *official* record of the quantity of insecticide use in cotton fields in the region.



Source: CIDT annual reports for various years

Figure 1.1: Development of cotton area and production in Côte d'Ivoire, 1960-1996

The Figure shows that most of the increase in cotton production came about by increasing the area cultivated to cotton rather than increases in yield or productivity (HAILU 1991, République de Côte d'Ivoire 1993). The adoption of cotton cultivation in the various geographical zones began at different time periods of time starting first from the core savanna zones in the north of the country from where it spreads southwards progressively to the fringes of the forest zone. As a result of the policy on the free distribution of insecticides and the historical path of cotton development, the period of adoption of cotton in each geographical zone also marks the beginning of pesticide use and exposure of farmers to these chemicals in the respective zones. The implication is that the cotton-growing zones can be stratified along a historical continuum of pesticide adoption periods. Depending on its relative position within this historical continuum, the level of cropping intensification, and the state of the natural resources of the agro-ecosystems in the different cotton production zones would differ from what they were in the pre-cotton era.

1.2 Statement of the Research Problem

The successful implementation of pest control programs requires adequate knowledge on how farmers perceive pests, their attitude, beliefs and practices to crop protection problems (ROTHER and LONDON 1998, TAIT 1987, HEONG and HO 1987). As mentioned by MUMFORD (1981: p. 250), “farmers make decisions on pest control ... on the basis of how they perceive the relevant factors and what they seek to achieve”. However, in spite of the rapid increase in the quantity of pesticides consumed in Côte d'Ivoire, little is known about farmers’ knowledge of pests or their perception of the effectiveness of pesticides. Apart from a few reports on farmers’ perceptions of rice pests (for example ADESINA et al. 1994), information on farmers’ perceptions of the contribution of pesticides to farm production is not formally documented. Such information is vital to the identification of opportunities and constraints to the adoption of alternative crop protection strategies. The previous studies (CIDT 1989: p. 3-5, RICHARDI 1992: p. 39-40, 44-47) indicate that farmers in Côte d’Ivoire misuse pesticides. The studies also show that actual farm level pesticide practices often differ from recommendations. However, the extent of the misuse of pesticides, the underlying reasons for such misuse and the consequences of the same have not been well understood[3]. Empirical information on how farmers have reacted to the elimination of the free distribution of pesticides (including the new trends in crop protection practices at the farm level) has not been well documented. Such information is required to provide necessary feedback to policy makers for future policy decisions on pesticides in the region.

Secondly, issues on pesticide productivity and in particular, the measurement of the marginal productivity of the chemicals are important in the efforts to fashion out appropriate agricultural policies. However, no study has been undertaken to evaluate the productivity of pesticides in Côte d’Ivoire. As a result, information is lacking on whether pesticides are currently under-utilized or over-utilized by cotton farmers. It is not yet well known if changes (over time) took place in the productivity of pesticides in the different production systems in the cotton region of Côte d'Ivoire.

[3] The studies cited in this paragraph were carried out before 1994 (when pesticides were supplied free of charge to farmers). It is not yet known how farmers in the different cotton zones have reacted after the removal of pesticides subsidies.

Thirdly, with the growing concerns relative to the negative externalities of pesticides — including human health effects and the impacts on the natural (biological) resources — questions on how productive pesticides are have become more important. Methodological approaches adopted in recent economic studies of pesticides including WAIBEL (1994), CRISSMAN et al. (1994) and ROLA and PINGALI (1993) have generated renewed awareness of the hidden health costs of these chemicals. In view of the misuse of pesticides, the non-adherence to appropriate application techniques, the use of cheaper but sometimes more hazardous products in Africa, and the fact that little or no protective clothing is used during spraying, farmers' health may be at risk. The extent of this risk among Côte d'Ivoire farmers still remains largely non documented. This study seeks to fill some of the gaps by conducting a detailed analysis on the pesticide use practices, and the economic productivity of pesticides (taking into consideration the impact of these chemicals on the biological natural resources and on farmers' health) in the cotton-rice agricultural systems of Côte d'Ivoire.

1.3 Research Objective

The general objective of this study is to obtain detailed information on the long term implications of the adoption of pesticides as the quasi-sole pest control method used in cotton fields at the farm level in Côte d'Ivoire. It aims at providing insights into the economics of pesticide use in the light of human health cost and the impact on natural resources and to contribute information towards improving crop protection policies and practices. The specific objectives are to:

i. analyze farmers' knowledge, practices and perceptions on pests and pest control and the implications for the adoption of alternative crop protection strategies at the farm level.

ii. estimate partial productivity of pesticides in two cotton zones with different ecosystems and levels of crop intensification, including the time that pesticides have been used.

iii. estimate the economic costs of the human health impacts of pesticides on farm households in the cotton zones of Côte d'Ivoire, based on the present level of farmers' attitudes to pesticide-related health symptoms and their level of information on the linkage between pesticides and human health.

1.4 Organization of the Thesis

The **second** chapter of this study discusses the neoclassical theory on the economics and the measurement of pesticide productivity. The results obtained from previous studies on pesticide productivity are synthesized and some missing links in the measurement of pesticide productivity are identified. This is followed by a discussion on the conceptual and theoretical basis for filling in some of the missing gaps that have been identified in pesticide productivity estimations. Within the context of the theory on natural resources and the concept on path dependence, the interpretation of productivity estimates is discussed for the two types of production ecosystems that have been transformed through their exposure to pesticides for different periods of time. The negative impacts of pesticides on human health and productivity are also highlighted with a view to understanding the economics of these chemicals. The impact of the information gap on the decision making on pesticide use by farm households is enumerated. The chapter concludes by formulating the hypotheses of this study.

In Chapter **three**, an overview of the general economic development of Côte d'Ivoire, including the agricultural sector is presented. This is followed by a discussion of the economic and agricultural policies that were designed and implemented by the government of Côte d'Ivoire to develop cotton production. The impacts of these policies on the use of pesticides and crop protection methods are highlighted. In Chapter **four**, the methodology of data collection including details of the sampling technique, sample size and type of data used for this study are presented. Chapter **five** presents the geographic, socio-cultural and household demographic characteristics of the study area. The agricultural economy including the prevalent farming system in the study area is also presented.

In Chapter **six**, empirical information on the knowledge, attitudes and practices relating to pesticides and crop protection among farming households isanalyzed. Information on the indigenous practices on crop protection, the actual and changing trends in farm level crop protection practices as well as reasons for the observed trends are presented. The chapter ends by providing information on the existing opportunities and constraints for the adoption of alternative crop protection technologies in the study area.

In Chapter **seven**, the empirical models for the computation of pesticide productivity are specified. The productivity coefficients and marginal value products for pesticides for different production ecosystems are computed using a Cobb-Douglas-production-function and various alternatives of the damage abatement function specifications. The estimation of the productivity of other farm inputs is also computed and discussed. Chapter **eight** contains an empirical analysis of pesticide-related health symptoms. This is followed by a presentation of the results of bio-medical tests to determine farm workers' exposure to pesticides and possible 'cause-effect' relationship between the health symptoms reported by farm workers and their exposure to chemicals. A framework for identifying and estimating the health costs of pesticide symptoms — with special reference to the African context — is presented. Using this framework, the actual health expenses that households made to mitigate pesticide-related health symptoms are estimated. The factors that influence the willingness of households to invest in health are identified. The chapter ends with a discussion on the relationship between exposure to pesticides, actual health expenses made by households and the attitudes of farm households to pesticide-related symptoms.

Chapter **nine** summarizes the findings of this study. In Chapter **ten,** the technical and policy implications of the study results are presented. Further areas of research relevant to this type of study are suggested.

2 Pesticide Economics and Productivity: Neoclassical Theory and Possible Extensions

This chapter is subdivided into five main sections. The first one is a discussion on the neo-classical economics of pesticides and the issues involved in the measurement of the productivity of pesticides at the farm level. The specification of pesticide productivity model as a damage control agent (rather than a conventional yield increasing input) is highlighted. Some missing gaps in the estimation of a pesticide productivity are identified. Second, the theory of degradation of natural resources is presented. It is discussed how relevant natural resources are for interpreting productivity estimates in production systems that have been transformed by previous use of pesticides. The concept of path dependence is highlighted, stressing the historical importance of the evolution of pesticides in pest control. In the third section, the need to incorporate the heterogeneity of ecosystems in pesticide studies is discussed. Fourth, the theory of the household is presented with special reference to the intrinsic relationship between the farms and the households. The impacts of pesticides concerning human health hazards on farm workers and how farm productivity is affected are discussed. The role of information gaps in the decision-making on pesticide use by the farm households is highlighted. In the fifth section, the hypotheses being tested in this study are presented.

2.1 Neo-Classical Production Function Approach in Pesticide Productivity Studies

Pesticides help farmers to compete against pests that would otherwise reduce the output obtained from fields. This role is nonetheless accompanied by dis-utility from health hazard caused by pesticides, i.e. a tradeoff between farm production in the present time and a potential health hazard in the future (LIPTON and DE KADT 1988). One of the challenges relating to decision-making on pesticides is to find the optimum tradeoff between these two opposing attributes of pesticides. Economic theory suggests that an input is only applied if the cost of doing so is less than the benefits to be derived therefrom.

A major question in pesticide economic studies is “What is the optimal use level taking into account negative impacts on health and the environment?” With growing public concerns on the effects of pesticides on the environment on the one hand versus the need to maintain food and fiber production on the other, it is important to investigate the true productivity of pesticides.

BABCOCK et al. (1992: p.163) state that “accurate information about the productivity effects of pesticides, in terms of both increased yield and enhanced quality, is increasingly important”. Such information helps to identify the appropriate policy instruments to drive pesticide use towards the optimal level. The measurement of the productivity of pesticides is a central issue. As CHAMBERS and LICHTENBERG (1994: p. 409) state, “the debates over pesticide policy hinge critically on productivity issues”. The measurement of the productivity of pesticides derives from neo-classical production economics theory[1]. It is often done within a production economics framework that analyzes how factor inputs perform and how they should be combined to reach optimal economic results.

A number of attempts have been made in various studies to measure the productivity of pesticides using the production economics framework. These studies may be categorized into two broad groups: studies that used generic Cobb-Douglas production functions and, those that suggested a modification of the generic functions by taking into consideration the unique characteristics of pesticides. Almost all of the ‘first generation’ studies that evaluated the economic performance of pesticides within the production framework used non-linear functional forms, essentially the Cobb-Douglas function[2]. Using the Cob-Douglas function, HEADLEY (1968: p. 21) reports that “the marginal value of a one-dollar expenditure for chemical pesticides is approximately $4.00”. CAMPBELL (1976: p. 28) reports that “the marginal dollar’s worth of pesticides input yielded around $12 worth of output”. These results imply that the opportunity cost of policies restricting pesticide use will be quite high in terms of the output that need be forgone. It further implies that it would be economically rational to increase the use of pesticides beyond the level that farmers were currently using. These results are not consistent with anecdotal

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[1] This theory holds that a firm that operates at a point where its marginal value product is higher (lower) than its marginal cost is considered inefficient. This is because the firm can still use more (less) inputs to maximize its profit. Quantities of input at lower levels represent under-exploitation of opportunities, while increasing output beyond this point is economically inefficient. Among other assumptions, the production economics framework assumes that producers use inputs in an optimal manner, and that they make rational economic decisions which are motivated by the goal of profit maximization.

[2] This functional specification was preferred because it is mathematically straight forward and generates the elasticities for the various inputs from which it can easily be determined if the productivity of the input is increasing, decreasing or constant. This type of equation nonetheless has some limitations: multi-collinearity, assumption of perfect substitutability of inputs (no provision for complementarity or supplementarity among the variables), and heteroskedasticity.

evidences that pesticides are over used. More recent studies follow a similar methodology but with some modifications, especially in the type of regressors included in the model. In cotton fields in India, PRABHU (1985: p. 136) reports that “when all the sample cultivators were grouped together, the marginal value product (MVP) of pesticides was 0.13” (i.e., less than unity)[3]. This implies that on the average of all the fields studied, the quantity of pesticides used was excessive and economically inefficient.

From a comparison of various productivity estimates of pesticides reported in previous studies, two fundamental questions arise:

a. What is the explanation for the sharp differences in marginal productivity estimates reported for pesticides in the literature?

b. Why do anecdotal observations and public concern about overuse of pesticides differ from what can be implied from the productivity estimates obtained in some pesticide studies, i.e. estimates that suggest that pesticides are underused?

Part of the answer to the above questions can be found in the relative degree of comprehensiveness of the various items of costs and benefits included in (or excluded from) the computations used in pesticide economic studies. If the pesticide costs included are only immediate costs of chemical use, and inter-temporal costs (e.g. pest resistance, chronic human health costs) are ignored, the estimates of productivity may be biased. As IDACHABA and OLAYIDE (1976: p. 26) state, “when there are other costs over and above the private farmer’s cost of using a pesticide (but) which are not reflected in his private costs, there is a divergence between (the) private and social costs of applying the pesticide”. The divergence may lead to ambiguous results of pesticide productivity and the economics of pesticide use. The recent study of WAIBEL and FLEISCHER (1998) in Germany shows that the social costs associated with pesticide use are substantial and that benefits are lower than is often assumed. For Asian rice agriculture, ROLA and PINGALI (1993: p. 5-6) found that “explicitly accounting for health costs substantially raises the costs of pesticides”. This will ultimately affect the estimates of the productivity of pesticides.

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3 The figures vary depending on the crop variety cultivated and the size of field, with higher MVP figures obtained in medium scale farms, followed by small and then large farms.

Using the production framework, several studies have been carried out to respond to either or both of the above questions. These include empirical simulation studies (e.g. LICHTENBERG and ZILBERMAN 1986, BLACKWELL and PAGOULATOS 1992, WAIBEL 1994, CARPENTIER and WEAVER 1997). Others are empirical investigations (e.g. ARCHIBALD 1988, CARRASCO-TAUBER and MOFFIT 1992, CRISSMAN et al. 1994, PRABHU 1985, ROLA and PINGALI 1993, WAIBEL and SETBOONSARNG 1993, WAIBEL and FLEISCHER 1997). The explanations provided by some of these studies are summarized below.

2.1.1 Special Characteristics of Pesticides in Productivity Estimation: Risk Premium Issues

The discrepancies in pesticide productivity estimates have been attributed to the special characteristics of pesticides i.e. as risk reducing agents. Under conditions of uncertainty; the variance in yield, farm output, farm income and profit increases. For risk averse farmers, they will opt for inputs like pesticides that ensure minimum variance in output rather than go for inputs geared towards achieving maximum yield (PRABHU 1985). The argument of PRABHU (1985: p.137) is that “risk aversion on the part of the cultivators, and uncertainty regarding the intensity of pest attack and effectiveness of pesticides explain the general ‘excess’ use of pesticides by the sample farmers”. She posits further that the yield loss reduction characteristics of pesticides imply that pesticide use may be governed by processes that are different from those underlying the use of yield increasing inputs like fertilizer and irrigation. PRABHU’s study recommends that necessary modifications should be made in the use of the production economics framework to analyze pesticide productivity. In the study among sugar beet farmers, MUMFORD (1981: p. 250) reports that his survey “confirms the widespread insurance motive for using insecticides”. In a summary, the basic argument used to explain the linkage between risk and pesticide use is that pesticides are valuable and that even if chemical based pest control does not necessarily pay for itself, it remains a means of insurance for farmers.

In a literature review of agricultural pest control and risk, PANNELL (1991: p. 361) states that “depending on the balance of forces to increase and decrease pesticide use under risk, in many circumstances, the net effect of risk on optimal decision making for pest control may be minimal.” The author concludes the review by stating that “risk does not necessarily lead to increased pesticide use by individual farmers.” In an empirical work, HURD (1986) uses an expected utility framework. His results do not support the common belief that pesticides are risk reducing agents. The results of the study of HURD (1986: p. 324) indicate that “pesticide expenditures, regardless of the estimation specification, do not to have any statistical relationship to variance in yields” and that “there was no empirical support suggesting that pesticides reduced risk”. The above results do not support the argument that even if the marginal cost of pesticide exceed its marginal revenue, the ‘excess net cost’ can be rationalized as a risk premium paid by risk averse producers. Giving an insight into the impact of pesticides on production risk, REGEV (1988: p. 97) reports that in reality “chemical pesticides often increase the risk of pest infestation by reducing the natural enemies of the pest” although farmers perceive pesticides as a type of risk-reducing inputs. Pesticides may reduce the variability of yields in the short run but they may increase production uncertainties (and hence risk) in the long run. The higher risk in the long run could be due to increased probability of pest outbreak arising from pest resistance or increased probability of pest infestation (due to the decimation of natural predators). The case of brown plant hoppers in Asia is a well known example (KENMORE 1991, 1996) of how excessive continuous use of pesticides induces or accelerates the development of pest outbreak in the ecosystem. The short versus long run effect of pesticides is highlighted by REPETTO (1985: p. 3) as follows: “farmers as a group must decide whether they would rather take some losses now or face bigger battles later on”. To sum up, it can be observed that there is no conclusive empirical evidence to support the notion that the divergence in pesticide productivity estimates can be explained only on the basis of risk reduction attributes of chemicals.

2.1.2 Special Characteristics of Pesticides in Productivity Estimation: Damage Reduction and Functional Specification Issues

To explain the paradox of pesticide productivity estimates, LICHTENBERG and ZILBERMAN (1986) suggest a modification in the functional specifications used in production function models. The central theme of LICHTENBERG and ZILBERMAN (1986) is that pesticides are damage control agents, and this characteristic makes the contribution of pesticides to output fundamentally different from other yield increasing inputs like land, labor and capital. They argue that if the important physical and biological properties of damage control agents are not incorporated in specifying the functional forms of production functions to take cognizance of this difference, it necessarily leads to upward biased estimates. According to the authors, this explains why estimates of previous models that are specified inappropriately are wrong, and why conclusions derived therefrom deviate from anecdotal observations. A number of studies have since tested the validity of the suggested functional specifications by using empirical data. Other authors have suggested modifications of the original ideas proposed by LICHTENBERG and ZILBERMAN (1986) to find a model specification that is most 'congruent' with observable evidence.

Some functions (e.g. linear forms) can be eliminated *a priori* because their characteristics differ from theoretical expectations of the behavior of typical production functions[4]. The selection of an appropriate functional form is not a simple matter. Expressed in an implicit form, a conventional production function for an input-output relationship is simplified as:

$$Y = f(X_1, X_2, X_3, X_4, \ldots X_n) \qquad (2.1)$$

where Y is output and X_1, X_2, X_3, X_4, …Xn are the various farm inputs.

Using the Cobb-Douglas function format, which is the most common form in production studies, equation 2.1 is written as

$$Y = aX_1^{a1} X_2^{a2} X_3^{a3} X_4^{a4} \ldots X_n^{an} \qquad (2.2)$$

The partial derivatives of the various inputs with respect to output (Y) represent the marginal productivity for the respective inputs as indicated in (2.3):

$$\frac{\delta Y}{\delta Xi} = MPi \qquad (2.3)$$

where MP is the marginal productivity $i = 1,2,\ldots n$

To incorporate the special properties of pesticides into production functions, LICHTENBERG and ZILBERMAN (1986: p. 262) suggest that "the contribution to production by damage control agents may be understood best if one conceives of actual (realized) output as a combination of two components: potential output and losses caused by damaging agents present in the environment". The output that a producer obtains is regarded as a *net* result of two interdependent components: i.e., potential yield obtainable and potential loss to pests. Pesticides are incorporated in the latter component and are

4 An example is the linear function that does not conform to the law of diminishing returns or diminishing marginal utility theory because of its constant slope for all ranges of inputs use.

conceptualized in terms of their role in reducing output losses. With the addition of a new component to take account of the unique role of pesticides, equation (2.1) becomes:

$$Y = f(X_i, D(X_p)) \tag{2.4}$$

where the first component is essentially made up of equation 2.1 and the second component, $D(X_p)$ is the damage function.

$D(X_p)$ is defined as a measure of the effectiveness of pesticides, or the proportion of the destructive capacity of pests which is eliminated by the application of pesticide quantity X_p. The importance of pesticides depends on the level of yield loss. The yield loss is in turn determined by the extent of pest pressure in the production system. But given that the pressure from pests cannot be predicted with certainty, potential yield loss and hence the productivity of pesticides is an uncertain event, i.e. a stochastic event having the characteristics of a probabilistic distribution. Theoretically, this proportion of potential yield loss ranges from zero (i.e. total destruction of the crop) to unity (i.e. perfect control of pests). But, biological science suggests that in real life it is more realistic to assume that $D(X_p)$ takes values in the range $0 < D(X_p) < 1$. This implies that the damage function follows a cumulative probability distribution. As a result, it can be expressed in various econometric forms and then be tested empirically. The exact probability distribution function of pesticides is not yet known, but LICHTENBERG and ZILBERMAN (1986) suggest that it could be either exponential, logistic, Weibull or Pareto stochastic distribution forms. Based on this suggestion, $D(X_p)$ may take the following four explicit specifications:

Exponential: $$D(X_p) = 1-\exp(-\lambda X) \tag{2.5}$$

Logistic: $$D(X_p) = 1+\exp(\mu-\sigma X)]^{-1} \tag{2.6}$$

Weibull: $$D(X_p) = 1-\exp(-X^c) \tag{2.7}$$

Pareto: $$D(X_p) = 1-(K^\lambda X^{-\lambda}) \tag{2.8}$$

2.1.3 Synthesis of Empirical Tests of the Modified Pesticide Productivity Models

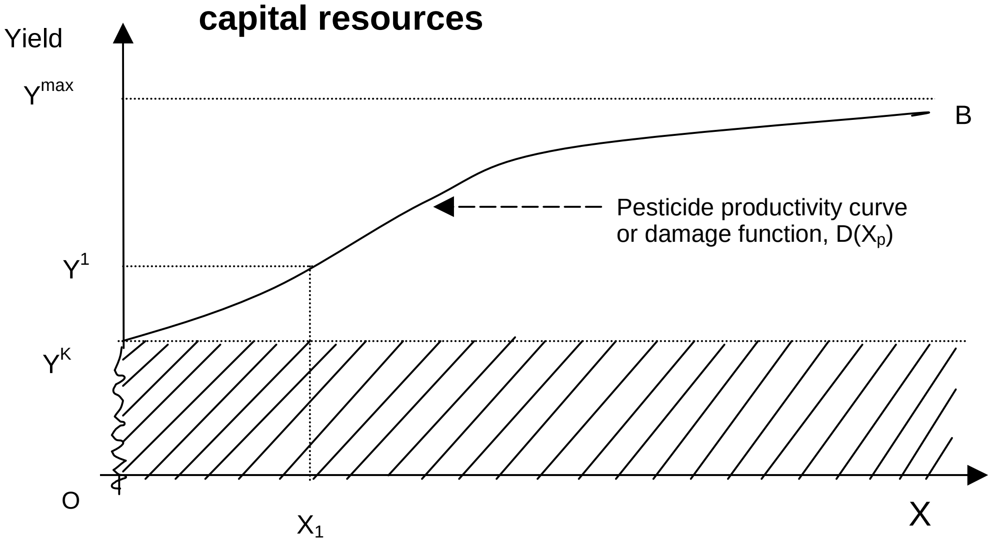
A number of empirical studies have been carried out to evaluate pesticide productivity based on modifications in model specifications to incorporate the special attributes of pesticides. It is common for these recent studies to use estimates of pesticide marginal productivity obtained by HEADLEY (1968) as the 'baseline' with which more recent pesticide productivity estimates are compared. The recent authors also compare the estimates that they have obtained on the basis of the various functional forms suggested by LICHTENBERG and ZILBERMAN (1986). The results of most of these studies suggest that the two questions raised above in section 2.1 about pesticide productivity cannot be answered conclusively based *only* on modifications in the functional specifications. RAMOS et al. (cited in CRISSMAN et al. 1994: p. 594) tried out various functional forms provided by LICHTENBERG and ZILBERMAN. They found that the quadratic form explains their data best. Their results indicate that the marginal productivity of pesticides is more modest compared to earlier studies. Nevertheless, the productivity estimates for fungicides is still high, and there is no indication of overuse of pesticides. Fitting various functional specification forms to empirical data in a separate study, CARRASCO-TAUBER and MOFFIT (1992) found out that with the exception of an exponential function, all other functional specifications indicate high marginal productivity for pesticides. Their result shows that an additional dollar spent on pesticides can be expected to yield about 5 to 7 dollars. The study indicates that there is yet no empirical proof of the superiority of any one functional form over the other specifications. CARRASCO-TAUBER and MOFFIT (1992: p. 161) conclude that the explanation for high productivity estimates in earlier studies (e.g. CAMPBELL 1976 and HEADLEY 1968) seems to lie somewhere other than with functional specification of damage control models.

2.1.4 The Missing Link?

Although the suggested modifications to the generic production functional model are theoretically logical, they are not yet supported by the available empirical work. This implies a 'missing link' between the theory and practice of the measurement of pesticide productivity. In the modifications of the generic production function model to estimate pesticide productivity, an important assumption has been made. Central to this assumption is that only pest control variables affect abatement efforts. In building the models, some factors are regarded as exogenous, and are eliminated from the models. The exclusion of the 'state' variables in pesticide productivity measurement is perhaps one of the main issues that recent studies have raised concerning the use of the suggested alternative functional specification models.

The main focus of pesticide productivity studies is to evaluate if the value of the extra yield that is saved (or loss that is prevented) by the application of an additional unit of pesticide is equal to, less than or greater than the cost associated with the pesticide use. One of the important factors that determines the outcome of such an evaluation is the type of production system being studied and the level of natural resources in such a production system. The changing levels of the importance of pesticides in a given production system is represented graphically in Figure 2.1 below:

Figure 2.1: The impact of pesticides on yield loss and on farm production under different states of the natural biological capital resources



Y^{max} = Maximum attainable yield

Y^K = Minimum yield under the worst pest attack

X_P = Pesticide inputs

B = Cumulative yield loss abatement function

Source: Own graphical presentation

In the above graph, Y^{max} is the maximum yield obtainable assuming that all pests are eliminated or that they do not exist at all. Yield level O is zero production, i.e. complete crop loss under the most extremely damaging pest attack. But in reality, total crop loss is an exception rather than the rule and in most cases, the *actual* minimum level of output that a producer obtains is greater than zero. The shaded area Y^k represents the yield obtained under a natural pest control (i.e. when no pesticide is used at all) or the ‘do nothing’ approach. Due to biodiversity and several biological and natural processes that play a regulatory role to control pests within the ecosystem, Y^k is usually higher than O. As shown in the figure, the difference between Y^k and O varies (represented by a collapsible line). The shaded area is determined by several factors including the type of crop, the level of biodiversity and the effectiveness of the natural regulatory mechanism of the ecosystem. These factors are further explained in section 2.2.1 *(natural resource degradation)*.

The difference between Y^{max} and Y^{k} is the maximum potential yield loss. This is a measure of the limit of the productivity of pesticides. It represents the maximum 'yield increase' due to pesticide use. If the natural regulatory mechanism in an ecosystem is poor/weak, the shaded portion becomes smaller, actual yield Y^{k} will tend towards O. As a result, potential yield loss and hence, the productivity of pesticides will increase. It follows from the graph above that the productivity of pesticides is *not* independent of the processes within the ecosystem being studied. Rather, there is a sort of *homothetical inseparability* between the two. A pertinent question here is 'What happens if no pesticide is used at all?' In that case, the level of yield will be Y^{k}. The yield level will depend *exclusively* on the efficacy of the natural regulatory mechanisms within the eco-system to reduce pest attacks and reduce losses.

A process modeling method which allows for the derivation of a production function based on biological and physical processes governing an agricultural ecosystem provides a more plausible approach to estimate the productivity of pesticides (BLACKWELL and PAGOULATOS 1992: p.1040). This is because "such approach results in a production function that include the state variables omitted in LZ specification". Furthermore, "econometric models that do not explicitly account for natural abatement will most likely overestimate the marginal productivity of the chemical control agent" (BLACKWELL and PAGOULATOS 1992: p.1042).

In a study carried out in France, CARPENTIER and WEAVER (1997) demonstrate that biased estimates in pesticide productivity studies are not due to symmetry or asymmetry of functional specifications[5]. The authors report that on the contrary, enough biological priors abound to suggest that problems in estimating pesticide productivity are a consequence of the heterogeneity of ecosystems. The multiple and complex input-output interactions existing among heterogeneous ecosystems contribute to estimates and inconclusive interpretations of results from earlier studies. The lumping together of observations across different ecosystems in the past constitutes a source of bias in the estimates obtained. CARPENTIER and WEAVER (1997: p. 50) state that "biological evidence supports the importance of allowing for interactions

5 One reason for this is that the veracity of the functional specification has not been confirmed by empirical studies.

among inputs, practices and outputs when non-experimental data is used." If the interactions between inputs, pest population and pesticide treatment[6] are left out in econometric models, estimates obtained therefrom are necessarily wrong. The authors argue that the above biases explain why the modifications of the models have not resolved the discrepancies in pesticide productivity estimates. In previous studies data were usually collected in a non-controlled setting from a sample whose pests and input-output mixes differ despite the fact that these are important in determining efficacy of pesticides (CARPENTIER and WEAVER ,1997: p. 48). The effect is that when heterogeneous ecosystems are aggregated in this manner they produce erroneous estimates. The implicit assumption of homothetical separability between conventional inputs and pesticides in the previous productivity studies cannot be supported. According to CARPENTIER and WEAVER (1997: p. 50), this is because such assumptions imply that "the productivity or efficacy of particular pesticides would be independent of other pesticide applications or pest control tactics and exogenous events". Such exogenous events include natural vegetation, type of pest, soil type. Such a viewpoint would be incompatible with current scientific knowledge. Where estimation ignores heterogeneity across the ecosystem variables that are mentioned above, then productivity estimates would most probably be substantially overestimated. As a result, functional specifications which are based essentially on economic theory without due considerations to biological interactions among inputs and production processes is likely to produce biased estimates.

2.2 Conceptual and Theoretical Issues for Applying Production Function to Pesticide Productivity

The summary of the issues mentioned above is that beyond functional specifications, the heterogeneity in cropping intensification and biological processes and changes in the natural resource base of the ecosystem are important. Some of the literature cited above has identified differences in natural ecosystems as part of the 'missing link' in explaining productivity estimates. How does heterogeneity across ecosystems and differences in the natural resource base of observations affect the estimates of pesticide productivity? Could biological priors explain to some extent the missing link? What is the significance of biological priors in the economic interpretations of

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6 The co-authors state that biological sciences suggest this relationship to be real.

productivity estimates? In the four sections of this sub-chapter, the issues raised above are analyzed and the questions answered. In the first section, the theory on how chemical-based pest control degrades natural biological resources available in an ecosystem is discussed. Second the analysis of inter-temporal linkage of production decisions and how previous technological choices relating to crop protection lead to changes in the natural ecosystem, and setting off a chain of reactions, i.e. technological path dependence. Third, the effect of changes in the resource base of an ecosystem and how it affects the interpretation of empirical results of productivity estimates is analyzed. Fourth, the implications of various agricultural policies on pesticide productivity estimates are discussed.

2.2.1 Natural Biological Resource Degradation and Pesticide Productivity

Two major types of costs are incurred when pesticides are used. The first are the obvious and direct monetary costs involved in managing the pest population. The second type of cost is less obvious and it is termed the resource (or user) cost. Resource cost refers to the deterioration and the depletion of the biological capital resources in an ecosystem through continuous use of pesticides. Biological capital resources provide natural regulatory mechanism in the ecosystem. The capital resources exist in two major forms — renewable and non-renewable resources. In the following sections, the two forms are described. Information on how each of the two forms affect the productivity of pesticides is presented.

Biodiversity or Renewable Biological Capital Resources?

The first form of biological capital is biodiversity. ALTIERI (1993: p. 257) describes biodiversity as a “salient feature of traditional farming systems in developing countries and (it) performs a variety of renewal processes and ecological services in agro-ecosystems”. Through the presence of predators, biodiversity maintains pest and predator populations in a reasonable balance within the ecosystem, and thereby keeps pests in check. When pesticides are applied, predators inadvertently fall victim (although these species may not necessarily be the targets during spraying operations). As a result, as more pesticides are used in an ecosystem over long periods, the natural biodiversity capital is gradually depleted[7]. The regulatory role of biological diversity on pest populations is well documented by ALTIERI (1993). Studies on the negative impacts of pesticides on biodiversity – both, flora and fauna species – have been reviewed by MCLAUGHLIN and MINEAU (1995). With the gradual depletion of the renewable biological capital by the use of pesticides, it weakens ecosystems that are otherwise endowed with some measure of natural regulations. As a result, the importance of pesticides in the control of pests in the ecosystems will increase. This has the tendency to increase the productivity of pesticides.

Pest Susceptibility or Non-renewable Biological Capital Resources?

A non-renewable capital resource is the “total susceptibility of a particular species to currently developed pesticides, susceptibility being defined as the negative of resistance” (HUETH and REGEV 1974: p. 543). For a particular chemical control, pest management also involves the management of an exhaustible resource (HUETH and REGEV 1974: p. 543). The natural susceptibility of pests is a resource because it facilitates the easy control of pests. Pesticides are a potential threat to the stability of agro-ecosystems because they can cause mutations that may alter the delicate ecological balance (SHARMA 1987). Increasing the use of pesticides leads to a cumulative buildup of adaptation processes within an ecosystem, and pests increasingly adapt to the chemicals and become more resistant to them. The increase in pest resistance gradually erodes the biological capital of pest susceptibility. Pest susceptibility is a “fixed quantity” and it can be exhausted. The potential to reverse pesticide resistance in the field is generally low under continued pesticide usage (KNIGHT and NORTON 1989: p. 295). As the non-renewable biological capital is depleted and pest resistance develops, a *greater* quantity of chemical products will be required to achieve the *same* level of results than it had been hitherto. As a result, pest resistance *reduces* the productivity (effectiveness) of pesticides.

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7 Given its renewable status, the rate of depletion of biodiversity is determined by the *net* difference between the rate with which predators are killed and that at which an ecosystem can replenish its stock of predators.

Impact of User Cost on the Productivity of Pesticides over Time

By depleting the two forms of biological capital, pesticides generate user costs. This causes a direct increase in future costs of production, over and above the costs required in the present period[8]. From the earlier discussion, it is seen that the depletion of the two forms of the natural biological resources can both increase and decrease the productivity of pesticides respectively. As a result, the overall impact of user costs on the productivity of pesticides is determined by a *net effect* of the two forces.

Where user costs are involved, there is often a linkage between production decisions and outcomes in two different time periods. Highlighting the inter-temporal nature of the user costs of pesticide use, HUETH and REGEV (1974: p. 548) define the "user costs" of pesticides as the "increased future costs of controlling the pest as a result of the decision to apply chemicals today". That is, the increased costs that will be required to control the same pest species in the future, than is presently required[9].

Optimal decisions on the application of pesticides are made when the management of *both* the direct costs of pest control and the associated indirect cost on biological capital are (simultaneously) optimized (HUETH and REGEV 1974). Thus, if the marginal value of a pesticide's (positive) contribution to plant growth and production is *less* than both the (negative) marginal cost of the pesticides *plus* the marginal cost of their use in reducing the stock of pest susceptibility, then the pesticide should not be used, and vice versa. The optimal level of pesticide use is attained only when the marginal benefit equals the marginal cost of the two major types of costs identified above. Other input levels (above or below this point) are sub-optimal. Thus, for a given individual producer, the discounted present value of streams of net returns from pesticides would be less if user costs are considered. ARCHIBALD (1988: p. 366) posits that "excluding production externalities can overstate (understate) productivity gains from technology as some costs (benefits) are not counted". It follows therefore that "accounting for the costs of resistance and the destruction of the natural control potential of an ecosystem changes the relative economic advantage of self-regulating measures (e.g. IPM) versus external inputs (pesticide)" (WAIBEL 1996: p. 38).

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8 As a result, user costs represent the opportunity cost of current production decisions on profits that could be obtained in the future.

9 The increased cost of pest control in the future is due primarily to the 'mining' of the non-renewable biological capital resource (pest susceptibility) by pesticides.

Given that pests are not unique to a single farm (due to pest mobility), pests are non-appropriable. This implies that unlike other resource inputs, pesticide resistance cannot be easily managed by individual farmers (KNIGHT and NORTON 1989: p. 298). As a result, biological capital cannot be easily appropriated by an individual producer. According to CARLSON (1977: p. 547), the "common property nature of non resistant pests suggests that private producers may under-invest in preserving this resource". This creates a social dilemma because for individual farmer, the outcome will depend on the *cumulative decisions* taken with regards to pesticide use by *all* of the farmers in the geographical area. This creates problems for the optimization of pesticide use because individual farmers will consider only the *present* level of resistance in their fields. There is a disincentive for a private producer to consider the implications of his contemporary pesticide use decisions on the level of pest resistance in the future. This creates a strong urge for producers to regard biological capital resources as a 'free' good, i.e. from a private economic view point, there is no relationship between the amount of the natural resource consumed and the costs paid[10]. As a result, individuals tend to use up as much of the resources as possible, while discounting the cost of doing so in their production computations. This leads to further degradation of natural biological capital. As the capital becomes depleted, there is a build up of pest resistance and in addition, the erstwhile natural regulatory mechanism (predators) against pests becomes less effective. The combined effect of these two situations leads to an increase in the level of pest populations and in the probability of pest attacks. It then becomes increasingly important to seek greater reinforcement against pest problems - often through the application of higher doses of pesticides or new and more expensive chemicals[11]. Increasing application of pesticides further depletes the natural crop protection resource and regulatory mechanisms in the ecosystem. This sets off a chain of events that makes agricultural production in the ecosystem more dependent on pesticides in the battle against pests, leading to a process known as path dependence. In the following section, the main features of the concept are first discussed, and then their relevance to crop protection and interpretation of pesticide productivity estimates is presented.

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10 For example, even if an individual producer does not use the resource at all, he still ends up paying the same amount as his counterparts who have used the resource intensively.

11 It must be noted that the increase in pest problems had been caused by the pesticides that had been sprayed in the ecosystem in the previous periods.

2.2.2 The Concept of Path Dependence

The central theme of path dependence is that the contemporary performance of an economy (or a production system) is considerably influenced by historical antecedents. DAVID (1985: p. 332) defines path dependence as a "sequence of economic changes where important influences upon the eventual outcome can be exerted by temporally remote events, including happenings dominated by chance elements rather than systematic forces".

In the initial period, there are several opportunities for decision makers to make a choice among alternative technologies. These technologies may exhibit increasing returns to adoption, i.e. the more they are adopted, the more experience is gained with them, and the more they are improved (ARTHUR 1989: p. 116). However, when two or more of such technologies compete in the market (i.e. for potential adopters), insignificant random events[12] (i.e. external interventions) in the adoption process or development pathway of a technology could tilt competition in favor of one technology against all the others. Such interventions may come from official policies and informal practices that favor one type of technology relative to others.

With positive feed backs and increasing returns to its adoption, the adopted technology enjoys the advantages of economy of scale. At the time that a technology is being chosen, it is usually thought that the best choice has been made (at least in the absence of full information on its negative effects). Once a particular technology path has been chosen, it increasingly permeates every aspect of the production system. A technology that has by chance got an early lead in the competitive process reinforces its competitive ability[13] and may eventually take over the whole market of potential adopters. By locking out other competitors, the technology increasingly dominates the economy, while the competitors become virtually extinct.

Unlike the natural selection process (where the fittest always survives), the occurrence of an insignificant event (that determines the pathway of future developments) is a probabilistic event. Because of the randomness of the events, their event or an artificial intervention in the competitive process may

[12] Examples of such insignificant random events are the unexpected success of the prototype of the technology, preferences of the pioneer manufacturers and political circumstances (ARTHUR 1989: p. 116).

[13] Through increasing returns to adoption as explained above

favor an otherwise weak competitor technology[14]. As a result, a technology that could have survived under free market competition may fizzle out due to the intervention forces that are biased against it. In the absence of perfect futures markets[15], the competition process may drive an industry prematurely into standardization that is not the most efficient. The resulting impact on the economy may be an *ex post* inefficiency because the technology that eventually emerges may not necessarily be the most superior technology. This could occur because there is a "possibility that self-reinforcing mechanisms might drive the economy to an inefficient outcome" (COWAN and GUNBY 1996: p. 521)[16]. In particular, an emerging technology may generate production externalities, that ARCHIBALD (1988: p. 366) describes as "the un-priced, unintended 'products' from widespread adoption and cumulative use of a particular production technology". It is *ex post* because some information on the externalities would be known only after the choice of the technology has already been made. A reason for this is because gains in productivity due to the adoption of a technology are easier and more rapidly recognized, but their negative effects often begin to attract attention only at a much later date (ARCHIBALD 1988: p. 366). As weaknesses manifest, there is a gradual threat to the high expectations from the technology but they may be ignored at first as 'minor' problems. As the inefficiencies become more obvious and can no longer be ignored, decision takers respond by asking: 'How do we *re-adjust* within this technology?' and seldom is the question asked: 'How do we *change* this technology?'. Several reasons could be adduced for this comportment. Using the QWERTY-DKS typewriter as a case study, DAVID (1985: p. 334-335) provides three of such reasons. First is technical inter-relatedness or compatibility among the various components of the production system. Second is the increase in economies of scale for the emerged technology to such an extent that it virtually becomes 'the standard'. Third is the quasi-irreversibility of investment. Changing an already established technology may lead to radical changes e.g. obsolescence of previous training, need for re-training in the new technology. The effect of technological change also includes endangering the

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[14] Examples of where these situations have occurred include the development of typewriter keyboards and the narrow British railways system (ARTHUR 1989: p. 126).

[15] The assumption of perfect future markets here implies that all decision makers have perfect *a priori* knowledge of the benefit and cost including externalities that would be generated by a chosen technology.

[16] The case of the QWERTY versus DKS typewriters which is highlighted by DAVID (1985) indicates that the choice of a technology is sometimes determined by historical antecedents, rather than economic rationality or efficiency.

economic fortunes of the people that are directly affected by the changes. Another reason is myopia or the fear of the unknown. In such situations, there is a tendency to proffer arguments that since a technology has permeated virtually all areas in the economy and adopted by almost everyone, it is no use re-inventing the wheel. Rather, arguments may be made to the effect that it is better to make *adjustments* to accommodate or reduce observed defects rather than *changing* the technology completely. But because the weakness is inherent in the technology, re-adjustments may accentuate the defects the more, requiring further greater adjustments. The process of adjustment and re-adjustment continues repeatedly, making the production process increasingly dependent on the technology and in managing its defects. With time, the defects increase and adjustment costs become prohibitive, while available choices and the possibilities for a technological change will decrease. In the long run, change is hardly possible as the economy *locks in* (an euphemism for '*getting hooked'*) on the technology that it has chosen.

The initial success of pesticides has provided the 'insignificant event' that shaped the course of crop protection technology. With the euphoria of the initial success of pesticides and the high expectations, various intervention programs were launched to promote the adoption of use of the chemicals. These support programs – especially subsidies on pesticides – provided external interventions that shifted the competition among alternative pest control technologies in favor of chemical control. KNIGHT and NORTON (1989: p. 298) state that pesticide "subsidies encourage growers to use more chemicals and not to use other pest control methods". Also, the absence of information on other methods of control makes the technological competition process biased in favor of pesticides[17]. In a direct or indirect manner, almost all of these support measures reinforce the dependence on chemical-based control. WAIBEL (1994) provides details on the various types of supports that governments provide for pesticides, and how they reinforce dependence on pesticides (see Chapter 3 of this study).

As a result of this support, pesticides were increasingly adopted by farmers. Research to improve the efficiency of chemical control formed the bedrock of crop protection. On the contrary, alternative methods became gradually locked out and in some cases, pest control technology is almost synonymous with the use of pesticides. In spite of the initial success, pesticides are nonetheless

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[17] Such official policies include the one in which government imposed penalties on farmers who fail to use pesticides (as reported by TOBIN 1994).

accompanied by negative externalities such as pest resistance, degradation of biological capital, human health and sustainability of agricultural production. Current information indicates that the rate at which insects are developing resistance to chemical insecticides is increasing while the discovery of new control mechanisms has slowed down. BARNES (1997[b]: p. 27) states that “as the condition of the environment goes steadily downhill, the agricultural community recognizes that total reliance on chemical pesticides becomes environmentally and economically unsound”. This view is supported by KNIGHT and NORTON (1989: p. 293-294) who state that “for some pests the availability of efficacious pesticides is already low to none”. Often, the solution that is being suggested to the reduction in the effectiveness of the available pesticides is to use more chemicals or to develop more effective products. In this manner chemical control of pests sets off a chain of events, which makes pesticide use self-reinforcing. The process has been described in various terms such as ‘pesticide treadmill’, ‘pesticide dependence’ or ‘chemical spiral’. Although pesticides exhibit inefficiencies (i.e. negative externalities), there has not been a major shift away from the use of the chemicals (COWAN and GUNBY 1996, TOBIN 1994, HEONG and SOGAWA 1994). This may be a possible indication of path dependence on pesticides. As COWAN and GUNBY (1996: p. 539) note, “early choices tend to be reinforced, and (that) it becomes difficult to dislodge a technology, sometimes even when there is a crisis”. The path dependence on pesticides is succinctly described by NORGAARD (cited in ROTHER and LONDON 1998: p. 43) as follows: “it appears that we cannot simply stop using pesticides because our agro-ecosystems and agro-economy have been transformed by their use such that they must continue to be used”.

The next section of this chapter discusses the theoretical relationship between the transformation of ecosystems (through the degradation of its biological resources) and path dependence in the estimation of pesticide productivity.

2.2.3 Interpreting Pesticide Productivity Estimates in a Transformed Ecosystem

When the natural resource base is degraded by chemical control, the agro-ecosystem is transformed. As a result of the transformation, the yield gap (i.e. obtainable less actual yield) widens between fields that are sprayed with pesticides and fields that are not sprayed. The yield gap is further increased by improvements in science and technology that increase potential yield of crops (WAIBEL and FLEISCHER 1997). As a result, pesticide applications appear more economic, and the marginal productivity of pesticides increases commensurately. Similarly, when an ecosystem is degraded, the probability of pest outbreak increases. The increased risk of pest outbreaks leads to increases in production risk (REGEV 1988). As a result, pesticides become more valuable (productive) in reducing uncertainties in output. As a result, the productivity of pesticides and the economic justification for the use of these chemicals increases commensurately.

The graphical illustration for the explanation of increased productivity of pesticides under heterogeneous ecosystems and natural (biodiversity) resource degradation is presented below. Figure 2.2 represents input-output relationships for a production system at an initial period t_0 when the natural resource base has not been tampered with pesticide application. The curve Y^S represents the production function in a field sprayed with pesticides while Y^{NS} represents the input-output relationship in non-sprayed field. It is assumed that only one yield increasing input (fertilizer) and one damage control input (pesticides) are used in the production process. The cost of pest control is represented by the intercept of the total variable cost (fertilizer + pesticide costs). "The net benefit accruing to pesticide use is equal to the difference in the revenue curve minus pesticide cost" (WAIBEL and FLEISCHER 1997: p.139).

Figure 2.2: Economics of pesticide use at an initial phase of an ecosystem, time t_0

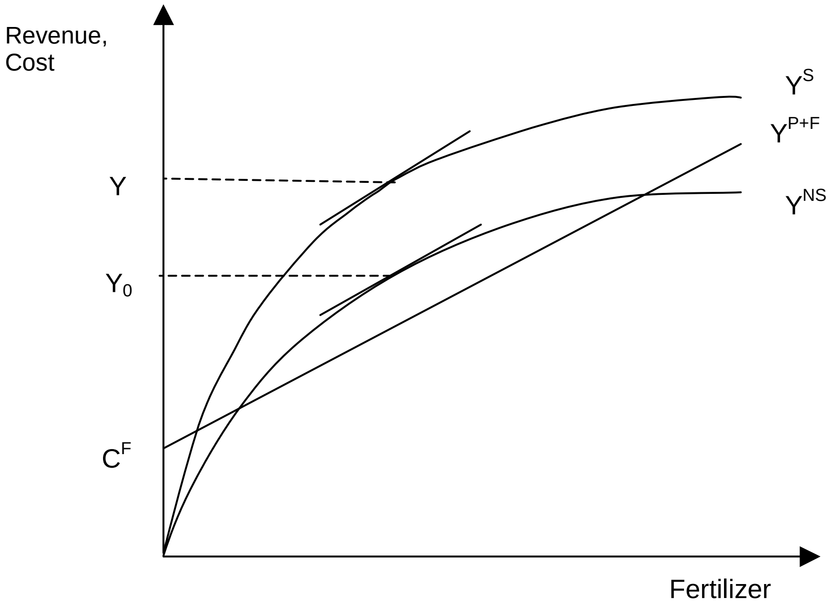
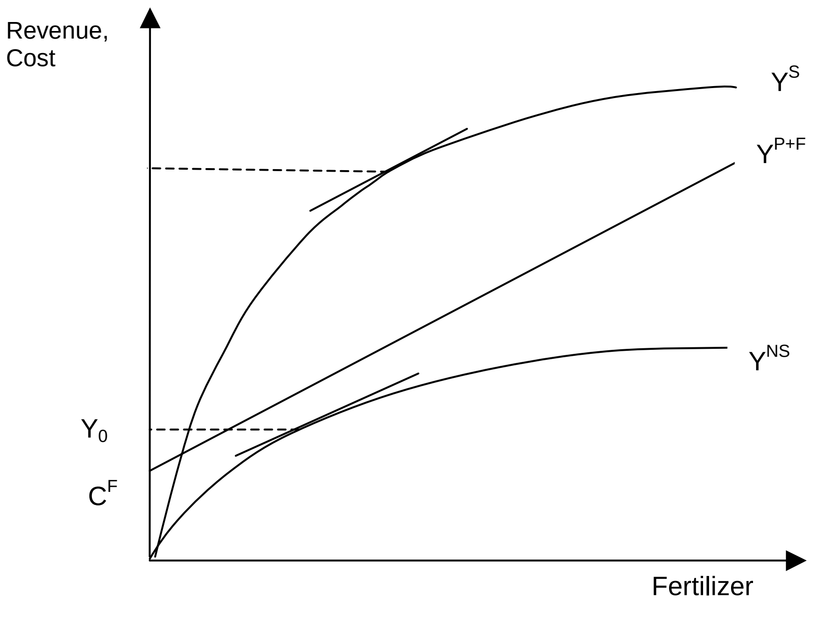


Figure 2.3: Economics of pesticide use in transformed ecosystem at a later period, time t_1



S= Sprayed field P= Pesticide C= Cost
NS= Non-sprayed field F= Fertilizer Y= Yield

Source: Adapted from WAIBEL (1996) and WAIBEL and FLEISCHER (1997)

It is assumed that input markets operate under perfect competition, i.e. the cost curve is linear. At zero level of fertilizer use, the two curves begin from the origin. But as more fertilizer is used, the attainable yield increases and the difference between the two output curves widens.[18]

With repeated use of pesticides over time in the ecosystem, say at time t_1, the depletion of the biodiversity leads to higher pressure from pests. The impact on yield is shown in Figure 2.3. Higher pest pressure widens the difference in yield and revenues between the two types of fields — for every level of fertilizer use — compared to the differences in yields observed in Figure 2.2[19]. WAIBEL and FLEISCHER (1997: p. 139) pointed out that "as long as the divergence in the revenue curve is larger than the increase in cost curves, the marginal product of pesticide use will increase". Therefore, pesticide use *appears* to be increasingly profitable over time. WAIBEL and FLEISCHER (1997: p.139) state further that "the process is stopped when the net revenue curves of the current cropping system falls below an alternative, presumably less pesticide-intensive system". This highlights the important role that policies on pesticide subsidies play in determining the economics of pesticide use.

2.2.4 Impact of Agricultural Policy on Pesticide Productivity in a Transformed Ecosystem

Agricultural policies and distortion in the input and output market prices are important factors that determine the productivity of pesticides including the level that pesticide use reaches before it becomes uneconomic. This is because the most efficient level of a variable input depends on the relationship between the price of the input and the price of its output. To determine the optimum level of production and input use, the important factor is not the absolute level of inputs or outputs, but the ratio between them (ELLIS 1993). This is especially true for market oriented (or cash) crops, where the *economic value* rather than the *physical quantity* of output produced is of utmost importance to producers. For a private investor (farmer), input price policy influences the magnitude of the difference in the cost that he pays for the pesticides to spray his crops. Similarly, the policies on output marketing

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[18] Similar result will be observed if improved seed varieties and other yield increasing inputs are used.

[19] The magnitude of gap between the two production curves depends on several factors. These include the rate of degradation of stock and renewable natural resources, time span between period t_0 and t_1, rate of inputs use intensification, and the level of diversification of cropping systems.

determine the *economic* benefit that he gets from the different *physical* yields obtained in sprayed and non-sprayed fields. In economies where a pesticide subsidy exists, the frontier of the quantity of pesticide input that assures net positive returns to producers also increases accordingly. The magnitude of the increase is determined by the degree of price distortion caused by the subsidy. Theoretically, where there is a full subsidy on pesticides, the productivity of pesticide will be greater than unity for *any* level of quantity used or until the point where there is *complete* pest resistance, i.e. where additional use of pesticides has no effect at all. Thus, a pesticide subsidy has the impact of increasing the net economic value of the yield gap between sprayed and unsprayed fields. It also increases the range of inputs within which the chemical based technology is economically superior to the alternative (i.e., presumably less pesticide dependent systems).

Another policy that affects the economics of pesticides (and resource inputs in general) is produce taxation and the structure of output marketing. If the domestic product market is monopolized, prices tend to be lower than they would have been under a perfectly competitive market structure. In such a situation, internal price distortions often give rise to a negative nominal price coefficient of output, making the unit price of output lower[20]. When there is a negative nominal price coefficient, output prices are lower and so the ratio between input and output prices will increase accordingly. But under a monopolized output market, even if total *physical quantity* of production remains unchanged, the negative price distortion causes the *economic value* of the total production to fall. As a result, the *economic* value of the contribution of pesticides declines and the period of time and the range of input levels over which pesticide use is profitable will decrease.

If individual policies are analyzed separately, the effect can be an increase or decrease in the economic optimum of pesticides use. What happens when agricultural policies cause distortion in *both* the cost of pesticides and economic returns to output generated by pesticides? The effect of such simultaneous policies on pesticide productivity estimate will depend on the

[20] The Nominal Price Coefficient (NPC) is the ratio of the price that is paid to producers in the domestic market relative to the international border price level. An NPC ratio less than unity implies that the product is indirectly taxed and producers get less income than they would have done in the open international market. If NPC ratio is more than unity, then the product is artificially high in the domestic market and it may be an indication of a government price support policy for such products.

magnitude of the impact of individual polices and a *net result* of the contrasting effects produced by the two polar forces.

2.3 Conceptual Framework for Incorporating Natural Resource Degradation Issues into Production Function Economics

This sub-chapter presents a conceptual framework that takes cognizance of the impact of natural resource degradation in the measurement and interpretation of pesticide productivity. If economic analyses are based on production systems that increased pest problems themselves, then estimates are likely to be biased. The estimation of pesticide productivity without making reference to the relative level of depletion of natural resources (that has occurred over time) within the ecosystem could lead to incorrect estimates. Results from previous studies indicate that as an ecosystem specializes in mono-cropping, use of pesticides increases at a faster rate than in mixed cropping fields where there is greater biodiversity (OSKAM et al. 1992). Empirical data cited by WAIBEL and FLEISCHER (1997: p. 137) show that “in a diversified system, the regression coefficient for pesticide inputs has a negative sign while the coefficient is positive in specialized farms” i.e., mono-cropping fields in which the biodiversity base is narrower. The implicit assumption of homogeneity across all observations and, fitting of a single production function model into an otherwise heterogeneous group of observations could be a major source of the high productivity estimates of pesticides in previous studies.

An illustration of the bias arising from observations that have been taken from heterogeneous ecosystems is given below[21]. In Figure 2.4, the production function of a field sprayed with pesticides, say at an initial period t_1, is represented by the curve Y_1^S. At this period, the difference in the yield between sprayed and unsprayed fields represented by Y_1^{NS} is small[22].

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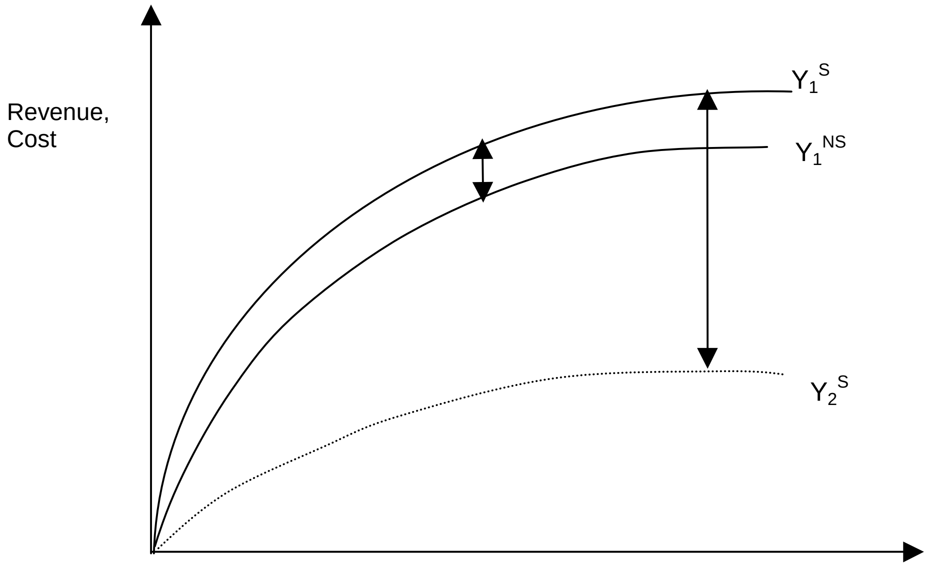
[21] “Heterogeneous” in terms of the different levels of depletion of the natural biological resource base of the respective ecosystems.

[22] This is because there is a reasonable amount of internal resources and self regulatory mechanisms to control pests in the ecosystem.

Figure 2.4: Production function in ecosystems with different natural resource base



S= Sprayed field
Y= Yield
NS= Non-sprayed field
1, 2= different time periods 1 and 2.

Source: Own presentation

Pesticides will be less critical in the period t_1 and as a result, their productivity will be relatively low. As pesticides continue to be used and as they have further impact on the natural resource base, in later periods, say in period t_2, yields in non-sprayed fields will fall to a lower level Y_2^{NS} than they were in time t_1. With time, the yield gap between sprayed and unsprayed fields will widen. The productivity of pesticides will also increase commensurately. But, if the different observations are forced into a unique production function to obtain a single productivity estimate, the results may be misleading. Heterogeneity across data observations is a major source of bias in pesticide productivity studies (CARPENTIER and WEAVER 1997). Concurrently, as farmers continue to use pesticides over a long period, they tend to become more knowledgeable about crop protection and on managing factor inputs. Often, farmers acquire this knowledge informally by experience or sometimes by chance through incidental unplanned experimentation through a ‘learning by doing’ approach. They may also gain practical knowledge and/or evolve indigenous methods of pest management. Such knowledge helps them to use pesticides more efficiently. It therefore influences the productivity estimates of these inputs across a continuum of years of experience.

To minimize the estimation bias discussed above, the analysis of pesticide productivity is better carried out by stratifying observations into homogeneous groups. The stratification must be done to reflect differences in the historical duration and intensity of pesticide use including the possible impact on the natural resource base of the ecosystems and on crop production practices. Various production function models may then be fitted separately on the quasi-homogenous group of observations. From the different economic estimates obtained for each group of observations, a better insight will be obtained which would allow for a more plausible interpretation of the pesticide productivity figures.

2.4 Effects of Pesticides on Human Health and Productivity Estimation

Apart from the effects of pesticides on natural resources of the ecosystem, pesticides also affect the productivity of (or contributions from) other conventional inputs like labor. The nature and the extent of the influence that pesticides have on other inputs ultimately affect the true productivity of the chemicals. Until now, this study has stressed that if realistic productivity estimates that are congruent with observable phenomena on pesticide use are to be obtained, then due consideration of the unique role that this input plays in production is important. Pesticides have the characteristic of a joint input (ARCHIBALD 1988) i.e., a given quantity of the chemical produces intended outputs and also produces simultaneously unintended 'outputs' like negative health effects. To further investigate the 'missing link' in pesticide productivity studies, a discussion of the negative influence of pesticides on other inputs becomes pertinent.

2.4.1 Human Health Cost and the Optimum Level of Pesticide Use

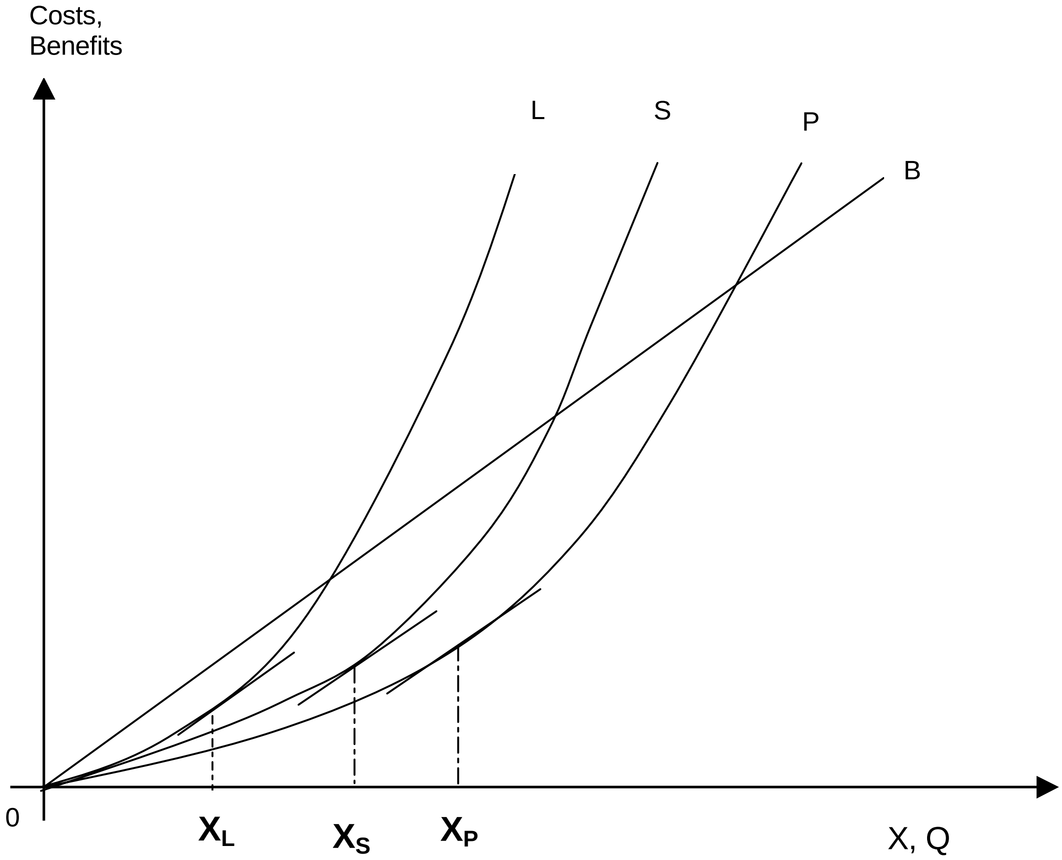
The effectiveness of pesticides derives from their 'kill function' which in turn is related to their level of toxicity. As a result, pesticides are thus necessarily by nature made to be toxic, else they would not be effective. As toxic products, they are biocides that kill pests but inadvertently negatively affect human health. The negative effects of pesticides on human health and productivity have been documented by several authors including ANTLE et al. (1998) and

ROLA and PINGALI (1993). Given that labor is one of the most important factors in agricultural production especially in developing countries, pesticides necessarily lower aggregate potential output through their negative impact on the health of household members and farm workers.

In the analysis of empirical data, ROLA and PINGALI (1993: p. 5) demonstrate that "explicit accounting for (human) health costs substantially raises the cost of using pesticides". ANTLE and PINGALI (1994: p. 428) report that "the estimates of the rate of return to rice research based on experimental predictions of yield gains that do not account for health effects of pesticide use will be overstated" under the pesticide use practices of the farmers in Asian agriculture. These studies indicate that health considerations provide an explanation for the paradox observed in earlier estimates of pesticide productivity. Given that negative externalities are costs, the exclusion of such costs can result in an over-estimation of the gains from a given technology (ARCHIBALD 1988: p. 366). Thus, if human health costs are not considered, the economically optimum level of pesticide use will be biased upwards. The extent of the bias is proportional to the level of under-estimation of the human health costs associated with the use of pesticides.

In Figure 2.5 below, line OB represents the benefit from pesticides, i.e. the value of crop loss prevented. The line has a constant slope because of the assumption that the producer is a price taker. If only market costs that users pay for pesticides are used for computations, (i.e. perceived cost) the cost of pesticides will be represented by curve P.

Figure 2.5: Impact of human health cost on the optimum level of pesticides use



X_P = Optimum level of Pesticide (Perceived Private Cost)

X_S= Optimum level of Pesticide (short run)

X_L = Optimum level of Pesticide (long run)

X= Pesticide

Q= Potential Yield Loss Prevented by Pesticides

P= Perceived cost (Market cost only)

S= Short run cost (Market cost + short term observable human health costs)

L= Long run cost (Market cost + short term observable + long term unobservable chronic health costs)

Adapted from: WAIBEL 1994

The optimum level of pesticide use will be attained at X_p. Pesticides are biocides, and they are more likely to affect the health of human beings than other agrochemicals because of their intrinsically toxic properties (WHO 1990). This produces occupational health costs, i.e. short term health effects that are observable in the short run but not internalized into production computation.

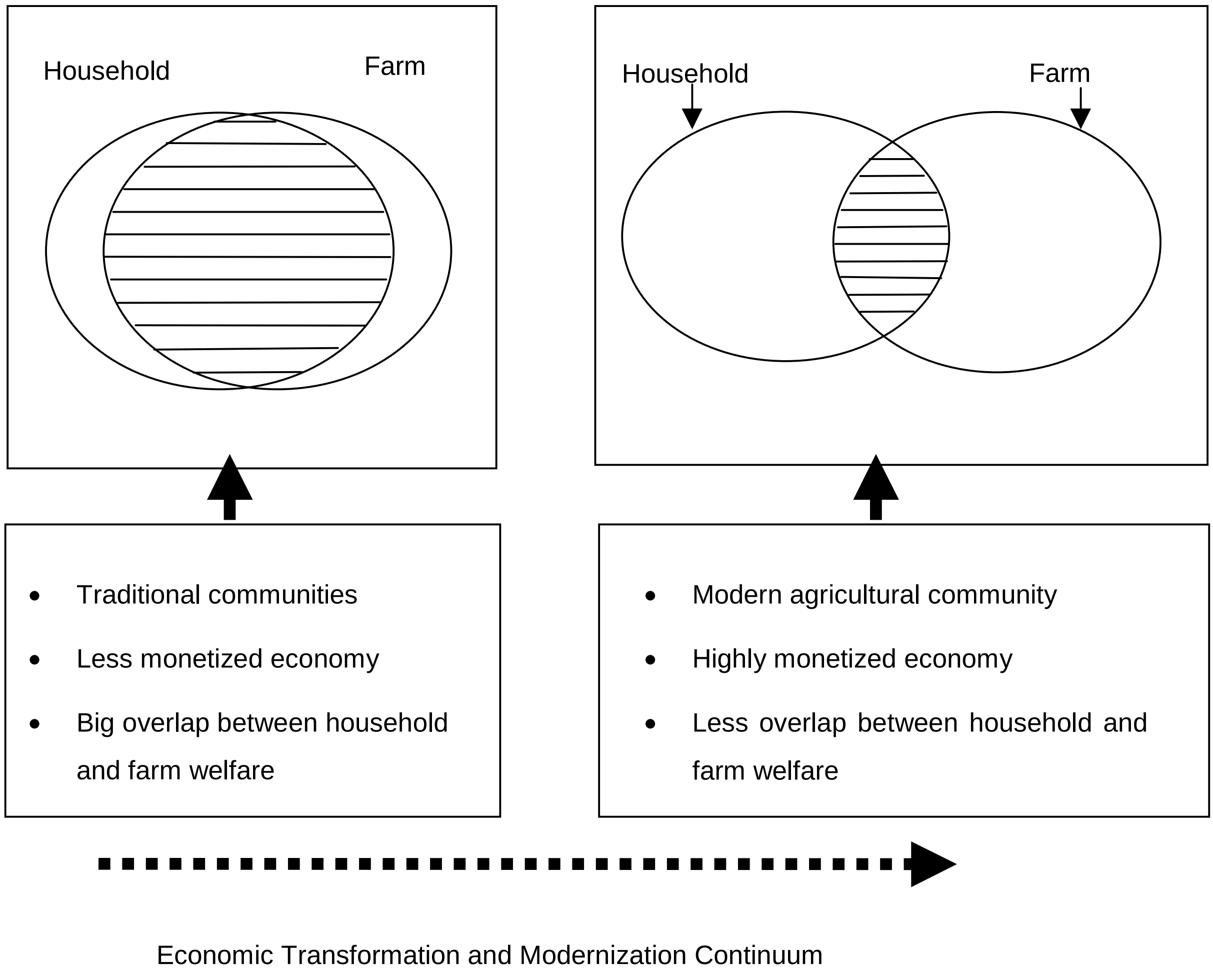
By internalizing this cost into cost computation, the cost curve shifts from OP to OS, and the economic optimum of pesticide declines to X_S. This implies that the productivity estimates for pesticide use between X_S and X_p are in reality less than unity. It can be shown that all productivity estimates between X_S and X_p are indeed upwardly biased. This is succinctly described by SWINTON (1998: p. 363) as follows: “where agro-chemical inputs increase yield but depress (human) health and the environmental quality, this suggests that ‘optimal’ choice of agrochemical inputs will result in lower levels of their application”.

Furthermore, if the costs of chronic (long term) human health costs are added, the cost curve increases to OL. The new optimum level of pesticides falls further to X_L. The larger the difference between OP and OS or between OS and OL, the greater is the degree of under-estimation of pesticide cost. Therefore, pesticide productivity estimates will be biased upwards. In this present study, attempts will be made to estimate the magnitude of OS. Due to lack of accurate knowledge on the relationship between pesticides and chronic illnesses, OL cannot be estimated yet.

2.4.2 Incorporating Pesticide Health Costs into Agricultural Household Theory

Social and economic theory suggests that with increasing modernization of society, economic units become more specialized in production of goods and services. The resulting increased division of labor leads to a higher level of economic transactions between constituent units. The economy becomes more formalized and more monetized. Classical economic theory assumes that production and consumption take place in separate distinct economic units, that make independent economic decisions. In agricultural households however, empirical studies suggest that this theory is restrictive and less plausible because households are the locus of both production and consumption decisions (DOSS 1994). In Less Developed Countries, household production and consumption decisions center on the farms because the household is intrinsically tied to these farms. The household depends on the family farm for food security and employment, and in return the household provides most of the resources particularly labor to the farm. The overlapping of these economic decisions increases as the agricultural household is more traditional[23].

Figure 2.6: Linkage between agricultural household and farms in typical developed and developing economies



Source: Author's own presentation.

The level of effect of pesticides on household health (and household utility) generally depends on the extent of inter-dependent relationship existing between household and farm. The integral relationship between households and farms is represented in Figure 2.6 above. The agricultural household model has been used to examine household behavior in developing countries.

[23] Perhaps, this explains why in doing the mental accounting of profitability of their farms, most farmers in traditional agricultural communities consider only external resources that they directly pay for, but disregard all other resources that came from within the household taking them as 'free' inputs.

The household faces a constrained optimization problem. It seeks to maximize utility by consuming staple foods, market goods and leisure.

In its quest to maximize utility, the household is faced with both cash flow (income) and available labor resources (time) constraints. Pesticides affect both constraints, and at a certain level of food production, trade-offs have to be made between them by the household. This trade-off is discussed below within the context of developing countries' agriculture.

2.4.3 Pesticide Use and Health-Income Trade-off Decisions.

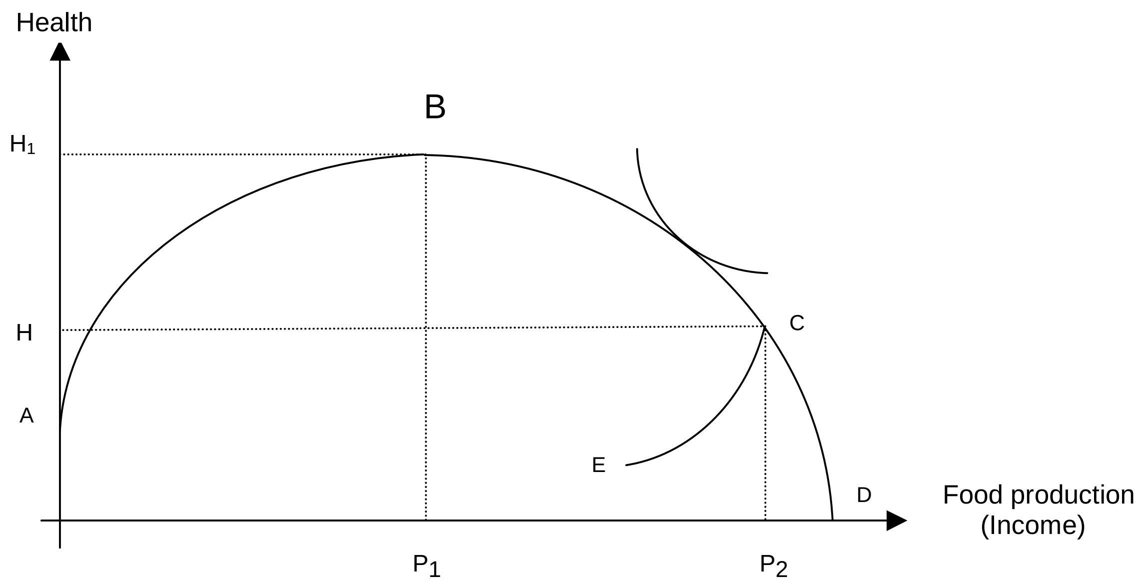
The initial use of pesticides may enhance household utility initially, i.e. through improved food production and better-quality nutrition, the health status of the household will most likely increase. This may be true particularly in food-deficit nations. This stage is depicted by the AB curve in Figure 2.7 below. After a certain level of food production, say at P_1, the household may choose to further increase farm production (and hence its income) through for example, increases in the level of pesticide use. In view of its biocidal properties, an increase in the level of pesticide use has the tendency to impair the human health status of the farm household[24]. Due to the high interdependency of households and farms, an impairment of the health status of the household members imposes potential negative effect on farm production. The negative effect may manifest in a lower level of agricultural production (i.e. through a reduction in the number of active persons that are available as household farm labor). It may lead to lower income for the agricultural household (i.e. through a reduction in the level of farm output that the household can sell). Another type of effect is that it may lead to a reduction in the time available for the household (i.e. through a reduction in the amount of leisure time available for sick household members or a greater pressure of work for the healthy household members who have to work harder to fill in for sick members)[25]. Any of the above possible effects may create perturbations in the amount of resources available to the household and introduces uncertainty in farm

[24] This is especially true where farm workers do not wear protective clothing against exposure to the chemicals. On the other hand, when farm workers wear some protective clothing, the health cost may be reduced, but the expenses incurred to procure the clothing will constitute additional costs that will necessarily increase farm production costs.

[25] More details on the possible effects of an impaired health effects of the household on agricultural production are discussed in Section 8.1.2.

production[26]. The competition will be higher between the two opposing objectives of the household: an income objective (which requires pesticide to produce food) and a health protection objective (which requires the use of less pesticides)[27].

Figure 2.7: Maximization of utility by a household facing multiple objectives



Source: Adaptation of ANTLE, CAPALBO and CRISSMAN (1998)

The optimal decision making by the household to maximize its utility within the context of these conflicting multiple objectives can be analyzed through trade-off curves as shown above in Figure 2.7. ANTLE, CAPABLO and CRISSMAN (1998: p. 28) argue that "trade-off curves used in policy analysis are closely related to the concept of the transformation frontier used in economic theory." The concept of trade-off provides essential information for making choices among alternatives because they show how much of one unit of a desired outcome (i.e. farm production) must be given up to obtain a unit of some other desired outcome (i.e., human health). At point B, the food production level of the household is P_1 and its health status is at point H_1. The household may decide to increase the level of its agricultural production, say P_2. This is accomplished by a decrease in the household health status to a lower level H_2.

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26 This may be uncertainty in farm production and household food security (for food crops) and or income (for cash crops). In either case, pesticides could function as a risk-inducing agent.

27 Improvements in technology may lead to less toxic pesticides or non-chemical methods that are less toxic to workers, but these necessarily cost more and the household loses in terms of income.

Beyond point C, the household may continue to increase agricultural production and trade-off its health status theoretically until it reaches point D. However, “if health also adversely affects productivity, then beyond a certain production level, (say at point C) both health and production will decline” (ANTLE, CAPABLO and CRISSMAN 1998: p. 32). Under this situation, the production vs. health trade-off follows the CE segment of the transformation curve instead of the CD segment.

If households are aware of the health consequences of production, they would choose to operate along the CE curve where the marginal cost of increased health risks just equals the marginal benefit of higher agricultural production health risks (ANTLE, CAPABLO and CRISSMAN 1998: p. 32). Given that labor is one of the most important factors in agricultural production especially in developing countries, pesticides therefore lower potential output through negative impacts they have on the health of household members and farm workers. Production models that do not consider this effect of pesticides on human health are likely to lead to over-estimation of productivity of these chemicals. In summary, where pesticides increase farm yield but depress health, the ‘optimal’ choice of pesticide input will result in lower levels of application.

2.4.4 The Role of Information and Awareness of Pesticide-related Health Costs on the Household Utility

Given that the indifference curve (Figure 2.7) is a subjective evaluation, it is highly influenced by the level of awareness and accuracy of information that agricultural households have about the health problems associated with pesticides. Thus, the level of awareness and knowledge of households are key issues in efforts of agricultural households to attain optimum pesticide use. These include the knowledge about health costs, the perception and the importance that households attach to pesticide-related health issues. Where an information gap exists on the health impact of pesticides, health costs are most likely to be excluded from farm production costs and decision-making. This may result in sub-optimal production decisions and cause an upward bias in pesticide use. As ROLA and PINGALI (1993: p. 55) state, “farmers who do not know about the harmful effects of pesticides sometimes overvalue their benefits and use more than is good for them or their communities”. The foregoing highlights the high importance of the accuracy of farmers’ knowledge and perception about pesticide-related health problems.

One of the objectives of this study is to examine the health implications of pesticides as caused by the behavior and the perceptions of farmers and households. Theoretically, pesticide use practices and human health costs are expected to be influenced by the level of information that farmers have on the potential hazards and the short and long term consequences of pesticide use. Under an improved information situation, farmers will probably use more protective clothing and/ or spend more money for medical treatment than they are currently doing. In either case, extra costs are incurred. The additional costs associated with pesticide use (hitherto neglected) have the effect of lowering the initial level of productivity of pesticides. The extent of reduction in productivity will depend on the amount of the human health costs induced.

2.5 Research Hypotheses

Based on literature review, the theory discussed above, and given the evolution of cotton development and the associated crop protection policies in Côte d'Ivoire, the following hypotheses are being formulated for testing in this present study:

- Pesticide use in the cotton fields of Côte d’Ivoire is accompanied by user cost resulting from the depletion of the natural biological capital of the production systems. The user cost increases as the length of period in which pesticides have been used in the different production systems (geographical zones) increases and this affects the pesticide productivity estimates obtained from production models.
- Negative health effects of pesticides exist, which lower the economic value of pesticides at the household level. As a result, if the health costs of pesticides are not taken into consideration, the estimates of pesticide productivity will be biased upwards.

In addition to giving insights into the main objectives of this study outlined in section 1.3 above, a test of these hypotheses will also provide a comparison of the productivity of pesticides in cotton fields that are grown under varying levels of crop intensification and ecological conditions.

3 Economic Development, Agricultural and Crop Protection Policies of Côte d'Ivoire

This chapter consists of four sections. It begins by presenting information on the socioeconomic development and demographic indices of Côte d'Ivoire. The second section provides an overview of the agricultural sector. In the third section, agricultural policies to develop northern Côte d'Ivoire through the promotion of cotton production, are highlighted. The final section appraises how the various agricultural policies (inadvertently) promote pesticide use over and above other crop protection methods, and exerting a structural impact on pesticide use that still exists at present.

3.1 Socio-economic Factors of Development

Côte d'Ivoire is made up of administrative units called *régions*. Each region is sub-divided into *départements*, *préfectures* and *sous-préfectures*. The country had steady economic development during the 1960s and 1970s, and GDP increased at about 7% per annum[1]. This is a record for sub-saharan Africa. However, in the past two decades, Côte d'Ivoire has been experiencing a downturn in its economic fortunes primarily due to a fall in international prices of its most important export crops, i.e. cocoa and coffee. GNP per capita is estimated at $710 and life expectancy at birth is estimated at 46,7 years (UNDP 1999).

The current population of Côte d'Ivoire is estimated at 14,1 million inhabitants. It has one of the highest population growth rates in the sub-region estimated at 3.4% per annum (UNDP 1999). This increase is a result of the combined effects of a high natural birth rate and high immigration especially from the northern neighboring nations Burkina Faso, Mali and Guinea. The total national territory is about 322,000 km^2 and population density is estimated at 44 persons/km^2. The population density is significantly higher in the southern parts than in the northern parts of the country, because of better economic opportunities and migration, especially of youths from the north to the south. Since independence, there has been a general decline in the proportion of rural dwellers. For example, "in 1965 there were 3 rural dwellers for every one urban dweller, but in 1990 the ratio between rural to urban population was

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1 The economic successes witnessed during the period mentioned above were due to political stability and a favorable external environment.

1.5:1. It is estimated that if the trend continues, there will be more people living in the urban areas than in the rural areas by the year 2015" (République de Côte d'Ivoire 1993: p. 2). Due to school attendance causing youth and rural-urban migration, there is a steady aging of the farming population. As a result of these factors, there is increasing pressure on the rural population to increase production to meet the food demands of an increasing urban population.

The industrial sector is developing gradually. Most industries are based on the processing of products from the agricultural sector or manufacturing inputs for the same. About 80% of the pesticides used in Côte d'Ivoire is formulated locally while the remaining share is imported in a ready-to-use form (FAO 1990). Côte d'Ivoire does not yet possess the technical ability to manufacture active ingredients for pesticides.

3.2 Overview of the Agricultural Sector in Côte d'Ivoire

3.2.1 Role of the Agricultural Sector

The agricultural sector in Côte d'Ivoire plays a significant role in the socioeconomic development of the country. The impressive annual growth rate in real GDP recorded by the country, especially in the first two decades after its independence, was realized almost exclusively on the basis of contributions from the agricultural sector. Côte d'Ivoire does not have substantial natural mineral resources[2]. The agricultural sector places first on the export list for the country, though there has been an increase in exports from non-agricultural sectors. The country is one of the world's leading producers of cocoa and coffee, and it ranks among the top three producers of cotton in Africa. Recently, it has become an increasingly important producer of pineapple and banana/plantain.

Although the relative contribution of agriculture to the national economy has decreased in recent years, UNDP (1999) estimates that the sector still contributes about 27% to GDP in 1997 and provides employment for about 50% (FAO 2000) of the labor force. The agricultural sector induces growth of the industries producing pesticides and fertilizers. Thus, the sector contributes indirectly to employment generated in the industrial and service sectors of the

[2] Petroleum was discovered recently along the coast in the south of the country, but this resource has not yet been fully exploited.

economy. Due to the successes recorded in agriculture (often dubbed the *Ivorian miracle)* and the close relationship between agriculture and the economic development of the country, it has almost become a national refrain that: *"le succès de ce pays repose sur l'agriculture"* (the success of this country rests on agriculture). Ivorian agriculture will remain the dominant sector of the economy for some times.

3.2.2 Characteristics of Agricultural Production

The cash crop sector is dominated by cocoa and coffee in the southern (forest) region and cotton in the northern (savanna) region. The major food crops cultivated include rice, yam, maize, plantain and other cereals. In general, the average size of cash crop fields is larger than that of food crop fields. Agricultural production has increased over the years at an average rate of 4% per annum (République de Côte d'Ivoire 1993: p. 2), but most of the production increases in the country came about by increasing cultivated area rather than by increased productivity per hectare (République de Côte d'Ivoire 1993, HAILU 1991). Changes in the production systems have been minimal and the agricultural technologies used in the country are still generally dominated by manual methods, though animal traction and tractors are common in the savanna. The increase in agricultural production through extensive growth rather than increases in land productivity appears to be a common feature of the agricultural sector in most West African countries (NYANTENG 1986, SPENCER 1986)

3.2.3 Economic Policy in the Agricultural Sector

A characteristic feature of Ivorian agriculture is that "the post-colonial agricultural policy favors cash crop production to the detriment of food crop production. The policies of agricultural pricing, crop diversification, agricultural credit and market and transformation of agricultural products are primarily oriented to cash-cropping" (KOUASSI 1993: p. 67). The national plan for agricultural development is underlined by a permanent concern to bridge the level of development between the northern and southern regions of the country. The policy objectives of the previous agricultural development plans were to reduce the disparity in the level of development between the north and the south of the country, and to diversify agricultural production[3]. Other

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[3] The aim of the agricultural diversification is to reduce the impact of perturbations in world prices of export crops.

objectives include achieving national food self-sufficiency, modernization of agriculture to encourage youths to take up agricultural vocations and so reduce rural-urban migration, and reducing crop loss through the use of pesticides (NDABALISHE 1995, PRAT/EUROPA 1990). In the current agricultural master plan for 1992–2015, the basic emphasis of agricultural policy is to improve the productivity and competitiveness of the agricultural sector, to further diversify agricultural production[4], and to develop the maritime and lagoon fisheries. Other objectives are to further increase the level of self sufficiency and security in food production, and the rehabilitation of the forest stock (République de Côte d'Ivoire 1993: p. 3-4). But unlike previous years when the state intervened in almost all the activities in the agricultural sector, a major change in current policies is the increasing liberalization of the agricultural sector through the reduction of state intervention.

3.3 Agricultural and Cotton Development Policies in Northern Côte d'Ivoire

The development of cotton in Côte d'Ivoire is closely linked to the historical antecedents of the northern region[5] of the country and to the strategy to develop the region after independence. At the time of political independence, there were sharp disparities in socioeconomic development between the northern and southern parts of the country. There were well-developed cash crops particularly cocoa, coffee and timber in the South, but such opportunities were lacking in the savanna region[6]. This led to migration of people especially youths to the southern forest regions. As a result, the North became merely supplier of farm labor for the plantations in the forest zone. During this period, the greater proportion of the manual labor in the South originated from the North and about half of the population in the North aged between 20-29 years had migrated to the South. Levels of income also differed sharply between the two regions. The value of production in the South was seven times higher than that of the North, and income per capita in the South was eleven times higher during this period (AUBERTIN 1983: p. 41). Agricultural exports which were (and

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[4] It is expected that the share of cocoa and coffee in the agricultural exports will fall in the medium term from the present level of 41% to 30%..

[5] This region is sometimes referred to as '*Le grand Nord*' (the Great Northern region) and it comprises the totality of all the geographical and administrative zones in northern Côte d'Ivoire.

[6] In this study, 'savanna' is synonymous to 'north' while 'forest' is used in the same sense as 'south'. These two synonymous terms may be used inter-changeably.

still are) the largest source of foreign exchange earnings are highly concentrated in the South[7]. School attendance also differed markedly between the two regions. The resulting low income in the savanna led to twin problems in both regions i.e. labor shortages in the North and relatively high population pressure in the South (HAILU 1991, KOUASSI 1993: p.67). For reasons of socio-political expediency, the government decided to redress this trend by introducing cotton in the northern region (POKOU 1992). Cotton was chosen because the climatic and soil conditions in the North do not support profitable production of cocoa and coffee. It was also intended that cotton would be used to explore the potential for the successful implementation of agricultural mechanization in the country. It was expected that agricultural modernization would encourage the youth to take up a career in farming and thus help to mitigate the problems of North-South migration and the regional divisions in economic development.

Although farmers have been cultivating cotton in northern Côte d'Ivoire since the 18th century (HAU 1988), it was traditionally grown as a minor crop and in a mixed cropping system with food crops[8]. During this period, only a small amount of low quality *mono* cotton was produced and Côte d'Ivoire relied on imported cotton (STIER 1972). The traditional system of inter-cropping cotton with food crops posed major constraints to successful intensification and development of cotton. To overcome this limitation, the administration at that time made it compulsory for farmers to plant cotton as a monocrop. This obligatory and radical change in cropping systems led to initial problems and negative reactions from farmers. To overcome the initial limitation, several strategies and policy incentives were put in place. These consisted of some mutually reinforcing price and non-price subsidies. The price policies included several direct subsidies on inputs and farm operation costs to cotton farmers. The non-price policies were indirect and they are essentially institutional and infrastructural assistance for cotton production. Examples and details are discussed later in this section. In terms of the level and duration of subsidies, the most important among these policies were subsidies on insecticides. Between 1966 and 1994, insecticides were given to farmers free of charge.

7 For example in the early years after independence, only three crops - cocoa, coffee and timber - all of which were produced in the South generated more than 80% of the national agricultural exports.

8 Farmers found this system to be advantageous. These advantages included reduced labor time for farmers working on inter-cropped systems compared to when the crops were planted solely in the fields. They also included better disease resistance for the *Barbadense* variety that was traditionally planted and better preservation of soil moisture in the dry region (KONAN 1990).

Cotton production gradually became associated with sole cultivation and increasing use of insecticides as farmers responded favorably to these policy incentives. As a result, the agricultural economy of northern Côte d'Ivoire became increasingly dominated almost exclusively by cotton. The nation also emerged as one of the major pesticide consuming nations in Africa, and it utilizes one of the greatest amounts of insecticides for cotton production in the West African sub-region. Due to the free distribution of pesticides for cotton production, several of the policies on cotton development affect pesticide use both directly and indirectly.

3.4 Impacts of Agricultural and Cotton Development Policies on Pesticide Use in Northern Côte d'Ivoire

The cumulative effects of various economic and agricultural policies in a nation often determine the dominant crop protection practices. WAIBEL (1994) provides a framework to analyze national pesticide sectors with a view to identifying policy factors that may induce or discourage the use of pesticides over other alternative crop protection technologies. He classifies crop protection policies into four groups presented as a two by two matrix: price and non-price factors on the one hand and, obvious and hidden factors on the other. The framework has been applied in the analysis of national pesticide use in Costa Rica (AGNE 1996), Thailand (JUNGBLUTH 1997), Côte d'Ivoire (FLEISCHER et al. 1998) and for several developing countries (FARAH 1994). The framework is used in Table 3.1 below to identify how various cotton development and other agricultural policies promoted and reinforced pesticide use in northern Côte d'Ivoire. The details on these factors are discussed in AJAYI (1996).

Table 3.1: Policies which promote pesticide use in cotton in northern Côte d'Ivoire

	Price factors	**Non price factors**
Obvious	♦ Subsidy & credit financing of insecticides and herbicides ♦ Subsidy & credit financing of fertilizers ♦ Credit financing of spraying equipment ♦ Exemption of pesticides from various taxes ♦ Free cotton seeds	♦ Free anti-intoxication drugs and soaps ♦ Farm mechanization promotion policy ♦ Development of cotton co-operatives ♦ Emphasis of crop protection trials on the efficacy of pesticides ♦ Government carrying out pesticide spraying operations for farmers
Hidden	♦ Guaranteed price and market for cotton output	♦ Tying assistance in food crop fields to the cultivation of cotton and use of pesticides ♦ Non implementation of promising results on non-chemical pest control ♦ Pesticide procurement policy ♦ Reward system for extension officers ♦ Little information on non-chemical methods to farmers

Source: Based on AJAYI (1996), and using the framework by WAIBEL (1994)

Subsidy and credit financing of pesticides: The cumulative cost of the subsidies on insecticides in 1986 alone was estimated at 23 billion CFA or about 92 million US dollars (KONAN 1990). Farmers' reaction to this policy was a tremendous increase in the area planted to cotton and in the number of cotton growing households (see Figure 1.1). The development of cotton in Côte d'Ivoire became associated with mono-cropping and an increasing use of agrochemical inputs. Free insecticides were abolished in 1994/95, due to the re-organization of the national agricultural sector but it has since been replaced by a policy of credit financing of pesticides. Under the new policy, the cotton company buys pesticides and distributes them to farmers on credit. The interest rate charged on the credit for pesticides is below the market rate. The cost of the chemical is deducted at source from the farmers' production at the end of the harvesting season.

Subsidy and credit financing of fertilizers: Fertilizers were distributed for free for cotton production until 1984. The free distribution has been replaced by a credit financing method. Free fertilizers (distributed per unit of land cultivated) encouraged the cultivation of larger cotton fields. As the size of cotton fields increases, the quantity of pesticides that is needed to spray the large fields increased commensurately.

Credit financing of pesticide spraying equipment: Spraying equipments are supplied to farmers on credit basis (repayable between 2-4 years). The easy access and availability of pesticide spraying accessories enhance greater use and improve knowledge on chemical control method relative to non-chemical alternatives.

Exemption of pesticides from taxes: Pesticides are exempted from various forms of taxation (see FLEISCHER et al. 1998 for details). This policy lowers the price that farmers pay to use pesticides, making chemical-based pest control methods cheaper compared to non-chemical methods.

Free cotton seeds: Cotton seeds are distributed for free to farmers in each season. This contributes to increases in the area planted with cotton and as a result, it leads to increases in the quantity of pesticide use. This policy is on-going.

Free anti-intoxication drugs against pesticides poisoning: Free anti-intoxication drugs (and soaps) were distributed for free by the government/cotton agency to cotton farmers. RICHARDI (1992: p. 39) reports that in the high intensive cotton production regions, all the antidote drugs that were distributed to treat pesticide poisoning were always exhausted by cotton farmers during each agricultural season. The cost of managing the negative health effects from pesticides constitute an additional cost of chemical-based crop protection (WAIBEL, 1994). This has the opportunity cost of limiting the amount of resources that are available to promote alternative non-chemical control methods. The free distribution of anti-intoxication drugs has since been eliminated.

Farm mechanization policy: With the introduction of animal traction, intermediate and fully motorized mechanization of cotton farms, the area grown to cotton crop increased[9]. The mechanization scheme was supported by generous subsidies from the government. The increase in the area grown to cotton led to a proportional increase in the quantity of pesticide use.

Development of farmers' cooperative groups: Cotton farmers' cooperatives or *GVC (Groupement à Vocation Coopérative*) were originally 'top down' administrative units created by the government to facilitate the distribution of pesticides and other farm inputs to farmers (SISSOKO 1992). The scope of activities of the groups has since expanded to include the direct procurement of herbicides from chemical firms on behalf of their members.

Crop protection research: The crop protection research and almost all the changes that have been occurring in crop protection in the region have essentially been internal adjustments *within* pesticides rather than a *shift from* pesticides. Such research and adjustment include changes in the type of the active material used, changing from a single product to a binary mixture (pyrethroid-organophosphates) and evaluation of the efficacy of different formulations of pesticides.

Official pesticide spraying operations on behalf of farmers: At the initial phase of cotton development, government officials carried out pesticide spraying on behalf of farmers. Presently, pesticide spraying operation is carried out by the farmers themselves, but the policy has given a head-start advantage to pesticides and enhances its adoption relative to other methods of crop protection.

Guaranteed price and output market: The government assured cotton production by providing a ready and secure market for all output. Subsidies were given to textile factories to purchase cotton and ensure a reliable cotton market. This has an indirect effect on pesticide use, i.e. the protection from possible output market failure encouraged farmers to grow cotton and use pesticides.

Tying assistance for food crops to cotton and pesticides: The introduction of cotton led to initial bottlenecks in farm production[10]. The conflict was reduced through the assistance that is provided concurrently for cotton and the major food crops. The access to inputs and other support for food crops was

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9 The major factors that contributed to the successful introduction of animal traction in the agricultural system of Côte d'Ivoire farmers are detailed in MONNIER (1983).

10 LE ROY (1983: p. 71) gives details of the effect of the introduction of cotton on food crop production in northern Côte d'Ivoire.

given to farmers only on the condition that a farmer cultivates cotton. This increased the propensity to grow cotton because of the 'spill over' benefits on food crops. Such a spill over benefit is the potential yield improvements from fertilizer residues for food crops grown in rotation with cotton. In addition, with the improved access to free cotton pesticides, farmers can subsequently divert the same on their food crop fields. Similar spill over effects in pesticide use on cash and food crop among Kenyan farmers have been documented by GOLDMAN (1987).

Lack of follow-up of promising results of non chemical methods: Several experiments conducted in northern Côte d'Ivoire (ANGELINI and COUILLOUD 1972, ANGELINI et al. 1976, ANGELINI et al. 1980, DANMOTTE 1974) demonstrated that great prospects exist for biological control in the country. Trials on action threshold techniques (ANGELINI 1971, DANMOTTE 1974), indicate that the number of insecticide applications can be reduced without significant change in cotton yield. ANGELINI (1971: p. 470) states that "the application of the (threshold warning) method allowed the number of insecticide treatments in cotton fields to be reduced from 12 per year to between 2 to 4 treatments in the northern zone and between 4 to 6 in the southern zone. Cotton yield that was obtained from the threshold method varied between 85% to 95% of the yield obtained in the fields where 12 insecticides were applied". Promising as the results may be, the results were not implemented because the extension service found it more expensive in comparison to (the then) free insecticides (OCHOU 1994). There is a close substitutability between pesticides and alternative pest control strategies. As a result, the adoption of alternative crop protection methods is responsive to the availability and level of subsidies on pesticides (REPETTO 1985). It is therefore not too surprising that the pest control strategy that has evolved to date in Côte d'Ivoire has been relying almost exclusively on pesticides.

Pesticide procurement policy: Before or during land preparation, projection of each individual farmer's requirements for pesticides is obtained in advance. The quantity is then aggregated for all farmers in each GVC, zone and region respectively to determine national requirements of cotton pesticides. But because the recommended brand of pesticides and chemical firm/suppliers change yearly, the implication of the pre-programmed procurement method is that once a quantity has been ordered, there is a strong pressure on the cotton agency to make farmers use all of them during the year. Otherwise, the remaining stock will become 'obsolete' in the following year and constitute a loss to the cotton company. The pressure promotes pesticide use beyond efficient levels.

Reward of extension officers: The official staff reward system recognizes field staff that the highest yields are obtained by farmers that he supervises. The covert competition among field staff is a pressure on farmers to use pesticides.

Crop protection information: The available institutions for cotton (e.g. the GVCs) provide information on pesticide use while the same is not done for alternative crop protection methods. Training sessions on crop protection centered almost entirely on pesticides. NIÉRÉ (1995) reports that extension work on herbicides began in 1978, but their use has been increasing.

Summary of the crop protection policies

Free pesticide distribution has been eliminated, but the current policy of credit financing of pesticides still promotes pesticides and tends to reinforce chemical crop protection technology compared to alternative methods. Therefore, the pesticide subsidy policy as it existed in the old form has ended, but it is nonetheless present through its indirect influence on pesticide use consequent upon the changes it brought about in the farming system of northern Côte d’Ivoire. The case of crop protection in Côte d’Ivoire provides an example in which previous policies and historical antecedents inadvertently affect the outcomes of choices in the later period.

4 Methodology of Data Collection and the Type of Data

Three sections are presented in this chapter. The first contains an overview of the sampling methodology of the study. The different stages adopted for the selection of the regions, villages and households involved in the study are presented. In the second section, the approach used to determine the size of sampling unit that were selected from each region and village is presented. The third section provides information on the type of data that were collected for the study. A description of the method used for the collection of these data is also presented.

4.1 Sampling Methodology

As a result of the difference in time with regards to the introduction of cotton and simultaneously, pesticide use, two distinct areas were selected. These are areas with a long history of pesticides (i.e. about 40 years) and a second one where cotton growing has been introduced at a later period through a gradual diffusion of cotton growing into other zones[1]. Over time, slow and imperceptible changes may occur within an agro-ecosystem that has been subjected to stress from continuous pesticides application (SHARMA 1987, WAIBEL and SETBOONSARNG 1993). Due to lack of field panel data [2] to measure the natural resources degradation effects from pesticides, a technique of stratified random sampling was applied to obtain cross-sectional data from cotton zones that are at different stages of development of intensification. This stratification method has been proposed to account for such ecosystem changes over time. A map showing the diffusion of cotton adoption in Côte d'Ivoire is presented in Figure 4.1. The scheme of the methodology of the sampling technique is presented in Figure 4.2.

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1 Some of the ‘new‘ cotton regions were not part of the original target zones for cotton, but were attracted to grow the crop because of the free inputs.

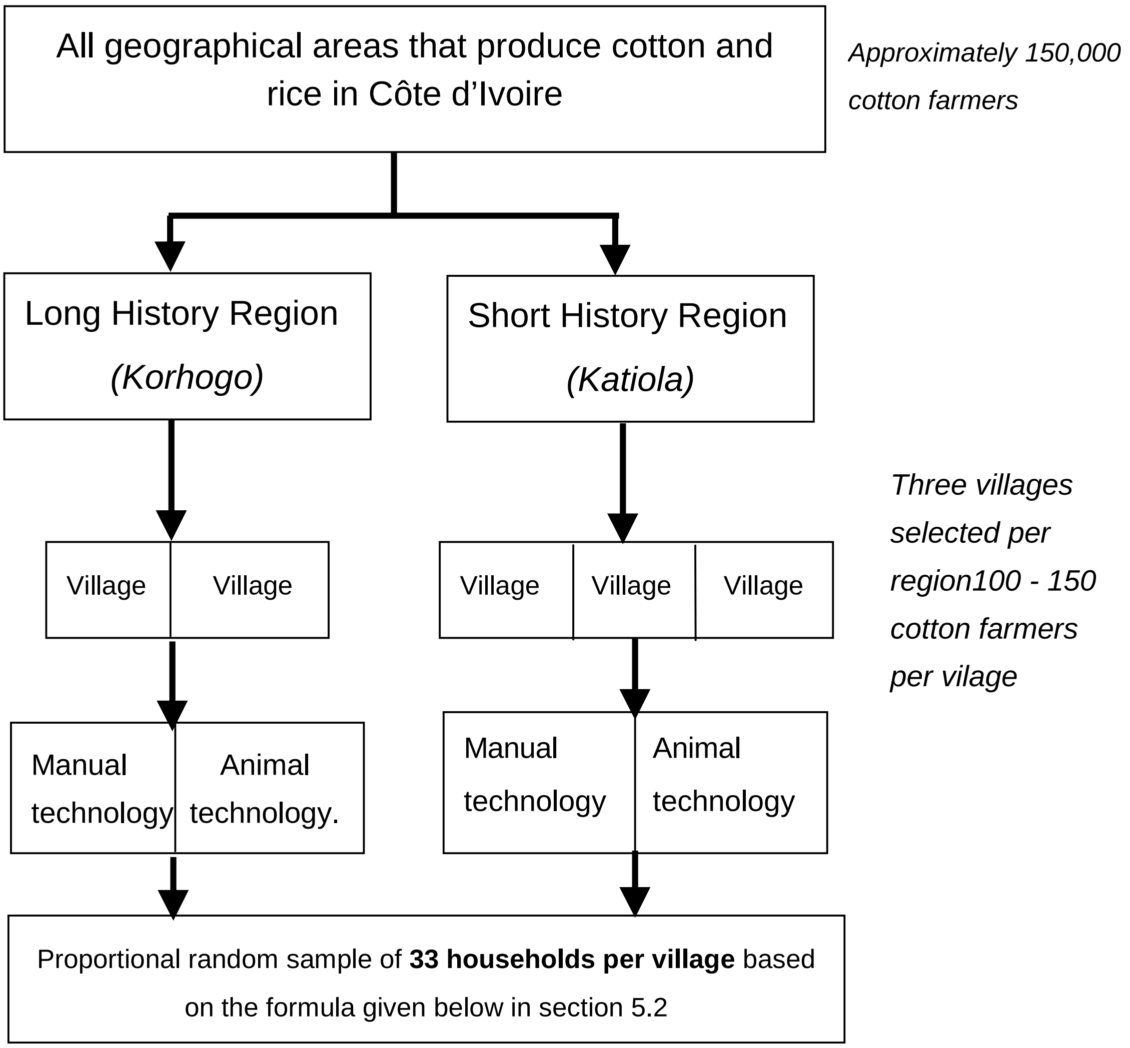
2 Panel data refer to cross sectional data that are collected repeatedly from the same set of observations over a long period of time.

Figure 4.1: Map of Côte d'Ivoire showing the historical diffusion path for cotton development and pesticides use

⟶ : Diffusion of cotton adoption

Source: Map generated by WARDA GIS laboratory

Figure 4.2: Scheme of the steps used in the data sampling methodology



Source: Own presentation

Historical data on pesticide use and cropping systems were collected from secondary sources[3] on cotton cultivation and use of pesticides for all cotton growing zones from the early 1970s to 1994 (or the most recently available data). In the 'long history' region, the average size of cotton fields per household is larger and the quantity of pesticide use is higher than in the 'short history' region. National vegetation and population distribution maps of Côte d'Ivoire were consulted to characterize the cotton growing zones before the study sites were selected. This ensures that the two regions identified share

[3] Principally CIDT annual reports of several years and other publications.

relatively common initial natural soil and vegetation and have a similar human population culture. This procedure helps to control external influences as far as possible. This consideration played a role in the eventual selection of the two zones that represent the two macro research sites for this study. For each selected zone, a sampling frame listing all cotton growing villages with a minimum of fifty households were obtained from CIDT regional offices[4]. Appendix 4.1 contains the organizational setup of all the cotton-producing zones of Côte d'Ivoire. This procedure was then followed up with reconnaissance and 'ground truthing' visits to the villages identified. In each region, all of the villages that met the criteria specified above were numbered. From among these villages, three villages were selected per region. An enumerator was assigned to each village to monitor farmers. Throughout the field level phase of the study, the enumerators resided in the villages to collect data on production inputs and other information.

Stratification by Method of Production Technology

In each selected village, a list of all farmers cultivating *both* cotton and rice were obtained from the resident agricultural extension officer[5]. These two crops dominate the agricultural systems and farming operations and they alone consume almost all pesticides used for agricultural purposes in the study area. All farmers were then grouped according to their basic method of production technology into 'manual-based' or 'animal traction-based'[6]. The policy on agricultural mechanization is closely linked to the history of cotton and farm intensification and follows the same trend as that of pesticide use in the study area. Stratification by degree of mechanization was carried out because the literature indicates that these differences are related to the area grown to cotton, total quantity of pesticide applied and exposure to chemicals. In addition to manual and animal traction technologies, a third production

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4 The requirement for a minimum of fifty households per village ensured that there was sufficient sampling population from which a minimum sample of households for the statistical analysis could be drawn.

5 The list was updated for this study because some information had become obsolete (e.g. some farmers who had left the village or who had abandoned cotton still had their names on the official list).

6 These terms are used because no household in the study area practices exclusively manual or animal traction technology. Manual-based households do not posses oxen and they carry out most of the operations on their farms manually. However, they may rent oxen from their neighbors to carry out difficult farm tasks like land preparation and transport of produce to the village. Animal traction based households own at least a pair of work animals with which they carry out most of their farm operations but some activities (e.g. application of fertilizer and harvesting of cotton) are still done manually.

method exists, i.e. motorized technology. But only a very small proportion of households (less than 2%) in the study area uses this technology.

4.2 Sample Size

A random sample of 33 households per selected village was drawn (34 in one village). The sample size was determined by the relationship given below:

$$S_{ij} = \frac{n_{ij}}{N} \cdot (33)$$

Where:

S_{ij} = sample size drawn from technology i

n_{ij}= number of households belonging to technology i

N= total number of all cotton households in the selected village, i.e. total sampling frame

The proportionate nature of the random sampling procedure ensures that households have an equal chance of being included in the sample irrespectively of their production technology or period of exposure to pesticides[7]. The households in each selected village formed the total sample that were monitored for data collection between July 1996 to April 1997 in the first season. The second season data collection took place between May and December 1997 in four villages only, i.e. two villages per study site. The data for the two periods are used in the analysis and the empirical results that are presented in Chapters five through eight [8].

4.3 Type of Data and Method of Data Collection

The data for this study were collected through monitoring of household and their farm activities between July 1996 and December 1997. The data were collected using structured questionnaires, direct observation and measurements of important variables. Field notebooks to document important observations and informal interviews with farmers concerning several issues related to the objectives of this study were kept. Some of the data were

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7 As a result, cell sizes are not equal.

8 In the first year, one of the enumerators had a serious motorbike accident in which he broke his arms, and was hospitalized for three months between October to December 1996. A person to effectively replace him by staying in the village was not readily available. Only data that were collected in this particular village before the accident took place are included in the analysis.

collected during single visits while others were obtained through repeated visits to households on a weekly basis. A summary of the data collected is presented in Table 4.1 below. A copy of some questionnaires used is presented in the Appendix.

Table 4.1: Type of data and method of data collection

Single visit data		Multiple visit data monitoring	
1	Household demography	1	Sources and utilization of pesticide
2	Field size and characteristics	2	Field observation of pesticide spraying
3	Farmers' knowledge, attitude and practices (KAP) on Pesticide	3	Health economics data for pesticide applicators during spraying season
		4	Household morbidity and health economics data
		5	Agro-economic data of input and output
Bio-medical and laboratory tests			
1	Biological enzyme activity or AchE test	2	Pesticide exposure and residue analysis data

Source: Own presentation

4.3.1 Single Visit Data

Household demography and farm size: Household theory suggests that the size, composition and vocation of household members affect decision-making and agricultural practices. Data were obtained on the number and characteristics of all members of the household. The data include age, sex, residence, relationship to household head, primary and secondary employment and farming experience. Farm holdings of households by type of crop, number of field and farm size were also enumerated.

Field size and characteristics: As is common in developing countries, farms are irregularly shaped, and farm holdings are often fragmented. Accurate information on farm sizes is critical to farm analysis computations because economic indicators are usually expressed on a per unit area basis. All the fields where agro-economic data were collected were measured with a pair of compasses and tapes. All the fields for which closing error exceeded 5% were re-measured. Information on the name and types of crops intercropped, number of years of continuous cultivation of the field was collected for all the fields.

Knowledge, attitude and practices on pesticide: The decision to adopt an agricultural technology is strongly influenced by perceptions that farmers have concerning the technology (TAIT and NAPOMPETH 1987, ADESINA and ZINNAH 1993). Farmers' perceptions are influenced by the knowledge they have about a given technology. Several studies including RICHARDI (1992), CAFFEIRO (1990), CIDT (1989), YOUDEOWEI (1989), GOLDMAN (1987), ATTEH (1987) and BOTTREL (1983: p. 181) document various practices and attitude of farmers in Africa that border on misuse of pesticides. Many of these deviations from recommended pesticide practices are linked to perceptions that farmers hold about these chemicals. Understanding the current state of knowledge, attitude and practices of pesticides measures the perception that users have about pesticides and also provides insight into the likely reactions of farmers to alternative technologies.

Information was collected on knowledge, attitude and practices of farmers on pests, pesticides and crop protection methods with the aid of a structured questionnaire. These include data on indigenous pest control methods, IPM, farming and non-farm activities. The interview sessions for the KAP questionnaire were conducted in the off-farm season (between January and April) when farmers had more 'free' time to respond to questions.

4.3.2 Multiple/Weekly Visit Data

Agro-economic data: Agro-economic data were collected on a weekly basis. They include labor inputs by type (men, women, children) and source (family, hired or exchange). Farm inputs like fertilizer, and pesticides in terms of quantity and value were recorded. For cotton fields, farm production output data were obtained from the cotton development company immediately after the marketing season ended. For rice, production data for each field were determined by the cumulative weekly quantities of rice [9].

[9] Rice is grown as food crop in the study area. As soon as the rice field is matured, the household usually harvests in piece meals on different days. The harvested rice stalks (which are re tied in bundles called *bôttes*) serve as food for the household on the particular day when it is harvested. The piece meal harvesting takes place for some time before the general harvesting of the whole rice field takes place.

Data on the source of pesticides and the use of pesticides for non-farm purposes were as well collected [10].

Field monitoring of pesticide spraying: The type and quantity of pesticides that farmers use are expected to be strongly correlated to the health effects on farm workers. In addition, the field situation at the time of spraying is expected to be important. Data were collected on the type of pesticides sprayed, the quantity sprayed, duration of spraying (exposure) and protective clothing worn by sprayers. Other data include the method of transportation of chemicals from households to farms, precautionary measures taken against wind, dosage and method of mixing pesticides, type and condition of spraying equipment used. All these information were collected by direct observation.

Pesticide health economics and household morbidity data: Two sets of health economics data were collected. The first questionnaire was administered exclusively on individuals from within the household who regularly spray pesticides on households' fields. The interview sessions were held after each spraying operation throughout the agricultural season. Data collection for this type of questionnaire followed a similar approach used by KISHI et al. (1995). A health symptom that farm workers reported is regarded to be associated with pesticide spraying *only* if the victim did not suffer from it before spraying operation, and the symptom only began during spraying operation or shortly after that. For this present study, only the health symptoms that started during pesticide spraying operation or within 24 hours after spraying were enumerated in the questionnaire. The second questionnaire is on health economic data for general morbidity of all household members. This was done on a weekly basis.

For the two sets of questionnaires, information were collected on the causes of symptoms reported, number of work-days lost partially or completely due to the health symptoms and the type of medication taken by victims (local or modern medicine). Other data collected include direct costs of the symptoms, i.e. consultation fees and pharmacy costs, and indirect costs, i.e. transport fares to/from health centers (where applicable). Also collected was information on the monetary value of other expenses that were paid in-kind rather than cash, and other costs that the victim *actually* incurred on the symptoms reported.

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[10] Pesticides supplied by the cotton development company were obtained directly from farmers' cooperative membership and account cards on which input transactions are recorded. Information on other sources of pesticides was obtained through structured questionnaire.

4.3.3 Biomedical and Laboratory Test Data

Theoretically, the incidence of pesticide poisoning and the occurrence of health symptoms increase as farm workers are exposed to pesticides. Biomedical and laboratory tests could help to establish a possible ‘cause and effect’ relationship between health symptoms reported by pesticides applicators and the biological indicators of exposure to the chemical. The two different tests of exposure to pesticides that are carried out in this present study are explained below.

Pesticide exposure/residue analysis data: Exposure of farm workers to pesticides during the mixing and application of pesticide solutions increases the risk to human health. A method to determine the exposure of farm workers to pesticides is by evaluating the proportion of chemicals that falls on the sprayer himself rather than on the intended target (crops). In this present study, two pieces of new clothing materials (20 cm^2 each) were super-imposed on pesticide applicators a few minutes before they began the spraying operation. The quantity of insecticides (active ingredients) that would have fallen on applicators during spraying was determined by analyzing the active ingredients that were absorbed by the cloth tissue which had been embossed on the applicators. The pieces of cloth were collected at the end of spraying operation and wrapped in aluminum foils. The pesticide spray deposits in the tissue materials were extracted in the ecological laboratory (*Laboratoire d’Ecologie*) located in Korhogo[11].

This experiment was done with a total of 72 farm workers (i.e. 18 farmers in each of the four study villages). Data on the duration of exposure, type of spraying equipment, quantity of chemical sprayed were collected for each applicator. The results of the extracted residues were reported in micrograms (µg) of active ingredient per cm^2 of body surface. The technical details on the laboratory procedures for the extraction is presented in Appendix 8.1 of this study.

Cholinesterase pesticide-enzyme activity data: Cholinesterase tests provide a biological indication of exposure to pesticides and may also provide insight into whether pesticide poisoning could be associated with illness in exposed persons. The pesticides used in Côte d’Ivoire are a mixture consisting of organophosphates and pyrethroids. Organophosphates deactivate cholines-

[11] This is one of the pesticide residue laboratories in Côte d’Ivoire specializing in the analysis of pesticides residue in soil, plants, water, etc.

terase enzymes, and cause symptoms of over stimulation of the nervous system that are typically experienced when a person is exposed to toxic chemicals. The symptoms include headaches, dizziness, vomiting, nausea and weakness as well as more severe cases (EQM 1991).

With the aid of the EQM Test-Mate OP Kit, a baseline Erythrocyte Acetylcholinesterase Assay Procedure was carried out on 182 individuals during the pesticide 'off season' before pesticide spraying operation began for the agricultural year. The test was repeated at the end of the spraying season on 162 individuals[12]. The individuals tested consisted of one or two per household who regularly spray pesticides and forty other individuals in the village who engage in non-farming jobs. These two groups of persons constitute the 'exposed' and the 'control' group[13]. During the two tests, data were collected on cholinesterase enzyme activity (units per ml of blood), hemoglobin level (grams per dl of blood) and hemoglobin-corrected cholinesterase enzyme activity (units per gram of hemoglobin). The percentage of intra-personal differences in cholinesterase activity level before and after the spraying season for each person indicate the cumulative effect of exposure to pesticides by the individual between the two reference periods. In addition, information on smoking and drinking habits of the individuals tested was also collected. This is because the cholinesterase level may be confounded with smoking and drinking habits (ROLA and PINGALI 1993, BARNES 1997a).

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[12] 20 of the initial 182 individuals tested were not available when the test was repeated. This is because some persons went on a journey or they had relocated away from the village at the time the test was repeated.

[13] The 'control' group is made up of individuals who reside in the same village as the farmers but who are engaged in full time non-farm occupation such as vulcanizers, school teachers, wood carvers, food canteen staff, bicycle mechanics. This group of individuals formed the 'control' group. Location bias between test and control group of persons is eliminated because they share common residential status in the villages.

5 Agricultural Economy and the Geography of the Study Area

The first section of this chapter a succinct description of the geography and physical features of the two major research sites and the villages selected for this study. Second, ethnographic information on the human population is presented. The third section analyzes empirical data on farm households including the structure and other characteristics. In the fourth section, the agricultural economy, farming systems and the relationship between the family farm and the farm-household are presented.

5.1 Geography

The study area is part of the Great North (*Le Grand Nord*) of Côte d'Ivoire. It lies within latitude 8° and 9° north and longitude 5° and 6° west of the equator. In addition to the regional capital town of *Korhogo*, the major towns within the area of study include *Ferkéssédougou, Tafiré, Niakaramadougou* and *Katiola*. The rainfall regime is determined by shifts of the inter-tropical rains front (ITF). *Katiola* is the 'Short History' (SH) region and it is located in the southern part of the cotton zone. It has two seasons of rainfall (1600mm per annum). *Korhogo* is the 'Long History' (LH) region and it is located in the north. The LH region has only a single rainy season between 800-1200mm per annum (PRAT/EUROPA 1990). Annual rainfall decreases from the south in Katiola to Korhogo in the northern part of the study area. The vegetation closely follows the rainfall distribution pattern, with less savanna vegetation in the south than in the north. The overall population density of the study area is lower than that of the southern (forest) region of the country. Within the study area itself, the 'Long History' region is more densely populated (39 persons/m²) than the 'Short History' region (17 persons/m²). A map of Côte d'Ivoire showing the study location is presented in Figure 5.1.

Figure 5.1: Map of Côte d'Ivoire showing the study locations

Source: Map generated by WARDA GIS Laboratory

5.2 Population and Culture

The native population of the study area are the *Senoufo,* a major ethnic group comprising of several sub-ethnic groups who share similar customs and traditions. A majority of *Senoufo* people in the present days resides in the north of Côte d'Ivoire but some of their sub-ethnic groups are found in Mali and Burkina Faso. The dominant sub-ethnic group in the 'Long History' region are the *Senoufo-Nafara* while in the 'Short History' region , *Senoufo-Tagbanas* are the most populous. Other settlers and immigrants residing in the area include the *Peulhs* who generally look after livestock and the *Dioulas* who are essentially traders. Almost all members of the household are related to the head of the household by blood and they live in the same village. In few cases where they do not, the mutual economic and interdependent relationship remains the principal cohesive factor among them. The few members of the household who do not have a blood relationship to the family head are manual laborers from neighboring arid countries (Burkina Faso and Mali) who come to work in cotton fields during the farm season. These laborers return to their home countries at the end of the cotton season. Family heads usually provide housing for these laborers during their temporary sojourn and regard them as an integral part of their household during this period. *Senoufos* are readily open to strangers and often engage in 'joking relationship' especially those with whom they share common *alliance historique* (historical alliance)[1].

Senoufos have a reputation for holding tenaciously to their culture and traditions, especially *Poro* (initiation into manhood and the traditional elite of the community). Most men usually indicate their age with reference to the period of their initiation to the group. The village government is organized on gerontocratic principles. Strict customary discipline and local sanctions exist in the villages to keep people in line with communal norms. In the study area, these local village norms regulate wide aspects of community life, including agricultural production and farm activities. For example, there is a regulation

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1 Historical alliance is a strong social phenomenon existing among some ethnic groups in northern Côte d'Ivoire. Despite differences in the language that each of them speaks today, these ethnic groups believe that they descended from a common ancestral parent. In the course of this study, we were told several stories and legends to back up the belief in 'common ancestor theory'. A remarkable feature of this alliance is that members of one ethnic group can freely trade 'insults', mock and tease members of the other ethnic groups irrespective of their ages. Rather than get annoyed, the people always laugh over these 'insults' and the jokes usually help to establish immediate relationship among individuals (if they were meeting for the first time) or help to reinforce the same.

that on one day of the week (called *Kohotieri* day) it is strictly prohibited to carry out specific types of operations (e.g. involving the use of iron tools, cutlass or hoe) on the farms. Such days are reserved for the *génies de la terre* (the gods of the land). Local tradition also regulates locations where some specific crops (e.g. peanut) may not be cultivated, or define crops (e.g. onions) whose cultivation is totally prohibited in the community. As will be explained further in Chapter 7 of this study, these traditional regulations play an inadvertent but important role in the agricultural and pesticide use practices. There are several village markets in the study area and each of these takes place weekly on rotational basis. A detailed description of the culture of the *Senoufo* people is reported in COULIBALY (1978).

5.3 Household Demography and Characteristics

Households consist of individuals who share mutual reciprocal responsibility, i.e. people who are obliged to look after each other (to feed, house and clothe) and who in return owe the responsibility to render services, particularly for farm activities. Details on household structure are presented below in Table 5.1. The average number of members per household is 8.5, and it is not significantly different in the two study sites (Pr>F=0.6740). But household size differs significantly (Pr>F=0.0001) based on the type of farm technology that a household uses.

The average household size is 7.7, 9.3 and 20 for manual-based, animal traction-based and tractor-based technology respectively. This difference is strongly related to farm sizes cultivated by these groups of households. More than half of the population (59%) falls within the productive age bracket (15 and 75 years) and are active on farms. Younger members of the family – particularly males who are 14 years or below also do assist in farm work – especially in tasks that are considered less tedious.

Table 5.1: Household size and composition in the study area

Description	Long history zone	Short history zone	Overall
Percentage of males	51	54	53
Percentage of females	49	46	47
Average number of household members	8.4	8.6	8.5
All male	**4.29**	**4.68**	**4.47**
Male: 00 - 05 years	0.41 (05)	0.89 (10)	0.64 (08)
Male: 06 - 14 years	1.23 (15)	1.39 (16)	1.31 (15)
Male: 15 - 75 years	2.63 (31)	2.39 (28)	2.51 (30)
Male: above 75 years	0.02 (<1)	0.01 (<1)	0.01 (<1)
All female	**4.06**	**3.93**	**4.00**
Female: 00 - 05 years	0.52 (06)	0.70 (08)	0.61 (07)
Female: 06 - 14 years	0.72 (09)	1.12 (13)	0.92 (11)
Female: 15 - 75 years	2.80 (33)	2.09 (24)	2.45 (29)
Female: above 75 years	0.02 (<1)	0.02 (<1)	0.02 (<1)
Children (≤ 14 years)	**2.88 (35)**	**4.10 (48)**	**3.48 (41)**
Adults (≥ 15 years)	**5.49 (65)**	**4.51 (52)**	**4.99 (59)**

Note: Percentages are indicated in parentheses
Source: Own field survey

Households are characterized by a low level of formal education (78% of the members did not attend formal schools at all). The age of household heads ranges from 17 to 84 with a mean of 41 years. Polygamy is common especially in the 'Long History' region. This may be due to differences in family farm sizes in the two regions and the need for 'free' family labor to work on the farms. More than 60% of households have a dependence ratio that is less than 2.00 household members per adult[2]. The dependence burden is much lower in households in the 'Long History' region than those in the 'Short History' region. There is no notable difference in dependence ratios between manual-based and animal traction-based households. The dependence burden within households is expected to increase if any of the active workers in the household is disabled due to illness. Agricultural inputs that affect the health

[2] This is the ratio of total household size relative to the number of household members aged above 15 years. It provides an indication of the burden that working members may be carrying within the households.

condition of farm workers have an overall negative impact on the household. Further details on the household characteristics and dependence ratios are presented in Appendix 5.1 and 5.2 respectively.

5.4 Agricultural Economy of Northern Côte d'Ivoire

The agricultural economy of northern Côte d'Ivoire is dominated by crop production. The rearing of livestock is generally a minor activity. Some households keep domestic animals (pigs, fowls and small ruminants) for slaughter or for sale during local ceremonies. Farmers who own cattle use them to work on the farm and to transport farm produce to the village.

5.4.1 Land Tenure and Household-Farm Relationship

The land tenure system in the study are is similar to that in the traditional sub-Saharan African countries where land is communally owned. The communities regard land as an 'integral part' of the society that should not be sold but preserved for future generations. Individual members of the household have usufructuary rights to land, i.e. the right to use land but not to sell communal land directly. Most of the fields cultivated were inherited from parents or leased from land owning families. Farmers in the LH region face greater constraints for cultivable farm lands than their counterparts in the SH region. Farmers in the LH region are forced to move farther away from the villages to look for good cultivable land. The average distance between fields and village in the LH region is 4.8 km, which is significantly longer (Pr>F=0.0001) than the average field distance in SH region which is just 3.4 km.

Households are highly dependent on their farms. As a result, any positive or negative occurrence on the farm has a direct and commensurate influence on the household and vice versa. Apart from its role as the main source of food for family members, the family farm is also the dominant employer of household labor and serves as the main fixed asset for the sustenance of future generations of the household. Three out of four household members engage in farming as their primary occupation. The level of household-farm dependence is higher in the LH region where more than 80% of household members work on the farm compared to the corresponding figure of 63% in the SH region[3]. The labor input used on the farm has three major sources –

3 These figures include youth and children who have no other job apart from assisting their parents to carry out farming activities.

the household, hired labor and labor exchanges. The importance of the household-farm relationship is demonstrated by the high proportion of the farm labor that the household provides for farm activities in the study area. The details of source of labor for the different field activities the in various types of farms is shown in Table 5.2.

Table 5.2: Percentage contribution of labor inputs in various types of fields [4]

	Family labor			Non-family		Total		Family labor		Hired
Type of field	**AM**	**AF**	**YT**	**RL**	**HL**			**Direct**	**Indirect**	
Cotton	28	12	21	25	14	100		61	25	14
Lowland rice	27	18	15	29	11	100		60	29	11
Upland rice	24	19	30	19	08	100		73	19	08

Note:

AM=Adult male within the household

RL= Exchange labor (male and female)

AF= Adult female within the household

HL= Hired labor (male and female)

YT= Youths within the household (male and female)

Source: Computed from own field data

Exchange labor input is a form of indirect contribution of labor resources by households to farm activities[5]. Either directly or indirectly, the household carries out 86%, 89% and 92% of all the farm operations in cotton, lowland rice and upland rice fields respectively. These figures show that internal supply of labor from within households and hence the health status of household members is critical to the performance and productivity of the farm, and the welfare of the household.

[4] The figures are contributions of the various sources of labor, in absolute hours, i.e. not discounted into man-hour equivalence values.

[5] Exchange or rotatory labor is a common practice of farm labor organization in many parts of sub-saharan Africa. Individual farmers enlist in farm labor groups whose members work together in members' farms in rotation one after the other. The labor group carries out field tasks like land preparation, weeding and harvesting, jobs that take longer period or are more tedious to accomplish. Apart from psychologically easing the drudgery of the tasks, working in such groups further strengthens communal solidarity among members. The system also allows farmers to access labor even when they do not have money to pay for them directly.

5.4.2 Farm Technology

There are three types of agricultural production technology used in the study area. The first is manual technology, and it is used by households that generally have small farms. The second type is animal traction technology and it is used by households whose farms range between 2 and 10 ha. Animal traction represents the first phase of mechanization of agricultural production in the study area. The third type of production mechanization is motorized technology and it includes intermediate and conventional motorization, i.e. 45 HP and 60-67 HP tractors respectively. The degree of agricultural mechanization increases as one moves from the south to the north of the study area, following closely the same trend observed in the intensification of cotton production. Except in few locations (e.g. special agricultural development projects), irrigation is non-existent and agricultural activities are limited to rainy seasons only. Manual and animal traction technologies dominate in the study area[6]. The distribution of sampled households according to the method of farm technology is presented in Table 5.3 below.

Table 5.3: Distribution of households according to location and farm technology

Farm technology	'Long History' region	'Short History' region	Total
Manual	39%	91%	64%
Animal traction	57%	9.%	34%
Tractor	4%	-	2%
Total	100%	100%	100%

Source: Own field survey

[6] It has to be noted that these words used to describe the different types of farm technologies are in relative terms only because all the households in the study area (particularly those LH region) use a combination of these main types of technologies. No household uses either of the technologies exclusively for all operations. The terms reflect the dominant type of technology that a household uses.

5.4.3 Farming Systems and Farm Enterprises

There have been structural changes in the farming enterprises in northern Côte d'Ivoire since the 1960s. These changes are due primarily to the various cotton development policies (see Chapter 3.3). A particular important aspect of the structural change is that cotton has changed from its former status of being a mere secondary crop (about four decades ago), to emerge as the most important crop in the present farming structure in the study area.

Farmers in the study area cultivate multiple plots (average of five fields per household) in different locations. They practice crop rotation and grow a combination of different crops to satisfy the cash and food needs of the household. The major crops cultivated are cotton (average of 3.29 ha per household), upland rice (average of 0.78 ha per household), lowland rice (average of 0.15 ha per household) and maize (average of 0.94 ha per household). Other crops including peanut, cashew and yam are also grown. Cotton and cashew are grown exclusively for cash income while all other types of crops are cultivated partly for household consumption and also for cash income to meet other household needs. Tobacco is grown in pockets of small fields that are generally located close to the village. Vegetable crops are cultivated in small fields (usually by women) in lowland areas in the dry season. In addition they are grown as secondary inter-crops in the uplands during the rain season. In the uplands, cotton and other crops are usually planted adjacent to one another, this increases the risk of exposure to pesticides of household members who work on other fields when cotton fields are sprayed. Table 5.4 provides further details on the farm size and popularity of the different types of crops in the study area. Currently, cotton and rice dominate the agricultural economy of northern Côte d'Ivoire and the two crops alone make up 62% of the total area of all types of farms in the study area. In terms of total market sales from crops, cotton, cashew and yam dominate. Cotton contributes 74% to total farm income (more than 90% in the LH region and only 56% in the SH region), cashew contributes 9% and yam contributes 6%. Rice contributes a small proportion of household market proceeds because it is grown essentially for own consumption. Cotton assumes an increasing level of importance (in terms of the land area cultivated and income generation) as one moves from the southern zones to the core cotton producing area in the savanna.

Table 5.4: Percentage distribution of the total farm size for all the crops cultivated in the area of study

	Percent of total farm size		
Type of field	**Long history**	**Short history**	**All**
Cotton	51	31	44
Lowland rice	6	2	5
Upland rice	15	10	13
Maize	15	13	14
Ground nut	6	7	6
Cashew	3	17	8
Yam	1	17	7
Other crops	3	3	3
Total	100	100	100

Source: Field measurement and survey

Note: The size of an average cashew and yam fields is larger than most other crop field types, but these fields have a small proportion in terms of overall size of the crops cultivated because not all the households grow the crops.

In general, farms in the LH region are more specialized and have less crop diversity than obtained in the SH region[7]. Agriculture in the LH is more intensified with cotton and rice constituting 72% of total holdings while farming is more integrated in the SH, where these two crops account for only 44% of fields cultivated by households. These figures indicate to some extent the relative importance of these crops in the two study areas and the seriousness with which farmers attend to each crop. The various agricultural development policies discussed in Chapter 3 contributed to this trend. The most common cropping association in upland rice fields in the two sites is the inter-cropping of rice and maize. Lowland rice fields are not intercropped at all. Details on

[7] An emerging feature in the study area is that farmers now plant some crops within their cotton fields - a practice that was abolished in the 1960s and during the peak period of cotton promotion efforts. This phenomenon is much more marked in SH region where 37% of cotton fields are inter-cropped (especially with cashew and legumes). In LH region, only 9% of the cotton fields are inter-cropped. According to farmers, the major reason for this trend is the worsening comparative profitability of cotton production vis-à-vis compared to other major crops (especially cashew) since the abolition of free inputs for cotton.

inter-cropping and cropping sequence practices in the different areas are presented in Table 5.5.

Table 5.5: Number and proportion of fields that are inter-cropped in the study area

Region	Cotton (n=231)	Upland rice (n=156)
Long history zone	9%	54%
Short history zone	37%	79%
Overall	23%	64%

Source: Computed from own field measurement and survey

Another feature of the study area is that the agricultural system is characterized by several forms of diversification. Diversification manifests in the following ways:

(a) Type of crop: Farmers combine food crop production and cash crop production. All the farming households integrate these two major systems in various mixes. This creates a dilemma which according to SAVIGNAC (1979) is best expressed in the farmers' own words: 'we cannot stop producing cotton because we need money, yet we cannot afford to produce less food crops because we need to eat'. Other authors including CHALEARD et al. (1990) and KONAN (1992) suggest that the interactions between cotton and the food crops have been synergistic.

(ii) Type of field ecology: Most households cultivate both upland and lowland fields. A quasi-specialization on gender basis exists in management of farm operations in these two agro-ecologies: men manage farming activities in the uplands while women generally operate in the lowlands. However, overall decision-making on household agricultural activities rests with men who usually head the households.

(iii) Type of farm ownership: In special cases, youths (males) within the family may own a field apart from the land of the general household. The monetization of the village economy has led to the individualization of productive efforts. The existence of family group farms and personal farms is a form of diversification of the farming system (LE ROY 1983: p. 55). This arrangement gives some measure of economic independence to young adults, to set them on a 'weaning' phase from the bigger family unit and also to prepare them for agricultural leadership roles in their future lives.

6 Farmers' Knowledge, Attitude and Practices on Pesticides and Crop Protection

In this chapter, empirical results on farmers' knowledge, attitude and practices (KAP) relating to pests, crop protection and pesticides are presented. The chapter is organized in five sections. First, information on the indigenous knowledge and traditional practices of crop protection and sources of information for farmers are presented. Second, the sources and the patterns of use of pesticides in the various crops are discussed. In the third section, the changing trends in field level crop protection practices including the reaction of farmers to the new policies on pesticides since the restructuring of the cotton sub-sector in 1994 are analyzed. Fourth, farmers' perceptions on pests and pesticides are presented. Section five concludes by identifying existing opportunities and constraints of the present KAP for improving crop protection technologies (e.g. through the adoption of non-chemical methods by farmers) in northern Côte d'Ivoire.

6.1 Indigenous Knowledge and Sources of Information on Crop Protection

6.1.1 Indigenous Crop Protection Practices

Investigation of previous methods of crop protection that early progenitors in the area have used in the past reveals that most of these methods were primarily directed against rodents and other forest animals that destroy crops. Traditional methods include soaking the barks of a local plant *Parkia biglobosa* (commonly called *niére* in *Senoufo* language) and other botanical species in water for few days and then spray the liquid solution on crops. Farmers believe that the bitter taste of these products makes crops unattractive to ravaging animals. Another method is to fence the parcel against animals, to hunt the animals or to set traps. Still other farmers mentioned that they invoked *magnan* or used mystical means to ward off animals from attacking their crops.

Virtually no mention was made of specific corresponding traditional methods to protect crops against insects which are the most important pests nowadays. The major reason farmers gave for this was that insects posed less problems to agricultural production as did rodents in earlier periods. This could be an indication of a shift in the type of pests that are economically important in agriculture from the past to contemporary times[1]. The indigenous methods of crop protection have mostly been abandoned in favor of chemical control since the availability of free pesticides in the region. Only in a few cases (6%) did farmers continue to use some of these traditional methods, and even this use was limited to root and tuber crops. The majority of the present-day farmers are not well acquainted with the traditional methods because the majority of elderly progenitors with the traditional knowledge is no longer alive. A similar reason has been given for the near extinction of traditional knowledge of pest control in Kenya (CONELLY 1987) and in Sri Lanka (ULLUWISHEWA 1993). Another reason for abandoning indigenous methods of crop protection was that traditional methods are labor intensive especially given the increases in field sizes. This result compares with other studies elsewhere in Africa. In Nigeria where pesticides are distributed free of charge (or subsidized up to 67%), many traditional pest control methods practiced by farmers have been displaced (ATTEH 1987).

Some traditional agricultural practices that farmers in the study area employ incidentally reduce the build-up of pest populations and infestation and therefore, they provide a crop protection function. Such farm practices include inter-cropping, shifting cultivation, crop rotation and the 'slash-and-burn' system. During land preparation, farmers usually uproot the previous year's cotton stalks, gather them and burn them off in the fields. This provides a way of getting rid of soil borne pathogenic organisms which may have been 'carried over' from the previous year into the new season. Some farmers mentioned that they have observed that when such stalks are uprooted and burnt, the incidence of pests is reduced in such farms during the succeeding farm year. Similar unintentional pest control practices through farmers' traditional practices have been reported from other parts of Africa (CONELLY 1987). The traditional practices help to control pests even though the pest control is not the original intention of farmers to carry out these activities.

[1] A reason for this shift could be that crops were grown in a mixed cropping system and on a regular rotational basis before. Also land was more bushy in the past and so may have provided secured havens for rodents and other fauna which caused greater levels of crop loss.

6.1.2 Source of Information on Crop Protection Methods

Information is a powerful resource. Sources of communication to farmers influence the quality and range of useful information that gets to farmers and may help them to improve their agricultural practices and general living standards.

Farmers' sources of information: The majority of farmers interviewed (70%) obtains general news and information from two or more sources. The sources include fellow farmers, CIDT agents and the radio. For information on crop protection and agricultural practices, the cotton agency is the most important source, providing crop protection information for all households in the cotton zone. Informal farmer-to-farmer exchange of knowledge on crop protection takes place to a considerable degree (59%). Apart from a few posters mounted in the villages, the impact of agrochemical firms on pesticide information is quite small. This is because chemical firms do not have a direct link to individual farmers but usually go through the cotton agency (for insecticides) or the farmer cooperative groups (for herbicides). Most of the respondents are not aware of IPM and this could be traced to the restricted sources of crop protection information that farmers have. Other sources of crop protection information are ANADER and farmers' cooperative groups [2].

Method of dissemination of crop protection information: Personal contact with farmers is used in 85% of cases to disseminate crop protection information. Other methods used are audio and training sessions. Booklets and other published materials are seldom used because most farmers can neither read nor write. About one quarter (24%) of the household heads in the study area had attended formal training sessions before, for a cumulative average of five days. Almost all the training sessions (78%) were organized by CIDT, with some assistance from the chemical industry and some NGOs. The theme of about half of the training sessions centered on pesticides and spraying operations. Apart from formal training, CIDT resident village agents give training to farmers on an informal and ad-hoc basis. For so many years, the crop protection information available to farmers has been dependent on

[2] ANADER is the National Agency for Support of Rural Development (*Agence Nationale d'Appui au Développement Rural*). It was created in 1994 and has since been exerting a great impact on the awareness of farmers on IPM, particularly in rice. Its mandate in the core savanna zones of northern Côte d'Ivoire does not yet include cotton, and therefore it has relatively little impact as a source of crop protection information for cotton growers.

pesticides and based almost exclusively on the crop protection philosophy of the cotton agency[3].

6.2 Sources and Use of Pesticides

6.2.1 Sources of Pesticides

In principle, the government through its agency (CIDT) supplies the necessary quantities of pesticides to farmers to be used on specific crops in the cotton zone. In practice however, there are other sources and outlets of uses for these chemicals. Table 6.1 below summarizes the sources of pesticides and the relative importance of each source (in terms of the quantity) according to geographical location and type of farm technology.

Table 6.1: Sources of pesticides (in %) in households by site of study

Type of pesticide	Source	Long History region	Short History region	All
Herbicides	CIDT	57	87	61
	Friends	7	<1	6
	Market	35	7	31
	Old stock	1	5	2
	TOTAL	**100**	**100**	**100**
Insecticides	CIDT	85	94	87
	Friends	8	1	6
	Market	6	-	5
	Old stock	1	5	2
	TOTAL	**100**	**100**	**100**

Source: Own field data

The government (cotton agency) remains the most important source of pesticides to farm households, supplying 78% of all pesticides. The open

3 The farmers' cooperative groups were created by CIDT, and this agency also provides most of the training to farmers. The cooperative groups are *de facto* an extension of the cotton agency because in most cases the farmers' cooperative officials simply pass on to their members the crop protection information that they have received from the cotton agency.

market accounts for 14%. These markets include field outlets of registered chemical companies and small shops[4]. The 'old stock' consists of the remaining pesticide supplies that have been carried over to the current farm year from the previous season. Some farmers use these old stocks for non-crop purposes during the year, while others keep them as a speculative holding to shore up the quantity of pesticides available to them in the following year (in case pesticide prices increase). Since the government supplies most of the pesticides that remain from previous seasons, the total pesticide supply from government sources alone approaches 80% of the aggregate quantity of pesticides available to households. Farmers in the LH region are able to obtain pesticides from independent sources than do farmers in the SH region. Table 6.2 presents details on the sources of pesticides according to type of farm technology.

Table 6.2: Sources of pesticides (in %) in households by farm technology

Type of pesticide	Source	Manual	Animal	Tractor	All
Herbicides	CIDT	83	80	13	61
	Friends	3	4	10	6
	Market	10	14	77	31
	Old stock	4	2	--	2
	TOTAL	**100**	**100**	**100**	**100**
Insecticides	CIDT	92	95	66	87
	Friends	1	2	18	6
	Market	2	2	14	5
	Old stock	5	1	2	2
	TOTAL	**100**	**100**	**100**	**100**

Source: Own field data

The relative importance of each source of pesticides varies depending on the type of pesticide (herbicide or insecticide), the geographical location of the household and the type of farm technology used by households. The open market assumes greater importance for the supply of herbicides than for insecticides. This is primarily because the government control on herbicide

[4] These informal shops sell other farm materials ranging from cutlasses to pesticides.

distribution has been reduced unlike that for insecticides. Similarly, the proportion of pesticide supplies that farmers purchase from the open market increases as farm technology becomes more modernized. This is mainly because pesticides from the open market operate on a 'cash and carry' basis and only rich farmers have the necessary financial resources to make this type of transaction. If the monopoly of the cotton output market is relaxed and it allows farmers to obtain higher income (e.g. through higher purchasing prices for cotton), there are strong indications that farmers would seek greater autonomy from the cotton agency[5].

6.2.2 Pesticide Utilization Patterns

Despite the removal of direct price subsidies on pesticides in 1994, the cotton development policies have influenced the course of evolution of agriculture for many years, creating long term structural impacts on farming systems. There is a structural change in farm enterprises mix and a shift of the farming system from traditional inter-cropping to a mono-cultural agriculture for all cotton fields. With the removal of pesticide subsidies, farmers have been making some adjustments in pesticide use and practices. Herbicides and insecticides are the major types of pesticides used in the area of study[6]. The dominance of cotton in pesticide consumption in the study area becomes clear from Table 6.3 below.

[5] This may have implications on quality control and the health of farmers because farmers may opt for cheaper products on the open market.

[6] A small quantity of fungicides was given to some farmers in one of the villages during the 1997/98 farm year on an experimental basis.

Table 6.3: Pesticide utilization pattern by type of crop

Type of pesticide	Type of crop/use	Percent
Herbicides	Cotton	65.4
	Lowland rice	0.2
	Upland rice	22.9
	Maize	10.9
	Peanut	0.6
	Non-crop	-
	TOTAL	**100**
Insecticides	Cotton	98.8
	Upland rice	<0.1
	Maize	-
	Non-crop	<1.2
	TOTAL	**100**

Note: Percentage is based on the liters of pesticides applied per type of field

Source: Own field data

Farmers use herbicides on a wider range of crops but insecticides are used almost exclusively on cotton. Farmers use herbicides in upland rice and maize fields to delay the emergence of weeds and avoid the bottleneck in labor that would result from weeding these (usually large) fields[7]. On the contrary, little or no pesticides are used in lowland rice fields because it is still a traditional production system with very little use of external inputs.

6.2.3 Handling of Pesticides

Some pesticides are used on other targets than for they were recommended for. This especially occurs when farmers use a particular brand of pesticide on crops for which it is not officially registered[8]. For example, herbicides that are

7 Land preparation for upland rice and maize takes place at about the same time with that of cotton. The weeding operation for these major crops often falls due at the same time, and causes labor shortage.

8 Pesticide registration in Côte d'Ivoire is done by the Ministry of Agriculture based on the recommendations of an inter-ministerial pesticide committee. The committee is administered by the *Direction de la Protection des Végétaux et de la Qualité* (Dept of Plant and Quality Protection) of the Ministry of Agriculture.

registered for use in cotton fields are often used in rice fields and vice versa. Prices of herbicides for the different crops differ, and farmers take advantage of this difference to purchase and use cheaper brands. Misuse also arises through outright diversion of pesticides to non-crop purposes. An inquiry by CIDT (1992) shows that when insecticides were given free of charge to farmers, some farmers sell part of the chemicals to obtain extra income (when they are in need of liquid cash). About 10% of extension agents and the farmers interviewed said that sale of insecticides was generally practiced throughout the cotton zone. There is evidence that sale of pesticides on an extensive scale has since been curbed. As regards the use of pesticides for non-crop purposes, the results of this present study show that it is still practiced by many households but the quantity involved is less than 5% of the total amount of pesticides used. The major non-conventional use of insecticides in the study area is protection of harvested farm produce (especially maize and rice) against termites and other soil borne pests and also to protect grain in storage bins *(grenier)* when the produce arrives in the village (78%). Next is the use in vegetable gardens and minor crops like tobacco (11%). Treatment of wounds, removal of ticks on cattle and domestic animals and the control of ants, honey bees and bats in dwellings consumes 6%, while 7% is used to treat seeds. Almost all the cases of pesticide misuse occur with insecticides and especially during the 'off-season', i.e. the dry season following the completion of pesticide spraying for a given year.

Comparing the results obtained in this study on the proportion of pesticides used for non-crop purposes with the findings of earlier studies that were carried out in the study area (e.g. CIDT 1989, RICHARDI 1992), there are strong indications that the new pesticide policy of 1994 has greatly reduced the quantity of pesticides that farmers use for non-crop purposes. The cases of illegal re-sale of pesticides which were mentioned by several Ivorian government officials (personal communications) and TOBIN (1994) to be a serious problem in the cotton zone in the pre-1994 era have declined greatly in recent years[9].

Storage of pesticides: In addition to supplying pesticides to farmers on credit, the cotton agency handles all transportation arrangements to deliver pesticides

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9 None of the farmers admitted that they re-sell pesticides, but they mentioned that '*some individuals in the village'* may sell pesticides under special cases, e.g. need for cash to solve emergency household problems, or when a farmer foresees that a field was most likely going to fail in the season.

supplied through official sources to farmers in their villages. From the time of collection, farmers keep the pesticide consignments in different storage locations from where they take small quantities for each spraying operation. The period of storage usually lasts for few months but sometimes, it may last for a year (in cases where the pesticides are not used up during the season). Almost all pesticides are stored in houses and rooms within the household, with little or no special storage for pesticides. This reflects two things: (a) farmers' priorities (b) farmers' perceptions of relative risks. It may be that farmers attach a greater premium to the possible financial risks of losing their chemicals (e.g. to thieves) than the possible health risks to their family resulting from the possible accidental poisoning from these chemicals.

6.3 Current and New Trends in Field Practices in Crop Protection

6.3.1 Pesticide Spraying Practices

Precautions against exposure: Pesticide applicators appear to recognize the consequences of spraying against the wind, and they take precautionary measures to observe the direction of the wind before they start spraying. But what they use as indicators to determine wind direction is usually informal. Often, the indicators are at variance with the official recommendations. Farmers' methods are presented below in Table 6.4. A further description of precautionary methods is contained in Appendix 6.1 of this study.

Table 6.4: Farmers' indicators (%) to determine wind direction during spraying

Type of caution taken	Long history	Short history	All
Plant leaves	12	63	32
Flag/cloth	37	07	25
Sprayer vapor	85	27	62
Smoke/others	13	03	09

Note: The total percentage exceeds 100 because some farm workers use more than one type of indicator during the same operation to determine the direction of the wind.

Source: Own field monitoring data

In general, farmers in the LH region are more careful about knowing the direction of wind before spraying. Some farmers made attempts to protect themselves against pesticide exposure, but the materials that they use are sub-standard, i.e. primarily synthetic face caps or local hats (69%) and a piece of cloth or handkerchief (24%)[10]. On fewer occasions, farmers may also wear boots and hand gloves. The level of exposure to pesticides (indicated by proportion of active material that fell on sprayers' body rather than on crops) is presented in Chapter 9.

Table 6.5: Protective clothing worn by pesticide applicators (in %)

Type of protection	Long History region	Short History region	All
Nothing at all	30	91	53
One	46	08	32
Two	21	01	13
Three	03	--	02
Overall	100	100	100

Source: Own field monitoring data

Economic reasons (i.e. high cost and lack of money), non-availability within easy reach and lack of information are important reasons why farmers in Côte d'Ivoire do not use protective clothing. CAFFIERO (1990: p. 26) reports that due to their low income, many users of pesticides in Côte d'Ivoire place only secondary importance to their health. Heat is another factor for the lack of use of protective clothing by pesticide applicators.

Post spraying activities: After spraying, applicators often take a bath and when an applicator thinks that he has been exposed to pesticides, he may drink lemon juice (*citron*) and or massage his body with shea butter oil (*beurre de karite*). Farm workers perceive that these two items nullify the negative effects of pesticides. Pesticide containers are disposed off in various ways (described in Table 6.6). In 13% of the cases, pesticide containers are re-used by the household or by other persons (i.e. when sold). Households in the LH region perform far better (containers are re-used in only 5% of the cases) compared with their counterparts in the SH region where about one in every

[10] It is not easy to determine how effective these are as protection because the clothes are usually made of cotton materials and may absorb pesticide solution during spraying, thus bringing the chemical even closer to the applicators.

five old pesticide containers (16%) ends up being used by humans in one way or the other. The disposal methods do not yet conform strictly to recommendations, but there are indications of improvements compared to previous practices in the region as documented by RICHARDI (1992: p. 45).

Table 6.6: Methods of disposal of used pesticide containers

Disposal method	Long history region	Short history region
Left in the field	51	59
Thrown into the bush	32	14
Washed and used by farmers' household	2	11
Washed and then sold	3	5
Packed and burnt	4	3
Buried in the soil	3	2
Others	5	6
TOTAL	**100**	**100**

Source: Own field survey

Commencement and stoppage of pesticide spraying program: The calendar method (prophylactic treatment) is the officially recommended criterion for determining pesticide spraying operations in the study area. Farmers generally respect the recommended date for the application of the first round of pesticides. But the timing of subsequent spray regimes (and the number of sprays for each season) is done at farmers' discretion using other criteria. Farmers end the spraying operation in a given year by using the criteria specified below:

Table 6.7: Criteria for determining when to end pesticide spraying in a season

Type of criteria	Farmers (n=165)
When the cotton fruits begin to open	107
Calendar/prophylactic regime	51
When the production of new flowers stops	15
When insects disappear/reduce	12
When the pesticide supply is exhausted	12
When the production of new leaves stops	3

Note: Some farmers use multiple criteria

Source: Own field survey

Most farmers stop spraying their cotton fields as soon as the cotton fruits begin to break into flints, even if the recommended number of treatments has not been reached. Farmers generally believe that any pesticide application after cotton fruits have opened is simply a waste of chemicals.

6.3.2 New Practices and Changing Trends in Crop Protection

During the period when insecticides were given to farmers free of charge, a study was carried out by CIDT (1989) involving a sample of more than one thousand cotton farmers from all the cotton growing regions. The study shows that 89% of all farmers spray their crops at least six times and 45% of them spray seven times or more per season. A comparison of pesticide spraying between the LH region and the SH region is presented in Table 6.8. The details for all cotton zones are presented in Appendix 6.2 of this study.

Table 6.8: Number of insecticide treatments in cotton fields during the policy of free distribution of insecticides to farmers

Number of insecticide treatments	Long History region (Korhogo) *(n=129)*	Short History region (Katiola) *(n=120)*	All cotton regions *(n=1037)*
Five treatments or less	0	12	13
Six (recommended)	42	50	47
Seven treatments	55	32	33
More than 7 treatments	3	6	7
Total	**100**	**100**	**100**

Source: Extracted from CIDT (1989), Table 13, p. 9 (See Appendix 6.2 for details).

The Table 6.8 indicates that farmers in the SH region (Katiola) and the fringes of cotton regions (*zones des développements*) generally sprayed less. On the contrary, 'excess' insecticide spraying took place more often in the LH region where pesticides have been used for longer periods. Presently, the number of pesticide treatments has remained the same (at least in principle). However, farmers have generally decreased the quantity of pesticides that they spray presently compared to previous years. The details on the methods that farmers adopt to economize pesticide quantity is explained below:

The agricultural season of 1994/95 brought about a financial shock to Ivorian farmers in general and caused double shocks to cotton farmers in particular.

First, the local currency (CFA Francs) was devalued by 50%[11]. Second, the free distribution of insecticides was eliminated. At the end of cotton sales for the 1994/95 crop year, cotton farmers carried over a debt of 2.115 billion CFA to the following season (CIDT Annual Report 1994/95, p. 20)[12]. The shocks affected the economic fortunes of cotton farmers as production costs increased at a higher rate than the prices of outputs. Moreover, the output price of cotton increased at an average rate of 48% while the cost of inputs (fertilizer) increased by an average of 122% during the same period. A sample of price changes in major inputs and output for cotton before and after the new policy is given in Table 6.9.

Table 6.9: Change in prices before and after the new pesticide policy of 1994

Input and output	Pre-1994 price (in FCFA)	Post 1994 price (in FCFA)	% change
Grade A cotton (kg)	105	160	+52%
Grade B cotton (kg)	90	130	+44%
NPK fertilizer (kg)	80	185	+131%
Urea fertilizer (kg)	75	160	+113%
Insecticides (liter)	0	900	-

Source: Computed from CIDT Annual report 1994/95

Due to the economic issues mentioned above, there has been a mass boycott of cotton production by certain cotton farmers [13]. The result of this present study indicates that in most cases, the production of cotton still continues, but since 1995, farmers have been reducing the quantity of pesticides that they use on their farm. The reduction is achieved through the following methods[14]:

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[11] The rate of exchange of the CFA was 50 CFA = 1 French Franc before devaluation and 100 CFA = 1 French Franc after devaluation in 1994. In US dollars, it was 250 CFA = 1 US dollar pre-devaluation and 500 CFA = 1 US dollar after devaluation.

[12] The cotton agency was forced to reduce the prices of pesticides in the subsequent year by re-introducing small subsidies to motivate cotton farmers (*Coton: La Cote d'Ivoire Relance sa Production* Interview of CIDT Directeur Général with *Fraternité Matin Presse* on 19 August 1996).

[13] Examples include Katiali village in M'Béngué/Korhogo region and Ourégékaha, Tafiré and Timorokaha villages, all in SH region region.

[14] The information in this section is based on field observation and farmer monitoring notes. It is supplemented by some documentation by the CIDT.

- Under-dosage of pesticides through the dilution of chemicals or deviation from the recommended instrument discharge rate of chemical solution.
- Spraying pesticides when wind speed is high[15].
- Spraying only a portion rather than the whole field during a given spraying operation.
- Farmers declaring a lower cotton field size than they actually cultivate (see Table 6.9 below). Farmers do this to avoid high debt to the cotton agency for the pesticides delivered, and yet avoid the risk of possible reprisals from officials for refusing to follow official crop protection recommendations. Related to this is the practice of expanding the size of cultivated cotton fields by adding extra portions of farmland to a cotton field. Such additions to established cotton fields facilitate informal experimentation for farmers, and farmers popularly refer to them as their *Gbassou*[16].
- Late planting of cotton fields, so that the number of pesticide sprays that is required before cotton fruit begins to open/break is reduced. This strategy is used almost exclusively in the SH region.
- Delaying the start off of pesticide spraying regimes for the season.
- Stoppage of insecticide treatment when the fruits begin to open, even when the recommended six regimes have not been attained.
- Use of old stock of pesticides, which have been carried forward from the previous seasons.
- Use of supplementary materials and additive products like kerosene or the pesticides registered for the control against cocoa and coffee pests.

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[15] Farmers think that the high wind will assist them to spread the chemical solution to a wider area of their field and therefore, the quantity of insecticides (and hence the cost) that they would need to spray their crops would be reduced.

[16] *Gbassou* is a word in the local trading language *Dioula* language which literally means 'gift' or 'extra' or 'addition'. In commercial circles, the word describes the token additional units of a good which a seller gives to his client as a reward or goodwill for buying major items. But within the farming parlance, this word is borrowed and used informally to describe cotton fields that farmers cultivate (usually) after they have set their main cotton fields for the season. This type of field incidentally provides an opportunity for a sort of informal experimentation for farmers. Use of pesticides and external farm inputs in this type of field is low because farmers do not consider such fields to be their main field, and there is not much at stake. But despite relatively little investment, if any output comes from such fields, they regard it as an extra income for them. These types of fields are more common in LH region, but they are never reported to agricultural officials.

Table 6.10: Average percentage deviation between actual and officially declared cotton field size

Type of field	Farm Technology		Site of study		Size of farm		Overall
	Manual	Animal	Long history region	Short history region	Small	Big	
Cotton fields	12	13	18	7*	8	21*	13
Lowland rice	-53	-56	-64	-13*	-67	-31*	-54
Upland rice	-13	-11	-16	-6	-20	0.5*	-12

Note: *The two figures are statistically different from each other.
Positive figures indicate that farmer declared lower estimate than the actual size of field he cultivated under-estimated their fields and vice versa.

Source: Own field measurement and survey

Two of these new practices are explained in detail below:

Wind speed: Farmers spray when the wind speed is high so that they can take advantage of the wind to help them spread pesticides over larger number of rows. Thus a smaller quantity of pesticides is required than is recommended to spray a given field area. Doing so farmers have lesser loan/credit obligations to repay to the government agency at the end of cotton season.

Dosage and number of pesticide treatments: In almost all cases (more than 90%) when a herbicide is applied, the dosage is less than the recommended level. When farmers spray herbicides, they sometimes do not cover the whole area of the field. In cotton fields, some farmers spray the whole field area only half of the time, while in the remaining cases, they spray only portions of the field in order to reduce the quantity of herbicides. The main reasons given for the decreasing trend in pesticide use are essentially economic factors. This could indicate that farmers' reaction to pesticide policies is price elastic. Some of the farmers' pesticide practices on the fields show that farmers' actions may be due to the general pressure for economic considerations, rather than making mistakes. Farmers in Côte d'Ivoire have been economizing on the use of pesticides in recent years (*Afrique Agriculture* 1992, ADESINA et al. 1994, CIDT *Rapport Annuel* 1995, HALAJKANN 1995). In his study of cotton and coffee farmers in Kenya, GOLDMAN (1987) reports that actual farmers' pesticide practices are highly divergent from those that are formally recommended, and that dosages farmers applied are only about half of the recommended dosage. A recent study by HILLOCKS et al. (1999: p. 199) indicate that with the removal of subsidies on pesticides for coffee in Malawi, the use of commercial pesticides on the crop has declined.

6.4 Farmers' Perceptions of Pesticides and Pests

Previous studies (e.g. CRISSMAN et al. 1994: p. 594) indicate that when farmers do not have good knowledge of pests in their fields, the pesticides designed for the control of such pests are often inappropriately applied. In this section, the knowledge and the perception of farmers relating to pests and pesticides are discussed.

6.4.1 Perceptions on Field Insects

Years of farming experience have helped most farmers to learn to identify the different groups of insects in their fields. In more than 80% of cases, farmers in the two study sites claim that they can distinguish between mites, leaf eating, piercing/sucking and fruit boring insects[17]. In most cases, the most important criteria that farmers use to identify harmful insects are color, shape or size of the insect, in that order of importance. Other criteria include the odor of the insect, the behavior of insects (eating or rolling up of plant leaves). HILLOCKS et al. (1999: p. 200) also report a high degree of awareness of pests and diseases (described by their symptoms), by coffee farmers in Malawi. While insects are the economically most important pests in northern Côte d'Ivoire (especially in cotton fields), other pests include birds, rodents, weeds and cattle, diseases, monkeys, snails and fungi. Among these, insects, weeds, diseases and rodents are the economically most important pests.

6.4.2 Perceptions of the Contributions of Pesticides to Crop Production

Farmers' perceptions of the contribution of pesticides can be summarized under two broad headings: yield increase and rendering cotton harvesting operations easier (and faster). The majority of the respondents stated that they derive two or more types of benefits from using insecticides in their cotton farms. These benefits are summarized below in Table 6.11.

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[17] Farmers have local names for some of the insects. The names reflect the effects that the insect pests have on the leaves of cotton plants.

Table 6.11: Farmers' perceptions on the advantages of insecticides in cotton fields

Advantages of pesticides	Long history (n=66)	Short history (n=99)	All (n=165)
Increases yield	59	99	158
Kills cotton pests	49	68	117
Makes harvest easier/faster	24	46	71
Other reasons	9	09	18

Note: Some farmers gave multiple responses
Source: Own field survey

Farmers believe that insecticides help the cotton fruit to open and make the white fibers 'blow out very well', thereby ensuring easier and faster picking of cotton during harvesting. Since harvesting is one of the most labor consuming operations in cotton production, this perceived advantage of insecticides is important in farmers' decision making.

This present study shows that farmers in the study area over-estimate yield loss, as the actual yield difference between treated and control fields is smaller than the estimated yield loss given by farmers. Using a weighted average (see Table 6.12), farmers estimated yield loss in cotton at an average of 90%. Experiments in IDESSA in Côte d'Ivoire (VASSAL et al. 1993: p. 18-19) show that on average, yield loss in cotton fields ranges between 42% and 65% depending on the crop variety. A five-year trial in Côte d'Ivoire (OCHOU et al. 1998: p. 8) show that the average yield loss in cotton is about 41%.

Table 6.12: Farmers' perceptions of crop loss if they do not use pesticides

Perceptions of lost	Cotton field	Lowland rice	Upland rice
All yields will be lost	72	01	15
Three quarters will be lost	21	08	09
Half will be lost	5	07	11
One quarter or less will be lost	2	84	65
Total	**100**	**100**	**100**

Source: Own field KAP survey

Recent trials in rice fields (ANADER/FAO 1997: p. 13) show that yield in IPM fields (i.e. no pesticides) may actually be 6% to 24% higher than in the fields sprayed with pesticides. The tendency of farmers to over-estimate yield losses is reported for rice farmers in Asia (WAIBEL 1987). An explanation for this tendency is given by ROLA and PINGALI (1993: p. 4) who state that "both farmer's and policy's maker perceptions of pest-related yield losses are anchored around exceptionally high losses during major infestations even when the probability of such infestation is low". A clarification of the divergence between actual yield loss and farmer's perception of yield loss is further provided by MUMFORD (1982: p. 287) who posits that "the ways in which perceptions of pest losses are formed…are often not directly related to an actual pest threat, but to sometimes independent sources". In Côte d'Ivoire, farmers perceive pesticides to be less critical for successful crop production in rice fields and lowland agro-ecosystems than in cotton fields and upland ecology. The patterns of pesticide utilization for different crops follow the perception that farmers have regarding the relative importance of pesticides in the various fields. This implies that the program development to improve crop protection in northern Côte d'Ivoire would need to take cognizance of farmer's present perceptions on pesticides.

6.4.3 Perception of Trends in Pesticide Effectiveness and Pest Problems

Farmers are increasingly concerned that pesticides are now less lethal to insects than in the past. Almost nine out of ten respondents (87%) said that insecticides are *"less effective"* than before or that there is a 'declining strength' of the contemporary pesticides. In view of the assessment that pesticides are becoming less effective, it appears initially puzzling that farmers do not increase the quantity or the dosage of the pesticides that they use on their fields. This seeming paradox may be explained by several factors. First, farmers consider cotton cultivation to be less profitable because the output price is low, while input costs are high.[18] (See Table 6.9 for details). Second, and probably the most important factor is that farmers want to avoid carrying over unpaid debt to subsequent years (termed by farmers as '*impayé*'). The

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[18] There have been cases recently where cotton farmers threatened to sell their cotton in neighboring Mali where the producer price is higher. A similar problem occurred in the Ivorian cocoa sector where farmers were planning to take their produce for sale to Ghana where they can get higher income of almost 50% for their cocoa beans than they do presently in Côte d'Ivoire (Pan-African News Agency, October 27 1998)

'*impayé*' problem is a serious concern to farmers because it implies that the value of farm output at the end of the season is less than the cost of external inputs, i.e., even *without* considering the wages paid to hire labor, and the opportunity cost of the labor inputs from within the household. One third of cotton farmers in the study regions had been declared '*impayé*' at one time or another in the past[19].

6.5 Implications for the Adoption of Alternative Crop Protection Technologies

The history of free distribution of pesticides and the narrow information base on crop protection make it hard for farmers to know about other crop protection methods apart from pesticides. As a result, farmers take pesticides as a 'reference point' against which they would evaluate alternative crop protection methods. Improving the awareness of farmers of other methods will be necessary for their adoption. But this *alone* may not guarantee that farmers will adopt alternative methods. The results of this study reveal that farmers will most likely adopt alternative crop protection methods based on their perceived evaluation of the performance of alternative methods in comparison to pesticides. The criteria that farmers would use to evaluate 'new' methods are presented in Table 6.13.

Table 6.13: Characteristics of alternative crop protection methods if farmers would adopt them

Performance with respect to pesticides	No. of farmers (n=165)	Percentage
Cheaper or same price	119	72
Effective on pests	91	55
Simple to handle	73	44
Assures same level or more yield	53	32
Easily available within reach	50	30
Less toxic to farm workers	45	27
Adopted by half or more fellow farmers	41	25
Less toxic to the environment	07	4
Other diverse conditions	30	18

Note: farmers provided multiple responses.
Source: Own field survey

[19] The problem of '*impayé*' appears to be decreasing now, partly because of a slight reduction in the prices of pesticides and also due to the strategies that farmers devise to reduce pesticides and other inputs.

Economic consideration is potentially a driving force in the adoption of alternative crop protection practices in northern Côte d'Ivoire. Farmers are sensitive to the costs of crop protection methods. The pre-condition they gave to the effect that alternative methods should be effective may be linked to the complaints that pesticides are becoming less effective against pests. The condition that alternative methods must be adopted by many other farmers first before they join in (i.e. 'bandwagon effect') was cited by only few farmers. An explanation for this could be that a technology that fulfills the basic economic conditions as stated above would most probably have been adopted by a majority of farmers. Concern about the impact of new methods on human health and the environment has a lower priority and it was mentioned by a relatively small proportion of respondents.

Due to the land tenure and field ownership structure in Côte d'Ivoire, the adoption of IPM and alternative crop protection technologies will have a greater chance of success if they take advantage of existing opportunities for mass mobilization of the farming community[20]. This position is corroborated by ROLA and PINGALI (1993: p. 6) who state that the success of IPM "also depends on rural communities' ability to organize against pest infestation, for example by synchronized planting, collective rat control and communal pest monitoring". Some of the existing opportunities for IPM adoption in the study area are as follows:

(i) First, the traditional *Senoufo* culture including its social sanction system is conducive to ensure mass mobilization of the farming community in northern Côte d'Ivoire.

(ii) Second, all households growing cotton belong to farmers' cooperative groups in their villages. These are organized into large cooperative unions and could provide an instrument to reach individual farmers with information on improved and alternative practices of crop protection technologies.

(iii) Third, the concern that farmers currently have as regards the 'high' cost of pesticides, and their perception on the declining effectiveness of pesticides suggest that farmers would be more receptive to alternative crop protection methods now (pesticides are no longer free) than they were in the past when insecticides were distributed free of charge.

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[20] This approach is suggested rather than an outright 'land consolidation' strategy for two related reasons. First, land consolidation would most probably meet with failure because of the attachment of farming communities to their land. Second, land consolidation efforts in the past in other African countries have not been successful, e.g. East African land reform, Nigerian land use decree.

(iv) Fourth, the technical feasibility of less chemical-dependent methods has been demonstrated in Côte d'Ivoire. These include the threshold trials carried out in the 1970s (ANGELINI and COUILLOUD 1972, ANGELINI et al. 1976, ANGELINI et al. 1980 and DANMOTTE 1974). Others are the recent experiments that are carried out in rice fields (ANADER/FAO 1997: p. 13) and the trials carried out in cotton fields by OCHOU et al. (1998) and OCHOU et al. (1997: p.1). The latter studies show that with a reduced number of pesticide treatments, farmers obtain equal or higher yields than in fields where standard pesticide application practices were used.

It has to be noted that the low education level of farmers in the study area could limit the potential for alternative practices. Illiteracy poses a problem to the flow of agricultural information because only one quarter of the household heads have formal education.

7 Pesticide Productivity: Empirical Specification and Results

Previous empirical studies show that there is yet no conclusive evidence to support the superiority of one specific functional form over the others in the estimation of the productivity of pesticides (CARRASCO-TAUBER and MOFFIT 1992). Rather than using a particular type of model specification *a priori*, the Cobb-Douglas and the alternative specifications of the damage functions were fitted to field production data based on the expected heterogeneity in the natural biological capital resource base of the cotton fields in the two study regions. The empirical approach assumes that farmers in the SH region represent a baseline situation or a starting point of cotton production where farmers in the LH region had also departed from. As a result of the historical period of exposure to pesticides, the productivity of chemical pesticides in cotton fields is expected to be different in the two groups. The main idea of the empirical approach in this study is *not* to determine the 'best' functional specification models for pesticide productivity analysis. Rather emphasis is placed on how to interpret productivity estimates in the context of natural and biological processes in production agro-ecosystems, i.e. the intertemporal changes that are expected to occur in the natural biological resource base of the production systems over time.

The analytical procedure of the present study modifies the procedures and the methodologies that have been used in similar previous studies in order to accommodate some of the expected natural resource implications of pesticide use (as explained in Chapter 2). Since the same type of production function specifications are used across the groups of observations, this approach allows for an internal comparison of productivity estimates for each type of model across the two groups of quasi-homogenous data. The alternative specification of the models helps to evaluate the consistency of the marginal product of pesticides that is estimated from the functional forms for the different groups of observations.

The chapter is organized into five main sections. The first section contains the development of the base model used for the analysis. In the second section, the mathematical derivation of the marginal productivity of pesticides is presented. The difference in the mathematical derivation of pesticide productivity of pesticides and of conventional farm inputs is highlighted. The third section contains the empirical specification of the models. The variables that are included in the production models are also described in detail. In the fourth section, the results of the empirical model and the discussion of the same are presented. The fifth section ends the chapter by providing an overview of some preliminary conclusions emanating from the results of the empirical analysis.

7.1 Development of the Base Model

In line with previous studies, the development of the empirical model for this study begins with the typical production equation, using the Cobb-Douglas form as follows:

$$Q = AZ_i^{bi} \tag{7.1}$$

where Q= Output, A= Constant intercept term, Z_i= vector of production inputs.

An implicit assumption in the above equation is that pesticide input X_p plays a similar role to that of other inputs, i.e., it is taken as an element of input vector Z_i. If the two sides of the equation are converted to their logarithmic values, the elasticity of the respective inputs can be computed directly. This is typical for the model used in HEADLEY's (1968) study. A similar model is used in this present study and the productivity estimates obtained are compared with the estimates obtained from the alternative specifications of the damage functions.

The central point of the contribution of LICHTENBERG and ZILBERMAN (1986) is that a distinction must be made between pesticide inputs (X_p) and other conventional production inputs (Z_i), i.e.

$$Q = f(Z_i, X_p) \tag{7.2}$$

By conceptualizing actual farm output to be a result of a combination of two interdependent components – i.e. potential yield and potential loss to pests –, equation (7.2) may be written in a shorthand version and re-formulated as follows:

$$Q = f\,[(Z_i, D(X_p)] \qquad \text{where } i=1,2,3,\dots,n \tag{7.3}$$

Expressing equation (7.3) in a more formal production equation, it becomes:

$$Q = AZ_i^{\beta i}[G(x)]^{\gamma} \tag{7.4}$$

where G(x) is the damage function and other parameters remain as initially defined.

In line with the assumptions made in previous similar studies (CARRASCO-TAUBER and MOFFIT 1994, BABACOCK et al. 1992), the control of the value of parameter γ is restricted to unity. This assumption ensures that the control of pest damage is proportional to the damage function G(x). In view of this assumption, equation (7.4) may be expressed in logarithmic form as follows:

$$LogQ = LogA + \beta_i LogZ_i + Log[G(x)] \qquad (7.5)$$

LICHTENBERG and ZILBERMAN (1986: p. 263) suggest that the function [G(x)] represents the "damage" or "abatement" function. Since this function follows a cumulative probability distribution (as explained earlier in Chapter 2), it can be expressed in various econometric forms and then be tested empirically. The damage function can take either of the following explicit forms: exponential, logistic, Weibull or Pareto probability distribution function. But given that the most appropriate function still remains unknown, all the four different specifications are used alternatively as shown below in (7.6) through (7.9) respectively.

Exponential: $LogQ = LogA + \beta_i LogZ_i + Log\,[1-exp(-\lambda X)]$ (7.6)

Logistic: $LogQ = LogA + \beta_i LogZ_i + Log\,[1+exp(\mu-\sigma X)]^{-1}$ (7.7)

Weibull: $LogQ = LogA + \beta_i LogZ_i + Log\,[1-exp(-X^{c})]$ (7.8)

Pareto: $LogQ = LogA + \beta_i LogZ_i + Log\,[1-K^{\lambda}X^{-\lambda})]$ (7.9)

where, β_i, λ , μ, σ, K, and C are the parameters that are to be estimated from the results of the alternative model.

The non-linear nature of the above equations makes it necessary that non-linear procedures are used to estimate the parameters.

7.2 Derivation of the Marginal Productivity of Pesticides and Other Inputs

The coefficient β_i estimates the elasticity of the conventional input Z_i in the above production equations from which the marginal productivity of the inputs is computed. The marginal product of Z_i is computed from the relationship given below:

$$\text{Elasticity of input } Z_i = \beta_i = \frac{\partial Q}{Q} \times \frac{Z_i}{\partial Z_i} \qquad (7.10)$$

Re-arranging (7.10), the marginal product of Z_i can be expressed as in (7.11):

$$\text{Marginal product of } Z_i = \frac{\partial Q}{\partial Z_i} = \beta_i \frac{Q}{Z} \qquad (7.11)$$

However, for the damage function specification, the derivation of the marginal product of pesticide (X) is obtained in an indirect manner because the coefficient γ in the equations above estimates the elasticity of the function G(x) and not that of X (pesticide) directly. The indirect computation of the marginal product of X (pesticide) is done as follows:

$$\text{Marginal product of X (pesticide)} \quad \frac{\partial Q}{\partial X} = \frac{\partial Q}{\partial G(x)} * \frac{\partial G(x)}{\partial X} \qquad (7.12)$$

The two components of the RHS of equation (7.12) can be analyzed separately. Making the appropriate substitution following from the results obtained earlier in equations 7.10 and 7.11, the marginal product of G(x) can be shown to be:

$$\text{Marginal product of G(x)} \quad \frac{\partial Q}{\partial G(x)} = \gamma \frac{Q}{G(x)} \qquad (7.13)$$

By restricting the value of γ to 1 (based on the assumption of a proportional relationship between the damage function and damage abatement) and substituting for $\partial Q/\partial G(x)$, equation (7.12) can be re-written as:

$$\text{Marginal product of X (pesticide)} \quad \frac{\partial Q}{\partial X} = \frac{Q}{G(x)} * \frac{\partial G(x)}{\partial X} \qquad (7.14)$$

Substituting explicitly for G(x) in the four alternative functional specifications of pesticides, the marginal product of pesticide MP(x) can be shown to be equal to the equations in (7.6) through (7.9) respectively. The details of the formal mathematical derivations of the respective marginal productivities are presented in Appendix 7.1 of this study.

Exponential: $$MP(x) = \frac{\partial Q}{\partial X} = \frac{Q}{1- e^{-\lambda x}} * \lambda e^{-\lambda x} \qquad (7.15)$$

Logistic: $$MP(x) = \frac{\partial Q}{\partial X} = \frac{Q}{1+ e^{(\mu - \sigma x)}} * \sigma e^{(\mu - \sigma x)} \qquad (7.16)$$

Weibull: $$MP(x) = \frac{\partial Q}{\partial X} = \frac{Q}{1-\exp(-x^{c})} * \exp(-x^{c}) * cx^{c-1} \qquad (7.17)$$

Pareto: $$MP(x) = \frac{\partial Q}{\partial X} = \frac{Q}{1-k^{\lambda}X^{-\lambda}} * \lambda k^{\lambda}X^{-(\lambda+1)} \qquad (7.18)$$

The parameters of the equations β_i, λ, μ, σ, K, and C were estimated using the non-linear procedure (PROC MODEL) of the SAS software.

7.3 Empirical Specification of the Model and Description of Variables

In specifying the production models for pesticide productivity studies, one of the key issues to be considered is to determine how a functional form conforms to the theoretical properties and production processes. Similarly, the number and type of variables to be included in a model vary depending on the objectives and hypotheses being tested, and sometimes by the limitations imposed by the data available. The model specification of this study takes into account these issues as well as results of previous similar studies. Most studies on pesticide productivity use models in which the dependent variable (yield or farm output) and almost all the independent variables are expressed in terms of monetary value. The same approach is used in this present study because it allows a direct interpretation of the marginal productivity estimates of the various inputs, i.e. provides information on the level of monetary returns that are obtained for every unit of money spent on factor inputs. The explicit specification of the empirical model to analyze the data for this study and the actual description of the variables is given below (see Chapter 5 for details of the variables).

Q, the dependent variable, is the economic value of cotton output per hectare. In defining the dependent variable, this study follows a similar method used by CARRASCO-MOFFIT et al. (1992), PRABHU (1985), HEADLEY (1968) and CAMPBELL (1976) where the economic value of production is taken as dependent variable. The economic value is considered to be more appropriate than the physical quantity of output as the dependent variable (like in HURD 1994 and SAVADOGO et al. 1994). By using the economic value, both the physical quantity and quality (grading premium) factors of cotton production are integrated into a single variable. As mentioned by BABCOCK et al. (1992), ignoring quality considerations of farm output can lead to substantial under-estimates of the expected pesticide productivity. This is true for cotton where there is a distinct price premium for the quality of produce.

Variable X_1 is the fertilizer expenditure per hectare during the agricultural season. This is exclusively the cost of all the types of inorganic fertilizer applied. It does not include the monetary value of the (usually non-marketed) organic and farm yard manure which some farmers apply on their fields, especially in the LH region.

Variable X_2 is the total monetary equivalence of all total labor inputs used per hectare for all farm operations (from land preparation to harvesting) during the agricultural season. Data were collected on labor inputs (in hours) used in each field from the preparation of the land through weeding operation unto harvesting and transportation of output to the village. The labor inputs were then converted to their monetary equivalents. As commonly observed in sub-saharan African agriculture, labor inputs for farm production in the study area vary by source (family, hired or communal labor sources), by the type of worker (adult male, adult female and children) and the type of technology which farm workers use during a given farm operation (manual, animal or tractor labor inputs). Due to these variations, the labor inputs data cannot be aggregated by a simple addition. It requires a method of standardization for labor inputs of different farm workers. Various approaches have been used in previous studies to standardize labor inputs. HEADLEY (1968) and CAMPBELL (1976) used the relative age of farm workers to assign weights to the different labor inputs. Other researchers used subjective ratios (e.g. 0.5 for women labor and 0.25 for children labor) as the discounting factors to convert female and children's labor inputs to male labor equivalence. STESSENS and DOUMBIA (1996: p. 18) used a conversion coefficient based uniquely on age. Children aged between 6 to 8 were assigned a coefficient of 0.2, youths between 8 and 16 years were assigned a coefficient of 0.5, old persons above 55 years had

0.5 while those between 17 and 55 years were rated fully as 1.0. The principal assumption underlining the above methods is that women and younger people are not as efficient as men in farm operations and so their labor inputs should be adjusted to male-equivalent values The conversion of nominal farm labor of women and children into male-hour equivalence is still discussed controversial[1]. In the present study, the approach used is to standardize labor input by assigning weights to each type of labor based on the ratio of the average remuneration for each type of farm worker in the community[2]. The labor standardization ratio used in this present study is presented in Table 7.1.

Table 7.1: Ratios used to convert different labor inputs to their man-equivalents

Type of labor/technology	Conversion ratio
Men labor input (manual)	1.00
Women labor input (manual)	0.75
Children labor input (manual)	0.50
Animal traction labor input	8.00
Tractor labor input	54.00

Source: computed from the author's field labor data, using the average labor remuneration paid in the study area.

Variable X_3 is total expenditures on herbicides per hectare that were applied in the field during the season.

Variable X_4 is the farmers' age. This variable is used as a proxy for farm experience and management capacity of the farmer. Given that farming is the major vocation in the study area, and most individuals are introduced to farming as early as possible in their youth, it is assumed that their age will accurately reflect farm experience and managerial ability. Other proxy variables representing 'management' that have been used in previous studies

1 This assumption may be criticized because for some farm operations women are as efficient as men (like weeding and planting activities) while children may equally be efficient for operations like bird scaring. Some authors believe that farm households have learnt from experience to assign farm operations based on the tasks for which each gender is most efficient. Operations that are generally given to women are those for which women are as efficient as men, and as a result the conversion of female labor inputs to man-hours may not require any discounting.

2 An implicit assumption of this procedure is that the wage paid to farm workers reflects the relative productivities of the respective groups of farm workers.

are not included in the models for this study for various reasons. For example, management variables like the level of education of farmers were not included because there is only a small variability across observations. Most of the farmers in the study area have no formal schooling experience. Previous studies (AJAYI and WAIBEL 2000: p. 549, ADESINA and DJATO 1995: p. 7) show that farmers' level of education is not a significant variable to explain farm performance in northern Côte d'Ivoire. As in similar previous studies, the exclusion of most variables relating to the managerial ability of farmers is primarily because of the difficulty of measurement[3].

Variable X_5 is the quantity of insecticides (formulated products) that were applied in the field during the season. It was converted to monetary values and computed on a per hectare basis.

The quantity and the variety of seeds planted in each field are not included in the model because cotton seeds were supplied free of charge to all farmers and at a standard dose per hectare. Variation of this variable across observations is expected to be little or none. There is no specific variable for 'land and machinery' included in this present study because farm capital in the study area consists essentially of work animals/oxen and its accessory implements[4].

7.4 Results of the Empirical Model

7.4.1 Summary of the Data Used in the Models

The summary of the data used for the estimation of the models is presented in Tables 7.2 and 7.3.

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3 Various researchers in the US and Canada have adopted different procedures to reflect management in production models. HURD (1994) used age, education and farm experience as proxy for managerial inputs in pesticide productivity models, while CAMPBELL (1976) completely excluded management from his model. He assumed managerial differences across farms to be accommodated in the stochastic disturbance term.

4 Given that most households in the LH region (Korhogo) own oxen while almost all the households in the SH region (Katiola) do not, the difference in farm capital is assumed to have been taken care of by geographical location factor.

Table 7.2: Mean and standard deviation of variables in the model

		Long history region		Short history region	
Variable	Unit	Mean	Std. dev.	Mean	Std. dev.
Output	CFA	206.85	80.37	146.19	74.89
Fertilizer	CFA	35.54	13.87	28.43	19.15
Labor	CFA	83.61	39.18	69.57	44.82
Herbicides	CFA	10.47	10.28	3.21	7.09
Farmer's age	Years	41.00	14.75	43.77	12.86
Insecticides	CFA	20.23	6.16	21.60	6.36

Note: Costs are expressed in thousands of CFA per hectare (US$ ≅ 550 CFA, DM ≅ 330 CFA)

Source: Computed from the field data

The cost per unit of most farm inputs is similar in the two regions, and therefore expenditures on farm inputs given in the above table reflect the quantity of input use in the respective regions. With the possible exception of insecticides, the average quantity of external inputs used per hectare in the two regions is generally less than the officially recommended level. This observation is principally a reaction to what farmers call the 'non-profitability' of cotton production in recent years since the elimination of free distribution of farm inputs to the farming community. Though the same level of input is recommended for both regions, the farmers in the LH region use proportionately higher levels of herbicides and other major types of inputs (on per hectare basis and in terms of the absolute total quantity used). One reason for this difference is that greater importance is attached to cotton in the agricultural activity in the LH region. As shown in Chapter 6, cotton is more important for households in the LH region in terms of contribution to the household's total farm income and total farm size. Another reason is that the level of agricultural modernization in the LH region is generally higher. Unlike the trend for other farm inputs, farmers in the SH region used slightly more insecticides per unit area during the season. The reason may be because one of the villages in the SH region (*Petonkaha village)* was chosen by CIDT as the village where the cotton seeds that will be distributed for planting to the farmers in the cotton regions in the following year would be taken from[5]. The

[5] CIDT gives free cotton seeds to farmers each year. The seeds are obtained from the cotton-grain output obtained from specific villages that have been pre-selected in the previous season.

quest to have high quality seeds attracted special official attention and monitoring to this village. The farmers in this particular village were encouraged to use more insecticides than they would most probably have done under normal circumstances[6].

A simple correlation matrix of variables used in the model for the long term and the short-term groups of observation is presented in Table 7.3.

Table 7.3: Simple Pearson correlation coefficient for the variables in the model

		Short History region					
		Output	Fertilizer	Labor	Herbicide	Farmer's age	Insecticide
Long History region	Output		0.5910	0.3945	0.4815	-0.3570	0.4772
	Fertilizer	0.4153		0.6754	0.3487	-0.2751	0.4852
	Labor	0.1530	0.3444		0.1338	-0.0742	0.3120
	Herbicides	0.2995	0.2957	0.0104		-0.3410	0.1669
	Farmer's age	0.2287	0.1632	-0.1168	0.0548		-0.2931
	Insecticides	0.3358	0.5144	0.5348	0.0866	-0.1106	

Note: All variables are in monetary values (CFA per ha) except farmer's age that is in years.

Source: Computed from the field data analysis.

An interpretation for the positive correlation of the farm inputs in Table 7.3 is that depending on inputs intensification decisions and the amount of resources available, farmers who use a high level of one farm input will most probably use similar levels of all other farm inputs. The notable exception is in the SH region where the level of intensification of input use decreases with farmers' age. This could be because older farmers in this region who for a long time had been accustomed to receiving free inputs, find it more convenient to use less quantity of inputs now that they have to pay for them. Table 7.3 also shows that herbicides and labor are positively correlated. This is surprising because theoretically a negative correlation would have been expected between labor and herbicides due to substitution between the two inputs. An explanation for this could be that the (negative) substitution effect between the

6 A fallout of the very high level of input use in this particular village is that several farmers were declared '*impayé'* at the end of the agricultural season, i.e. the total value of the farm output of the '*impayé'* farmers was lower than the cost of the farm inputs that they obtained from the cotton agency. Many farmers carried forward a net negative income balance to the subsequent farm year.

two inputs is being counteracted by the (positive) input intensification decisions, that makes farmers to use high/low levels of *all* inputs. The correlation figure obtained may be a net effect of these two forces. It is important to note that the correlation between labor and herbicides is not significant, in both study sites with Pr>|R|= 0.9281 for the LH and 0.5040 for the SH regions respectively.

7.4.2 Determinants of Cotton Production in the Different Cotton Production Regions

The estimated production coefficients for the variables in the models are presented in Table 7.4. The table shows that for the two study sites, the expenditure on mineral fertilizer, herbicides, and insecticides are the most important determinants of the final output obtained in cotton fields. All these variables have the expected signs. In addition, the expenditure on labor also has the expected sign and it contributes significantly to explain variation in cotton output for the SH (Katiola) region. These results are robust for all five alternative model specifications.

Table 7.4 also shows that in the LH region, the value of cotton production is comparatively *less* responsive (i.e. lower elasticity) to the quantity of insecticide application (or expenditures on insecticides). This is because the coefficients of the independent variables in the models are the output elasticity for the respective factor inputs. The coefficient of insecticides shows that a 1% increase in insecticide expenditure in cotton fields will increase cotton output proportionally by 0.395% in the LH region and 0.460% in the SH region. Given that the contribution of insecticides to output is through the reduction of potential yield loss, the above result suggests that insect pests are relatively less responsive to insecticides in the LH region. The difference in the elasticity of insecticides across the two study regions cannot be explained by the type of insecticide used because the type and quality of insecticides are the same in both regions and are generally supplied from the same sources. At this point, an interpretation that can be given for the results obtained above is that insecticides are less effective against pests in the LH region where the chemicals have been used for a longer period of time.

Table 7.4: Summary of the estimated production coefficients for the Cobb-Douglas and alternative damage function specifications

	COBB DOUGLAS		DAMAGE FUNCTION SPECIFICATIONS							
			EXPONENTIAL		LOGISTIC		WEIBULL		PARETO	
FARM INPUT	Long History region	Short History region	Long History region	Short History region	Long History region	Short History region	Long History region	Short History region	Long History region	Short History region
Intercept	5.3431	2.7311	9.2958	7.3105	9.5427	6.9013	3.4812	3.9476	7.5068	4.1577
	(3.49)	(1.58)	(5.67)	(6.00)	(5.41)	(5.87)	(1.31)	(2.04)	(0.05)	(4.59)
Fertilizer [CFA/ha]	0.2219	0.1649	0.2291	0.1706	0.2219	0.1736	0.2726	0.2210	0.2280	0.1745
	(2.08)	(2.16)	(2.13)	(2.25)	(2.05)	(2.27)	(2.51)	(2.84)	(2.10)	(2.28)
Labor [CFA/ha]	-0.0158	0.3086	0.0008	0.3243	-0.0127	0.3431	0.0893	0.3382	-0.0035	0.3216
	(-0.12)	(2.89)	(0.01)	(3.07)	(-0.09)	(3.29)	(0.66)	(3.04)	(-0.03)	(3.03)
Herbicide [CFA/ha]	0.0235	0.0257	0.0225	0.0246	0.0233	0.0228	0.0238	0.0252	0.0232	0.0244
	(2.57)	(2.15)	(2.46)	(2.09)	(2.51)	(1.95)	(2.50)	(2.04)	(2.49)	(2.05)
Farmers' age	0.1749	-0.1763	0.1500	-0.1750	0.1689	-0.1630	0.1560	-0.2562	0.1647	-0.1740
	(1.56)	(-1.14)	(1.33)	(-1.14)	(1.43)	(-1.07)	(1.30)	(-1.63)	(1.39)	(-1.13)
Insecticide [CFA/ha]	0.3954	0.4597								
	(2.66)	(3.03)								
Lambda λ			$9x10^{-5}$	$8x10^{-5}$					0.0100	0.7400
			(2.57)	(2.50)					(0.01)	(0.76)
Sigma σ					0.6230	2.3719				
					(1.10)	(2.23)				
μ					$9x10^{-5}$	$2.5x10^{-4}$				
					(0.99)	(2.31)				
K									1.2558	4.5227
									(0.21)	(2.33)
C							0.2536	0.2733		
							(0.08)	(0.12)		
R-Square	0.34	0.47	0.34	0.48	0.34	0.49	0.30	0.44	0.34	0.48

Note: The values in brackets are the T ratios

Source: From the data analysis results

The result may be an indication of a gradual build-up of pest resistance to pesticides over time in the cotton production system. A lot of studies have been done on pesticide resistance of mosquitoes in the country but comparatively fewer studies focused on the resistance of agricultural pests to pesticides. Signs of insect (mosquito) resistance to the insecticides used in northern Côte d’Ivoire have been reported. In the trial carried out in Côte d'Ivoire, ELISSA et al. (1993: p. 294) state that “there is a significant drop in the knock-down effect of the two (insecticide) compounds (that were tested). This drop could be interpreted as a trend or a beginning of resistance to these insecticides”. Referring to the work carried out in West African countries including Côte d'Ivoire and Mali, MOUCHET (1988: p. 299) reports that “the selective pressure (in mosquito species) is due to cotton treatments with a mixture of endrin and DDT. From 1967 to 1975, there is a correlation between the increase in cotton production, the intensive use of insecticides for controlling pests and the increase in the resistance”. Insect re-infestation and resistance to temephos and chlorphoxim in Côte d’Ivoire has also been documented by N'GUENDENG (1985). In a recent work, CHANDRÉ et al. (1999: p. 53) report that “Côte d’Ivoire, where resistance was first pointed out is a country with intensive agriculture where huge amounts of insecticides have been used for many years” especially on cotton fields. The authors report further that “the current pyrethroid resistance observed in West Africa has been suspected to result mainly from the intensive use of DDT and, later on, pyrethroids for crop protection, especially in cotton”. KOFFI et al. (1998: p. 65) state that “it is possible that the pesticides used in crop production have had an effect on the (resistance) selection of other insects especially *Anopheles* in the zone”. In another study, CURTIS et al. (1998: p. 1770) state that there have been several reports from Côte d’Ivoire and Burkina Faso of resistance of *Anopheles gambiae* and that “the resistant gene is thought to have been selected by pyrethroids used on cotton”. The “high levels of pyrethroid resistance were observed in all thirty-three samples of *Cx quinquefasciatus* collected from Côte d'Ivoire and Burkina Faso suggesting that they had been submitted to strong insecticide selection pressure under field conditions” (CHANDRÉ et al. 1998: p. 360).

The problem of pest resistance to cotton insecticides appears to be common in the cotton producing zones of West Africa and it has already provoked an official response to redress the problem. As TRAORÉ and TEMBELY (1999: p. 77-78) report, “from the 1996/97 season, Burkina Faso, Côte d'Ivoire and Mali have initiated a program on a sub-regional level to manage and prevent the resistance of pests, principally *Helicoverpa armigera* to certain pyrethroid-based insecticides". Section 7.4.3 contains further discussions on this result.

Unlike in the SH region, labor input has no significant effect on farm output in the LH region. The result for the LH region diverges from theoretical expectation. The reason might be due to the significantly high level of use of communal labor in the LH region. The difference in quantity and proportion of communal labor used in the two study locations is important for the interpretation of the results because the wage rate paid for communal labor is not rated at its social opportunity cost. This issue of communal labor in northern Côte d'Ivoire has been pointed out in some studies. STESSENS and DOUMBIA (1996: p. 41) state that "among the *Senoufos* (population group in northern Côte d'Ivoire), one often encounters rotational labor arrangement. This practice could assume a character of a feast with 30 to 40 men exhibiting their dexterity with the hoe". In the study area, it is common to observe a communal labor arrangement (especially for cotton harvesting operation) where a large group consisting of more than 40 persons work on a relatively small field, sometimes less than 2 hectares. Commenting on communal labor practices, ADESINA et al. (1995: p. 8) report that "… the majority of the excess labor used in farm production (in northern Côte d'Ivoire) comes from the practice of reciprocal labor relations. It is not uncommon to find over 50 laborers working on a half hectare rice farm". No other payment is incurred to use communal labor apart from the token payment in form of food and drinks for the workers. There are strong indications that communal labor groups play a social role (i.e. to demonstrate social solidarity among the farming community) rather than being a strictly economic activity. Due to the social dimension, there could be measurement problems and as a result, communal labor inputs may not necessarily have a direct proportional relationship with farm output. The amount of communal labor inputs that the farmers in the LH region use per hectare is 69% higher than and, statistically different (F=0.0001) from that of the SH region[7]. The considerably high amount of communal labor input that farmers in the LH region use per hectare is probably responsible for the overall non-significance of labor input in the LH region.

Theoretically, it would be expected that farm output would increase significantly as the management ability (measured in terms of farmer's age) of

[7] Across the two study regions, the amount of labor inputs supplied directly by the farm household per hectare is the same (F= 0.1822). Similarly, the amount of hired labor inputs per hectare is also statistically the same (F=0.9432).

the farmer increases. However, the results in Table 7.4 show that farmer's age is not a statistically important characteristic to explain the variation in farm output in the study area. This could be because of the practice in which some cotton fields are owned by elderly farmers, but such fields are managed by someone else, e.g. a son staying in the same household or village. Some elderly farm owners have a nominal ownership on their farms and provide general guidelines on some major issues related to the farm, but some management decisions concerning the farms are taken by the son or younger brother of the old farmer ('*le vieux*'). Farmers' age thus becomes ambiguous, as can be seen by its simultaneous positive and negative signs across the two regions. SAVADOGO et al. (1994: p. 610) in a study in Burkina Faso found that "the age of the household head is negative and significant". In a comparative study of rice yields in Nigeria and Sierra Leone, AJAYI (1991: p. 54) found that "though rice yields increase with the age of the household head, the coefficient is not statistically significant". The results of these studies – all of which were carried out within the West African sub region – suggest that the effect of farmers' age on farm output is not yet conclusive and may sometimes be ambiguous. Future studies that will include farmers' age as one of the variables to be studied need to take cognizance of the above.

7.4.3 Results and Discussions of the Marginal Productivity of Pesticides across Ecological Zones

Table 7.5 contains the marginal productivity of insecticides, herbicides and other farm inputs. These figures are computed at the mean values of the respective inputs.

Marginal productivity of insecticides: As presented in Table 7.5, the marginal value product per unit cost of insecticides is greater than unity in the Cobb-Douglas model and in three of the four alternative damage function specifications that were suggested by LICHTENBERG and ZILBERMAN (1986). Interpreted in strictly economic terms, the results imply that farmers under-utilize insecticides and that they could increase the profitability of their farm if they increase the amount of insecticides beyond the level that they are currently using. This is similar to the interpretations that could be given to the results obtained in earlier studies including HEADLEY (1968), CARASCO-TAUBER and MOFFIT (1994). The Weibull model however gives a marginal productivity estimate that is more plausible for economic interpretation and congruent with biological processes (as discussed in Chapter 2). But a further examination of the models in terms of the percentage variation in the dependent variable that each model explains (R^2), the Weibull model does not provide a firm basis to conclude on its statistical superiority above the other functional specifications.

Table 7.5: Marginal value product of pesticides and other farm inputs

	COBB DOUGLAS		DAMAGE FUNCTION SPECIFICATIONS							
			EXPONENTIAL		LOGISTIC		WEIBULL		PARETO	
FARM INPUT	Long History region	Short History region	Long History region	Short History region	Long History region	Short History region	Long History region	Short History region	Long History region	Short History region
Fertilizer (CFA/ha)	1.29	0.85	1.33	0.88	1.29	0.89	1.59	1.14	1.33	0.90
Labor (CFA/ha)	-0.04	0.65	0.002	0.68	-0.03	0.72	0.22	0.71	-0.01	0.68
Herbicide (CFA/ha)	0.46	1.17	0.45	1.12	0.46	1.04	0.47	1.15	0.46	1.11
Farmer age	882	-589	757	-584	852	-544	797	-856	831	-581
Insecticide (CFA/ha)	4.04	3.11	3.63	2.62	4.39	1.71	0.74	0.47	3.63	2.30

Note: MVP figures are in CFA returns per CFA expenditure for all the inputs except for farmers' age where it is given in CFA per year.

Source: Computed from the result of the econometric models.

An important result of the productivity estimates presented in Table 7.5 is that all of the five alternative model specifications provide consistently higher marginal productivity estimates for insecticides in the production system with a longer history of pesticide use. Based on the theoretical discussions presented in Chapter 2 and the results of previous studies including ARCHIBALD (1988), CARLSON (1977) and KNIGHT and NORTON (1989), it is expected that when insects develop resistance to insecticides (as indicated in Table 7.4) the estimates of insecticide productivity will decline. In this present study, two reasons are provided to explain why the estimates of insecticide productivity are higher in the LH region (compared to the SH region) despite the indications of pest resistance in the study area.

The first reason is linked to a higher yield potential of cotton production in the LH region compared to the SH region. The possibility of a higher cotton yield potential in the LH region is supported by the consistently higher magnitude (and the higher statistical significance) of the intercept term of the production model in the LH region.

Secondly, the productivity estimates obtained reflect the *net effect* of the influence of both the pest resistance and changes in the biodiversity over time in the study area. Over the years, cotton development policies have led to a phenomenal rise in status and importance of cotton from being a secondary crop in the early 1960s to become the dominant crop in the farming system in the 1990s. Similarly, there has been a gradual shift in the farming system away from traditional inter-cropping systems towards mono-cultural agriculture in cotton fields. These shifts are higher in the LH region where only three crops (cotton, upland rice and maize) make up more than 80% of total cropped area. On the other hand, the farming system in the SH region is more traditional and the cropping system is more diversified. While the appearance of pest resistance tends to reduce the productivity of insecticides, the shift in cropping systems in the LH region leads to a reduction in biodiversity of the production system and results in an increase of productivity of insecticides. As discussed in the theoretical chapter, the productivity estimates of insecticides depend on the relative impact of these two influences.

Marginal productivity of herbicides: The role of herbicides in farm production in the study area is often an ambivalent one, i.e. they simultaneously reduce potential yield loss (due to weeds) and also help to reduce the quantity of (weeding) labor inputs that would be required for the farm production. But, since all the herbicides applied in the study area are of the pre-emergence type, almost all of them are applied by households with large fields; estimates for herbicides are best interpreted primarily with respect to the role of herbicides as a labor-saving input[8].

Contrary to the results obtained for the LH region, the marginal value product of herbicides in the SH region is greater than unity. The economic interpretation is that farmers in the SH region use less than the optimum quantity of herbicides. This result is expected because the average quantity of herbicides per hectare in the SH region is very small and, much lower than the quantity recommended (only about 20% of the official recommended level). See Table 7.2 for details. It can be inferred from the result that the farmers in Katiola (SH region) could improve the economic performance of their farms by decreasing the quantity of labor input and substituting the same with

8 This is a major reason for distinguishing between insecticides and herbicides in this study.

herbicides. The recommendation is plausible especially because in the SH region, labor is a relatively more limiting factor (as indicated by the higher wage rate for labor in the region). On the other hand, cultivable land is a relatively more limiting input in the LH region (as indicated by the level of land intensification and also the average distance that farmers in the region go before they get access to cultivable land). Chapter 5.4.1 contains more details on the latter. The marginal value product of herbicides is less than unity in the LH region. This implies that the economic profitability of cotton farms in the LH region could be improved if farmers reduce the quantity of herbicides that they use on their farms to cut down on some input costs. The sub-optimal level of herbicides in the LH region is most probably due to the ‘excessive’ amount of communal labor input that is used in the region. Given the possibility of a substitution between (weeding) labor inputs and herbicides, farmers in the LH region could improve the profitability of their farms by reducing the quantity of herbicides and substituting them with the ‘free’ (communal) labor.

7.4.4 Marginal Productivity of other Farm Inputs Across Ecological Zones

Marginal productivity of fertilizer: The productivity estimates of fertilizer across the two study areas provide interesting insights into the long-term effects of cotton production in the study area. The results of this study show that inorganic fertilizer is still underutilized in the LH region but over-utilized in the SH region. Theoretically, a direct inverse of these results would have been expected because farmers in the LH region use higher levels of inorganic fertilizer application per unit area of cultivated field as compared to their counterparts in the SH region. In addition there is a widespread use of farm yard manure in the LH region whereas practically no farm yard manure is used in the SH region. The reasons for this seeming paradox are two folds. The first is the possible potential yield difference between the two regions as explained above in Chapter 7.4.3. The second reason is that due to the longer period of continuous cultivation of cotton and the higher intensification of land use, the soil nutrient base in the LH region may have reduced over time. The gap in the soil nutrient base in the region may have been so wide that an increasing quantity of external fertilizer is required to maintain a minimum soil fertility that would support profitable agricultural production.

In a study that was carried out in the LH region, ZOUMANA and CÉSAR (1994: p. 20) found that “in the dense Korhogo zone men and animals over-use land, leading to a decrease in the fertility of soil. To maintain an acceptable production level, as a result, the farmer uses much mineral fertilizer at high costs with all the repercussions it has on the soil”. The rapid expansion of the land area grown to cotton and the over-exploitation of land has led to a breakdown of the natural ecology and exhaustion of soil resource base in the core cotton zones of Côte d’Ivoire (RAVENHILL 1979). Similar findings regarding the impacts of agricultural practices on soil resource base have been reported for other parts of the world by MCNAMARA (1990). THIAM (1994: p. 26) reports that in the main cotton area of Senegal, yields fell from 1440 kg/ha in the early 1970s to 1000 kg/ha at the end of the decade and that the yield decrease was due to land degradation. The supervisory cotton agency for Côte d'Ivoire has demonstrated an awareness of soil degradation problems in the core cotton regions of the study area for this present study (CIDT 1991/92), and has responded by establishing a special program ‘Soil protection and Rehabilitation’ (*Défense et Restauration des Sols DRS*). The program aims at encouraging farmers in the LH region to take advantage of the abundance of farm yard manure (in the village animal parks) to increase the nutrient base of their fields. Such soil amelioration programs are necessary, in view of the results obtained in this study. On the contrary, given that in the SH region, cotton production is less intensified and cotton has been cultivated for a relatively shorter period, the degradation of the natural soil nutrient base may be smaller. As a result of the smaller soil nutrient gap, only a small quantity of fertilizer – even smaller than the quantity officially recommended for use – is required for the optimum production of cotton in the SH region. The explanations given above are consistent with Table 7.4 showing that the production coefficient of fertilizer is higher in the LH region, i.e. cotton output is more responsive to the application of fertilizer in the LH region.

Marginal productivity of labor: A strict economic interpretation of labor productivity estimates is that in both study sites, the level of labor input that farmers realize is in excess of the level that is required to maximize farm profit. A major reason for this is that 86% of all the labor input used in cotton fields is obtained directly or indirectly from within the household. Given that farmers do not pay for these types of labor directly, there is a tendency for farmers to perceive such labor as ‘free’ input. Given that there is some social value of (communal) labor, the ‘output’ produced would be expected to go beyond the value of the physical quantity of farm production[9]. A strict economic

9 Beyond physical production, the ‘output’ that is ‘produced’ when communal labor is used include an improvement in the social solidarity at the village level, a factor that is often not included in conventional economic analyses.

interpretation and policy recommendation of the estimates on labor input in the study area therefore has to be done with caution.

7.5 Conclusion

The analysis of pesticide use in the two study regions of Côte d'Ivoire provides consistent results when using conventional models and the damage function approach. In accordance with previous studies, the damage function specifications show a lower marginal product of insecticide use. However, results indicate that there is a 'rent' from applying pesticides as marginal value product exceeds factor cost. While the level of insecticides used by cotton farmers is economical, there are indications of a decrease in the effectiveness of insecticides. The regression coefficient for insecticides in the region where these chemicals were used for a longer time is lower compared to the Short History cotton region. In the LH region, the value of cotton production is comparatively *less* responsive to the application of insecticides. The difference in the elasticity of insecticides across the two study regions is interpreted to mean that insecticides are less effective against pests in the LH region where the chemicals have been used for a longer period of time. The result indicates a gradual build-up of pest resistance to pesticides over time in the cotton production system. The result is consistent with complaints by farmers in the LH region that pesticides are no longer as effective as before. However, the results do not provide conclusive evidence for the existence of a technological path dependence on pesticides.

Another important result of the productivity estimates is that all of the five alternative model specifications provide consistently higher marginal productivity estimates for insecticides in the production system with a longer history of pesticide use. Two reasons are given to explain why the estimates of insecticides productivity are higher in the LH region compared to the SH region. The first is the possibility of a higher yield potential of cotton production in the LH region. The second is that the insecticide productivity estimates represent a *net effect* of the influence of both the presence of pest resistance and changes over time in biodiversity. While pest resistance tends to reduce the productivity of insecticides, the reduction in the production system's biodiversity leads to an increase in the productivity of insecticides.

The results of the analysis of fertilizer productivity indicate that over time, cotton production systems rely increasingly on external support from the application of inorganic fertilizer. This occurs particularly in regions where cotton has been grown for a longer period and where crop intensification is higher. The foregoing results may constitute a threat to the sustainability of cotton production in the long run especially if fertilizer prices increase (when/if all the covert and overt government subsidies on fertilizers are removed) and there is no commensurate increase in the producer price of cotton. Effective and appropriate measures like the current *DRS* initiative are required to reverse the reliance on fertilizers. This study also highlights that the current practice of recommending the same level of inputs across the entire cotton zone is not appropriate, as this policy leads to allocative inefficiencies for some cotton growing zones. Officially recommended levels of farm inputs should take cognizance of the relative historical period of cotton cultivation and the differences in resource degradation that exist among various producing zones in the country.

8 Human Health Costs of Pesticides: Empirical Trends and Model Calculation

The contact with pesticides leads to exposure with the chemicals for those who do the spraying and for other persons within the community. This may affect human health. Different approaches have been used in various studies to document the human health hazards of pesticides. COLE, CARPIO and LEON (1998) provide an extensive review of various approaches to measure the effects of pesticides on human health. The extent of human health risks from pesticides is affected by various factors including field practices, type of sprayer and crop characteristics (THORNHILL et al. 1996: p. 1175). Other variables are cultural and individual safety characteristics.

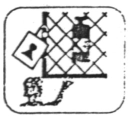
In this chapter, the health effects of pesticide use and exposure of farm workers are analyzed based on empirical data. The chapter is organized into four sections. First, empirical data on pesticides and human health effects are analyzed to determine if there are health problems associated with pesticide use in the study area. The level of the farm households' awareness of human health effects of pesticides is assessed. This is followed by a comparative analysis of the attention that households give to general illnesses and pesticide symptoms. In the second section, the results of bio-medical and laboratory tests of exposure to pesticides among the pesticide applicators of farm households are analyzed. In the third section, a framework to estimate human health costs of pesticides is presented. The actual amount of health expenses that households incurred on the pesticide-related health symptoms are analyzed. The factors that affect households willingness to invest in health are also discussed. Fourth, conclusions on the relationship between biological and laboratory test of exposure to pesticides on one hand, and the actual health expenses on the other hand are discussed.

8.1 Empirical Trends on Pesticides and Human Health Effects

8.1.1 Knowledge of Pesticide Warning Signs and Symbols and Farmers' Attitude

Farmers in the study area demonstrate some level of understanding of symbols on pesticide containers that warn against the potential dangers of pesticides (Table 8.1). Farmers' knowledge of pesticide symbols was assessed by showing them a diagram containing the various pictorial signs. They were then asked to indicate the significance of each sign and what message the pictures convey to pesticide users. The interpretation given for each of the symbols was recorded in the farmer's own words. The interpretations that farmers gave were then compared with the intended message of the pictograms. On this basis, farmers' responses were evaluated as 'correct', 'partially correct' or 'wrong'. A copy of the pictograms is included in Figure 8.1. The result of the evaluation of farmers' interpretation of the pictograms is presented in Table 8.1.

Figure 8.1: Symbols on pesticide containers to alert users

Pictorial	No.	Intended message
	**1**	How to handle the concentrated liquid
	**2**	How to handle the dry concentrate
	**3**	How to apply the product
	**4**	Wear gloves
	**5**	Wear breathing apparatus
	**6**	Wear a protective mask covering the nose and mouth
	**7**	Wear protective gloves
	**8**	Wear boots
	**9**	Wash after using pesticides
	**10**	Keep under lock and key, out of the reach of children
	**11**	Danger
	**12**	Dangerous, harmful to animals
	**13**	Dangerous, harmful to fish. Avoid contaminating lakes, rivers, ponds or water courses

Source: TOURNEUX (1994)

Table 8.1: Level of farmers' understanding of pesticide symbols and pictograms

	Accuracy of farmers' interpretation (%)		
Correct significance of symbol	**Correct**	**Partial**	**Wrong**
Wear glasses to protect eyes	83	02	15
Put on leg boots	81	03	16
Put on hand gloves	81	02	17
Protect mouth and nose	78	07	15
Alert on possible danger of death	61	10	29
Wash after pesticides operation	52	07	41
Handling of concentrated liquids	54	13	33
Handling of dry concentrates	52	16	32
Hazardous to animals	39	18	43
Harmful to fish and flowing rivers	39	01	60
Keep securely, out of reach of children	15	02	83
Method of pesticide spraying	08	64	28
Put on breathing apparatus	02	78	20
Average	**50%**	**17%**	**33%**

Note: 'Wrong' responses refer to the cases when respondents gave completely wrong interpretations to pictograms or when they said that they do not have any idea what the pictorial sign meant.

Source: Own field KAP survey

An important feature from the above table is that in both study areas some images are very well understood by farmers while others are interpreted in a wrong way. In general, symbols that instruct pesticide users to protect themselves were the most well understood. About four out of five respondents understood the meaning of these symbols. These are pictogram numbers 4, 6, 7 and 8. In a study carried out in Cameroon, TOURNEUX (1994: p. 21) reports that many farmers in the country understood this set of pictograms quite well. Given their knowledge on the possible health effects of pesticides on workers, farm households conceptualize these images and relate them more easily to the intended advice that they should protect themselves. In practice, some farmers made efforts to use some form of protective clothing that they have improvised by themselves. The effectiveness of these improvised materials is not guaranteed.

More than half of the respondents understood symbol number 11 and 9 very well. The first of the two symbols alert users on the potential health danger linked to pesticides and the second symbol advises pesticide users to wash themselves after spraying. The high level of understanding of farmers of these two symbols is not surprising because most farmers are aware that pesticides are dangerous. In many villages in the cotton region of Côte d'Ivoire, the common name that farmers adopted for insecticides is ‘poison’. However, the image of a tap water pump in the pictorial appears to be confusing to some farmers. Some respondents interpreted the water pump to mean that ‘tap water is the best to drink after pesticide operation’, or that they should ‘smell the odor of the pesticide mixture in basins before spraying’. Other wrong interpretations that farmers attach to the symbols are: ‘go to the next available tap water point to wash after pesticide spraying’, or ‘the use of tap water to prepare pesticides will improve spraying operation on field crops’.

Pictogram numbers 1 and 2 were poorly understood. Farmers interpreted these symbols in the way that they should protect their hands with gloves before they touch/take pesticide containers. Some respondents mentioned that the symbols is an advice that they should ‘pour pesticides into a cup’[1]. A number of respondents confounded the dry concentrate to mean ‘fertilizer’, ‘soap powder’ or ‘detergent’[2].

Only one third of respondents (39%) understood symbols 12 and 13. Some farmers interpreted symbol 12 to imply that they should ’drink cow milk and eat chicken regularly’, or ‘buy oxen to assist in doing cotton farm operations’, or ‘erect a barricade against animals to prevent them from destroying crops in the field’. Other wrong interpretations were ‘farm operations will be done faster if we work with animal traction and give chicken to farm workers to motivate them’ or ‘do not go fishing after completing a pesticide field operation’. The remaining three symbols 3, 5 and 10 were totally misunderstood. To some farmers, symbol 10 means that they should ‘use the pesticides on top of the storage rack first before using the ones below them’ or to ‘wash spraying equipment and keep them out in the sun to dry after operation’. According to

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1 A possible reason for the strange interpretation that farmers gave to this pictorial is provided as follows: In Côte d’Ivoire, for a long time, pesticides are packaged in small containers and the whole content is poured directly into the spraying equipment, without requiring any measurement. The image showing liquid being poured into a cup (which some farmers interpreted as a drinking glass cup) appeared confusing to some farmers, who associated the cup in the picture with ‘drinking water’.

2 Over the years, all the types of pesticides used in the study area came in liquid form only. Farmers must have had difficulties conceptualizing a ‘dry pesticide’, and therefore interpreted the picture in terms of the common farm inputs (i.e. fertilizer) and the items that they use on daily basis (i.e. detergent powder) which appear to be the closest to the item in the pictorial.

many respondents, symbol 5 is simply a rich man's version of the handkerchief or a piece of clothe which they are already using to cover the mouth and nose when they spray pesticides.

Synthesis of farmers' awareness of the negative impacts of pesticides

In summary, farmers better understood symbols that are similar to the items that are commonly found in the vicinity of their farm households. Most farmers interpreted pesticide pictograms in the light of basic materials that are available in their surroundings. Many of the wrong interpretations that farmers gave to the pictograms appear to be the closest 'correct' answers, within the context of the economic and social environment of the farmers. To improve the appropriateness of pesticide pictograms, it is necessary to take cognizance of the socio-cultural context of farmers, because of the wide range of possible interpretations that farmers gave to the various symbols[3].

As a result of the long period of pesticide use and the close collaboration with the cotton agency, farmers *appear to be aware* of the information on pesticides practices that they are expected to do, and the possible human health consequences linked to pesticides. Farmers' awareness is largely because most of them have suffered from health problems since they have been involved in pesticide application. In spite of this seeming awareness, 40% of the respondents neither read nor consider the warning labels at all while others (31%) do so only occasionally. Only 29% of farmers mentioned that they usually take cognizance of the labels. Apart from human health problems, farmers' level of information concerning the negative impact of pesticides on the environment is minimal. Only 16% of the farmers mention that pesticides 'burn' plants, while 2% said that pesticides have potential negative side effects on rivers and the environment.

But, the awareness that farmers seem to have on the potential dangers of pesticides to human health does not appear to have much impact on some of their field level practices (as shown in Chapter 6) and their attitude towards pesticide health symptoms (as presented in the latter sections of this chapter). Similar problems have been reported from other parts of the developing world. COLE et al. (1998: p. 73) state that "results from a number of developing countries indicate that despite considerable awareness of the toxicity of pesticides, irregular hygienic practices and rare use of personal protective

[3] For example, the picture which requires farmers to wear breathing apparatus during pesticide spraying is open to various interpretations, given that many farmers have never seen one before.

equipment result in greater levels of exposure for equivalent pesticide use in developing countries compared to developed countries". The study by CRISSMAN et al. (1994: p. 595) shows that although more than 70% of the farmers agreed that pesticides cause serious human health problems and also 81% of the exposed farmers and farm workers read pesticide warning labels, yet apart from rubber boots, these individuals used little or no protection against exposure during spraying operations.

8.1.2 Pesticide-Related Health Symptoms in Farm Households

Table 8.3 contains a list of health symptoms that pesticide applicators associated with spraying activities in the study area. These are specific health symptoms that applicators did not suffer from *before* they started spraying, but which began only *during* a spraying operation or *within 24 hours* after the spraying operation has ended. The time frame was short because the pesticides used in the study area consist of an organophosphate-pyrethroid mixture and they have essentially acute effects. It is expected that the health symptoms of exposure to these chemicals would begin to manifest within the specified short period. The type of pesticides used in the study area is presented in Table 8.2[4]. As a result, all health symptoms that appear (or which farmers noticed) *after* the stated time frame are not included in the data — i.e. the record of the health symptoms and the estimation of the pesticide health cost would most probably be conservative. Details on the symptoms that farmers reported were obtained during the follow-up monitoring visits to interview pesticide applicators after every round of spraying operation throughout the farm season.

The types of pesticides that were used in the study area during the period of this study are presented in Table 8.2.

[4] The specific type of pesticide formulations that are recommended for use in the study area may change from year to year. In most cases, the pesticide formulations are a binary combination of organophosphate and pyrethroid chemicals.

Table 8.2: Types of pesticides used in the study area (based on volume)

Type	Brand name	Active Ingridients	Percentage
Insecticides	Efethrine	Cypermethrine	36.9
	Serphos	Triazophos + Cypermethrine	22.8
	Polythrine 186 EC	Profenophos + Cypermethrine	20.8
	Cypercal EC	Profenophos + Cypermethrine	11.4
	Cyperphos 286 EC	Triazophos + Cypermethrine	5.2
	Others (6 brands)	Chlorpyriphos-Ethyl, Endosulfan, etc	2.9
		Total	**100**
Herbicides	Cotodon	Metolachlor + Terbuthryne	82
	Ronstar	Oxadiazon	7
	Others (11 brands)	Atrazine, Propanil, Cyanazine, etc	11
		Total	**100**

Source: Own field data

The aggregated health symptoms reported by pesticide applicators for the farm season are shown in Table 8.3. Pesticide applicators reported several types of pesticide-related health symptoms, five of these health problems are economically the most important ones.

Table 8.3: Health symptoms reported by pesticide applicators

Type of symptom	Percentage of occurrence
Headache	25
Rhume	18
Cough	17
Skin rash	13
Sneezing	11
Other symptoms	16
Total	**100**

Source: Computed from the post-spraying health monitoring data

The percentages given above are for pesticide applicators that reported at least one health symptom during or just after pesticide spraying operations. The results show that in one out of five times (20%) when insecticides were sprayed in cotton fields, pesticide applicators reported a health symptom *and* also took special attention to seek treatment. This compares with the results of KISHI et al. (1995: p. 130) who report that “of all the respondents (pesticide applicators), only 24% took medication”. There is a wide difference in the behavior of pesticide applicators across the two regions of study. In the long exposure region, applicators reported health symptoms and seek cures to them in only 8% of times that they spray pesticides. In the ‘Short History’ region, the corresponding figure is 37%. However, in both regions, the symptoms that applicators reported are those that they perceived to be the severe cases (see Section 8.4 for details). The majority of pesticide sprayers that were monitored (80%) reported that there was ‘nothing so special’ (‘*rien à signaler*’) from pesticide spraying operation. That is, such pesticide applicators did not think that they encountered extraordinary health problems that are beyond normal levels during the pesticide application. For the remaining times of pesticides spraying, applicators did not incur any direct costs or they used only home grown cures.

Among all the pesticide-related health symptoms that pesticide applicators mentioned, only in 2% of the cases (1.5% in the long exposure region and 2.4% in the short exposure region) did the victims visit health centers for medical consultation or to seek for formal medical assistance. For the remaining health symptom cases, the applicators bought drugs that were available in their vicinity and or they used home-grown healing methods. The study in Indonesia (KISHI et al. 1995: p. 130) shows that “less than 1% of pesticide applicators went to a health center with symptoms related to (pesticide) spraying”. These results suggest that the official records of pesticide poisoning/health symptoms are most probably under-estimated given that only the health symptom cases that are taken to formal health centers are documented. The official documentation of actual pesticide poisoning cases appears to be very low in many countries. The specific reasons for the low reporting of pesticide-related symptoms among applicators in this present study are discussed in Section 8.4.

WHO (1990) estimates official documentation of health poisoning cases in developing countries at 17%, i.e. only one out of six cases of medical (poisoning) symptoms of pesticides is reported officially. The report also indicates that the unhospitalized (unrecorded) cases of unintentional pesticide poisoning are many times higher than the hospitalized or officially recorded cases. In South Africa, despite a national law that classifies pesticide poisoning as ‘notifiable medical conditions’ — making it obligatory for farm workers to report them —, cases of pesticide poisonings are still grossly under-reported and under-notification remains a serious problem (ROTHER and LONDON 1998: p. 32). The various studies in South Africa show that the true rates of pesticide poisoning in the country "are anything between 5 and 20 times higher than the officially documented figures" (LONDON and ROTHER 1998: p. 32). A study in Ecuador (CRISSMAN et al. 1994: p. 596) shows that "only 9% of (pesticide poisoning) cases went for clinical care". In other studies that were carried out in different third world countries, JEYARATNAM et al. (1978 *cited in WHO 1990: p. 51*) report a hospital admission ratio of 9% of pesticide poisoning cases in Sri Lanka while KAHN (1976 *cited in WHO 1990: p. 85*) reports 1%. Based on several studies, WHO (1990: p. 51) estimated that "for every 500 symptomatic cases, there are 11 hospital admissions". In general, the official documentation ratio for (unintentional) pesticide poisoning cases appears to be directly related to the level of economic development, i.e. poorer countries tend to have lower documentation ratios and vice versa. The under-reporting of pesticide related health problems poses a problem because it does not allow policy makers to fully appreciate the extent of unintentional pesticide poisoning and to formulate appropriate policy interventions.

8.1.3 General Illness and Health Problems among Household Members

In this section, the results of the analysis of weekly morbidity data (i.e. occurrence of illness) are presented. The data for the morbidity analysis covers all members of the household, i.e. pesticide applicators and non-applicators. This specific analysis provides an insight into the occurrence of health symptoms between pesticide applicators and non-applicators within the same household[5]. The results show that pesticide applicators constitute only 17% of the entire household population in the study area (18% of the population in LH region and 16% in SH region), but they suffer from 45% of the illnesses reported in the study area (43% in Korhogo and 46% in Katiola). The occurrence of illnesses among all household members is closely influenced by individual characteristics (age, gender) and the degree and type of

[5] It is expected that if a health symptom occurred but was not reported by pesticide sprayers in Section 8.1.2 above (e.g. if the symptoms occurred after the specified short time limit) may reflect in the data collected over a longer time period.

involvement in farming activities (especially contact with pesticides). Individuals within the household who have direct contact/exposure to pesticides suffer disproportionately more illnesses than other members of the same household.

Table 8.4: Health symptoms and risk for pesticide sprayers and non-sprayers

Category of household member	Proportion of population	Proportion of symptoms	Symptom risk ratio
Pesticide sprayer	17 %	45 %	4.0
Non-pesticide sprayer	83 %	55 %	

Source: Author's calculation based on the household morbidity data

The above table indicates that when all illnesses reported by all members of the household are aggregated, pesticide applicators have on the average a four times greater risk to fall sick than an average household member living under the same conditions, and sharing similar diet and socioeconomic conditions.

8.2 Bio-Medical Tests of Pesticide Exposure of Farm Workers

Theoretically, exposure to pesticides is expected to be correlated with the occurrence of health symptoms. Two of the methods that may be used to measure pesticide exposure are cholinesterase blood tests and pesticide residue deposition tests. The test details and the methodology on how they were used in this study have been discussed in Section 4.3.3. The two tests were carried out to verify the empirical information on the pesticide-related health symptoms that pesticide applicators reported in Section 8.1.2 above. The purpose of the tests is to prove if a cause and effect relationship exists between pesticide exposure and the health symptoms that were reported by pesticide applicators. The underlying question would be: can we assume that the health symptoms are indeed related to pesticide exposure or not?

8.2.1 Cholinesterase Blood Test

Red blood cells and nervous tissue contain the neutron-type enzyme commonly referred to as the acetylcholinesterase (ACHE) – because of its preference for acetylcholine as a substrate. When cholinesterase reacts with organophosphate and carbamate pesticides, the enzyme is rapidly inactivated. The extent of change in the level of enzyme activity (i.e. its inactivation by pesticides) provides an indication of the level of exposure to pesticides among persons who have contact with these chemicals[6]. For this study, the calculation of the change in cholinesterase enzyme activity was based on Equation (8.1).

$$Percentage\ Change\ in\ ACHE = \frac{A_1 - A_2}{A_1} \bullet 100 \qquad (8.1)$$

Where: A_1= Initial Ache enzyme activity at the 'baseline' period before pesticide spraying operation

A_2= Ache enzyme activity after exposure to pesticide spraying operation

The data of the erythrocyte cholinesterase tests were analyzed using the General Linear Model procedure (GLM) to determine differences the level of changes in the enzyme activity across the different groups of observations. The result of the analysis is presented below in Table 8.5.

Table 8.5: Changes in the blood enzyme activity (in %) of pesticide applicators before and after exposure to pesticides

Type of change	Group of individuals tested		
	Pesticide applicators	Control group	Pr > F
Cholinesterase enzyme activity (units/ml of blood)	20.1	6.8	0.0001
Hemoglobin (grams per dl of blood)	12.2	0.6	0.0001

Source: Computed from the blood test data

6 Intra-personal comparison of change in the enzyme activity for individual persons is more plausible than comparing changes across a given population. This is because changes in enzyme activity in a population may be affected by some variables like infection and nutritional status (EQM 1991).

The change in cholinesterase enzyme activity is significantly higher among pesticide applicators than in the 'control' group. This suggests a higher level of exposure to pesticides among applicators. The result of the 'control' group appears initially puzzling. This is because theoretically, the 'control' persons are not expected to be exposed to pesticides at all and therefore, their enzyme activity before and after the pesticide season is expected to remain unchanged. The explanation for the changes observed in the enzyme activity among the 'control' individuals in this study may be due to the cumulative effect of pesticides that drift towards the village when cotton fields (especially fields that are located near the village) are sprayed. The pesticide drifts may have been increased by some farmers' practice who prefer to spray their fields when wind speed is high. The mean change in the enzyme activity of pesticide applicators in the long exposure zone is higher (22.3%) than of their counterparts in the short exposure zone (17.6%). The difference is not statistically significant between the two study sites.

Further analysis of the data shows that the change in the enzyme activity among the individuals tested was influenced by their personal habits. The individuals who were smoking (as at the time the second blood test was done) had a significantly higher level of enzyme inhibition compared to those who were not smoking. Drinking does not have any significant effect on the change in the level of enzyme activity of the individuals tested. The impact of individual's habits on cholinesterase test has been mentioned in other separate studies. BARNES (1997a: p. 32) reports that "alcohol intake was statistically associated with lower Ache enzyme levels".

8.2.2 Analytical Tests of Pesticide Residues on Clothes

Exposure to pesticides may also be evaluated by comparing the total deposition by body area across all pesticides and concentrations used by applicators (COLE et al. 1998). The test provides answers to questions such as: "What proportion of the total quantity of sprayed pesticides fell on the applicator's body rather than on the intended crops?" Theoretically, the higher this proportion, the higher is the level of exposure to pesticides and the probability of occurrence of pesticide-related health symptoms increases. An approach based on this principle was used in an experiment reported in THORNHILL et al. (1996). See Section 4.3.3 for the details of the methodological approach used in this present study.

Table 8.6: Quantity of the active ingredient residue of pesticides (in μg) (extracted per unit area of the cloth tissue attached on applicators)

Quantity of active ingredient residue (in μg)	Long Exposure region	Short Exposure region	Overall	Pr >T
Extracted residue per 1 x 1 cm area	202	91	146	0.1950
Quantity of pesticide residue per 100 x 100 cm area of cloth tissue (extrapolated)	2.02×10^6	9.06×10^5	1.46×10^6	0.1950
Quantity of pesticide residue per 150 x 150 cm area of cloth tissue (extrapolated)	4.54×10^6	2.04×10^6	3.29×10^6	0.1950

Source: Computed from the laboratory analysis data

The amount of pesticide residues that was extracted from the cloth tissue is a good measure of the amount of active ingredients that would normally fall on the body of pesticide applicators during spraying operation. Given the inadequate protection of applicators, the odds are that these residues would most probably be absorbed into the skin of applicators. The results show that pesticide applicators in the long exposure region are at greater risk of coming into direct contact with pesticides than applicators in the short exposure region. The applicators in the long exposure region carry the risk of being exposed to an average of 202 micrograms of active ingredients every square centimeter of their body surface during spraying operations in the agricultural season. The corresponding figure for applicators in the short exposure region was 90 micrograms of active ingredient per square centimeter of the body surface. Table 8.6 contains an extrapolation of the expected risk of pesticide residue on a body surface are of 100 cm^2 and 150 cm^2 respectively.

In Table 8.7 below, the proportion of the active ingredient of pesticides that fell on applicators are presented.

Table 8.7: Pesticide residue as a proportion of the active ingredient sprayed (in %)

Pesticide residue as a percentage of the active ingredient sprayed	Long exposure region	Short exposure region	Overall	Pr >T
Per 100 by 100 cm^2 of body surface	0.018	0.021	0.019	0.5086
Per 150 by 150 cm^2 of body surface	0.039	0.046	0.042	0.5086

Source: Computed from the laboratory analysis data

Table 8.7 shows that 0.04% of the *total quantity* of pesticides that are sprayed fell on every 150 cm^2 body surface of the applicator. The proportion is not significantly different between the two study regions. As a result, the difference observed in absolute quantity of pesticides residues found on applicators' body in the two study locations (Table 8.6) cannot be attributed to differences in the level of 'carefulness' of field spraying practices among applicators. Rather, the higher proportion of pesticide residues that were found on applicators in the LH region may be explained by three inter-related factors: cultivation of larger cotton fields, use of higher absolute quantities of insecticides per household and the longer exposure time to spray the large (and often multiple numbers of) cotton fields.

The summary of the results of the bio-medical tests of exposure is that there is evidence that the health symptoms that pesticide applicators reported are linked to their exposure to these chemicals. The question "What are the costs of these health symptoms to the farm household?" is answered in the next section.

8.3 Assessment of Pesticide-Related Health Costs

The study by ROLA and PINGALI (1993) and that of CRISSMAN, ANTLE and CAPABLO (1998) establish the empirical evidence for the existence of negative impacts of pesticides on farmers' health and productivity in developing countries. With its average contribution of 86% of all farm labor inputs, the household is clearly the most important supplier of labor inputs (both direct and indirect) that are required to operate farms in the study area. As a result, the health status of household members is critical for the management and productivity of family farms. Illness suffered by one or more members of the household affects the overall performance and productivity of the family farm in three major ways:

First, health symptoms reduce the productivity of the victim on the family farm throughout the period of illness, i.e. *partial* productivity loss. In more serious cases, the victim is forced to stay off work completely for the duration of the illness, thus denying all the productive contributions to the family farm that could have been made by the sick member, i.e. *total* productivity loss.

Second, health symptoms lead to production risk and resource constraint problems. When symptoms occur, the income that the household had earmarked to procure inputs for the family farm may be diverted to seeking medical help for the victim. This causes production resource constraints and introduces uncertainties in the expected income from the family farm enterprise. This risk effect is particularly important in the study area (as in many rural communities in less developed countries) where medical insurance does not exist.

The third effect of health symptoms is the fallout on the productivity of other members of the household. In addition to the sick person not being able to work on the farm, some members of the household (usually women) are often assigned the task to look after the sick. As a result, the family farm is denied the labor services of the (otherwise) healthy family members for as long as they are needed to attend the sick.

8.3.1 Framework for Estimating Pesticide Health Cost

As explained above, pesticide-related illness has other multi-dimensional cost implications for the farm households. The level of costs is closely related to the level of socio-economic development and the context of the prevailing culture in the sub-region. The costs range from expenses that are obvious and are directly associated with pesticides to other costs that are only indirectly linked to pesticides. Based on information collected during this present study, the costs may also be grouped as 'damage', 'preventive', 'mitigation' and 'unknown' costs. This grouping of costs and the items that belong to each group are discussed below.

i. Damage acceptance cost or the 'do nothing' stage: Generally, the first reaction of a typical pesticide applicator to health symptoms after he has sprayed pesticides is that he tends to accept the health symptoms as part of the damage that one should normally expect to be associated with pesticide operations. The applicator adopts a sort of 'do nothing' approach. An important characteristic of the damage acceptance costs is that the household does not incur any cost at all. This is because household members do not think so much about the symptoms and so they do not constitute 'costs' to them. Another characteristics is that the 'do nothing' phase of health symptoms usually has a short duration (generally one day) beginning from the time of spraying to the end of the same day. At this stage, pesticide applicators regard the negative health effects of pesticides as a 'normal' expected damage occurrence, and they perceive that such 'minor' symptoms do not require much attention at this stage. Farm workers also perceive that the symptoms will disappear on their own. Pesticide applicators in the study area mentioned that since they have been using pesticides for some times, they are now accustomed to the problems that are associated with the chemicals and so they do *not* regard these problems as extraordinary phenomenon.

ii. Mitigation costs: Farm workers incur costs to mitigate against the symptoms that they perceive to be ‘beyond normal’. It is believed that some expenses to reduce potential negative effects of the symptoms are necessary at this stage. The type of health symptoms and the mitigation expenses associated with them respectively may be summarized into three sequential stages.

Stage One: These are the first cases of health symptoms where applicators thought that they needed to do something against the symptoms. The mitigation costs for the symptoms are paid for in-kind rather than in cash, usually by using local home grown cures. There is very little or no direct out-of-the pocket expenses made at this stage. The various types of local treatment methods used in the study area include the following: rubbing local *shea butter* oil (*beurre de karité*) on the body, drinking lemon juice (*jus de citron*), eating fresh tomato fruit/juice, drinking fresh palm oil or a combination of these methods. Other methods include drinking honey or a local concoction that induces vomiting for the victim[7].

Stage Two: Farm workers treat more serious symptoms by purchasing medicines that are available within the immediate neighborhood/village. Such purchases are made over-the-counter, often without formal medical consultation or advice. The symptoms at this stage are those that last for a longer period and/or the level of pain associated with them is considered to be beyond the normally expected level. Meanwhile at this stage, the victim may continue to work on the farm but may only be able to operate at a lower capacity.

Stage Three: These are higher level cases and only symptoms are included that pesticide applicators consider as being very serious or extraordinary. For such type of symptoms, the victim may proceed to the clinic/health center for formal medical consultation and purchase the prescribed drugs. In addition (or as an alternative), the victim may also take one or two days off from farm work to recuperate.

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[7] The methods are widespread cures and are generally known by many farmers in the study area. However, none of the farmers could give precise information on the origin or the diffusion of the methods. They nevertheless believe that the methods are helpful antidotes against pesticide intoxication. The veracity of these claims or the efficacy of the methods could not be proved during this study.

Apparently, the amount of monetary expenses that are involved to mitigate the health symptoms increases from stage one to three.

iii. Preventive costs: These are expenses which households incur to purchase protective clothing and other materials that help them to avoid health symptoms. Such costs include the cost of hand gloves, boots, mouth and nose protectors. Based on the pesticide practices in the study area, another type of avoidance cost is the cost of materials that applicators drink as a preventive measure against intoxication. An example is fresh cow milk that some applicators drink for preventive purposes - whether the farm worker had health symptoms or not.

iv. Unknown costs: These are health symptoms in which pesticides are suspected to play some part, but the exact role of pesticides cannot be confirmed nor can its cost be evaluated. This incertitude comes from limitations imposed by the existing level of knowledge in medical sciences. This group includes the costs of long term chronic health problems which have been directly associated with pesticides, or in which pesticides play an indirect role by aggravating them. The identification and quantification of these types of costs will increase in the future as scientific knowledge in medicine increases.

Based on the above, a framework for the identification and grouping of health cost items is presented in Table 8.8. A description of the costs is provided thereafter.

Table 8.8: Framework to evaluate the human health costs associated with pesticides in the cotton households in Côte d'Ivoire

Damage Acceptance Cost	Mitigation Cost
➢ Labor productivity loss due to pesticide-related illness: ♦ Partial productivity loss ♦ Total productivity loss ➢ Loss of labor by family member nursing the victim of illness ➢ Increased farm production risk ➢ Cost of pain	➢ Cost of pharmacy/drug ➢ Consultation fee ➢ Transportation fares to and from the clinic ➢ Materials used in self administered local cures (e.g. shea butter, lemon, palm oil) ➢ Payment to village/traditional healer - in cash or kind. ➢ Travel and waiting time at the clinic/healer's home ➢ Time to prepare local healing mixtures e.g. acquisition of herbs and boiling of the same
Preventive Cost	**Unknown Cost**
➢ Cost of protective clothing- hand glove, mouth & nose protector, etc ➢ Cost of materials that applicators drink as a preventive measure against intoxication, e.g. fresh cow milk	➢ Long term chronic pesticide-related health symptoms ➢ Other health symptoms in which pesticides play aggravating roles

Source: Author's own presentation

Labor productivity loss: This is the economic value of the loss of labor due to illness. It may be a total or a partial labor loss. The labor loss is evaluated at the opportunity cost of labor or the wage rate of the victim.

Loss of labor by family member nursing the victim: This cost is as defined above. It may be a total or partial labor loss. It can be estimated at the wage rate of the family 'nurse' for the number of days taken off to attend the sick.

Increased farm production risk: Health symptoms may increase farm production risks. This is especially true in situations where the individuals who are most likely to be affected by pesticides (adults) are the same set of individuals whose contributions to household farm labor are critical to the farm. The level of production risk from health symptoms increases as the inter-dependence between the farm household and the family farm increases. Traditional farming communities would be expected to suffer more from greater farm production risks resulting from health symptoms than ‘modern’ farmers. To the extent that pesticides affect the health of household members, they create perturbations in the available labor resources which in turn introduces some degree of uncertainty in farm production. This may be uncertainty in household food security (for food crops) and/or income (for cash crops).

Cost of pain: This is the cost of pain, the deprivation of leisure and other uncomfortable dispositions that victims suffer from for the duration of health symptoms. This type of cost may be estimated with the technique of contingent valuation.

Pharmacy/drug cost: This is the cost of the purchase of drugs and/or the fees paid for medical test(s) that were carried out to heal the victim. In most cases in traditional farming communities, this cost refers to the self administered drugs that victims purchase within the immediate locality of the farmer. This type of cost is much easier to obtain directly from applicators.

Consultation fee: This is the cost paid for the services of a physician (on the few occasions) when farmers sought formal medical assistance. In a situation where the consultation fee is partly or wholly subsidized (as commonly observed in the rural community health clinics operated by religious bodies and humanitarian organizations), the fees charged may be compared with the competitive rates that are paid for the same services in private clinics located in the same region.

Transportation: This is the transport fare to and from the clinic/health center where medical consultation took place. This cost is relevant only for cases where the clinic is located outside of the victim’s village of residence. If a victim carries out other activities in the town — in addition to the medical consultation — the other activities must be accounted for (i.e. the transport fare be discounted) when estimating the proportion of the transportation cost that is attributed to the health symptom.

Material items used during home grown health cures: This is one of the most common health costs incurred by farmers. Farmers have devised various methods - drinking honey, lemon, palm oil, fresh milk, or a combination of these - which they perceive to be effective against poisoning symptoms. The cost may be estimated by using the market value of the item(s) that farmers consume in the process of the self cure.

Payment to traditional healer - cash or in-kind: Where village/traditional healers are consulted for medical assistance, payments are made in-kind rather than in cash[8]. Such payments may be valued by using the opportunity cost of the items exchanged or used up for the healing. Direct cash payment to local healers occurs less often, but where it exists, it may be added to the payment in-kind.

Traveling/waiting time at the clinic/traditional healer's home: This cost is estimated by first determining the total amount of the time spent on this activity. The time is then converted to monetary values by using the opportunity cost per unit time of all individuals affected, i.e. the victim and the family 'nurses'.

Resources required for preparing local healing mixtures: This is made up of the time and other resources required to fetch/prepare the items (e.g. herbs and other materials) that are used for local healing. The value of the firewood used for boiling the herbs may be included in this category of cost.

Cost of protective clothing: This is the total cost of purchase of all the protective clothing that applicators put on during spraying. The clothing referred to in this context are exclusively those that the farm worker puts on with the sole purpose of avoiding possible health symptoms from exposure to pesticides. Such items include hand gloves, mouth and nose protector, special spraying clothes. For a given season, the cost of the protective clothing may be estimated by depreciating the total cost of purchase of the items over their respective economic life-span.

Cost of protective consumables: This is the cost of materials that applicators drink as a preventive measure against intoxication, e.g. fresh cow milk.

In general, the estimation of some of the cost items mentioned above is

8 As a result of the strong social relationship existing among villagers, traditional healers in general, do not take money from victims for the medical assistance rendered. Nevertheless, the victim is responsible for the provision of the material items that may be required for the health care.

relatively straightforward. But others will require intensive monitoring to delineate the exact time and other resources that were spent on each activity/cost from other related activities.

8.3.2 Actual Expenses on Pesticide Health Symptoms by Households

Farmers who do not know about the harmful effects of pesticides sometimes overvalue their benefits and use more than is good for them or their communities (PINGALI et al. 1994). Such an information gap may exist when farm workers are unaware of the relationship between pesticides and health, or when they have only a *theoretical* knowledge of the relationship but it does not reflect in what farmers actually practice. But “once farmers are aware of the costs incurred due to pesticide exposure, the threshold levels that they use as decision rules to spray would increase further” (ROLA and PINGALI 1993: p. 63). In this section, the cost items associated with pesticides were first identified, and then followed by an assessment of the economic value of some of the cost items that the household actually incurred.

Households treat most of the pesticide-related health symptoms by using a combination of local and modern remedies. The factors that determine the type of health care that a household uses are the severity of the symptoms, the duration of the symptoms and the amount of costs involved. Other factors are the proximity to the health center and the ease (speed) with which assistance can be obtained from the health providers. The details on the expenses incurred as a result of pesticide related health symptoms by the households were monitored and are presented in Table 8.9. The costs are based *exclusively* on the households where at least one health symptom was reported by a pesticide applicator during the spraying season. The costs are based on pesticide applicators only. They do not include the health costs of non pesticide sprayers within the household or of non-household members who may have been affected during pesticide operations. The data used for the computation of the health costs have already been described in Section 4.3.

Table 8.9: Average pesticide-related health costs of households who report at least one health symptom during the pesticide season

Description of cost	**CFA/household***
Partial labor loss**	1153
Complete labor loss**	351
Local healing expenses (cash and in-kind)	0.7
Transportation	51
Medical consultation	330**
Drugs or pharmacy expenses	273
Total	**2159**

* Computed at the normal rate of medical consultation fee charged by private physicians (generalist).

** The cost of the complete labor loss is computed at the average daily wage rate per day for all the days that pesticide applicators took to rest at home as a result of the pesticide health symptom. The cost of the partial labor loss is computed at an equivalence of one third (33%) of the daily wage for each day of labor productivity impairment, i.e. one third of productive labor is lost to the health symptom.

Source: Computed from the author's own field data

The economic value of the expenses related to the health costs of pesticides is 2160 CFA per household. The cost is computed only for households that paid attention to pesticide-related health symptoms and which incurred at least one type of cost during the farm year. This figure needs be interpreted with caution for two important reasons:

(i) The figure represents only the cost items that were measured by the available data for this study. It excludes other costs which have been identified during the course of this study but which could not be measured for methodological reasons.

(ii) The cost is computed exclusively for the health symptoms that pesticide applicators reported based on their present perception of pesticide-related health symptoms, i.e. the *actual* cost that they incurred based on applicators' current perception. It does *not* refer to the cost that is required to restore their health status to the normal level.

As seen from the above table, the direct out-of-the-pocket expenses constitute only 18% of the estimated total health costs. The low proportion of direct expenses tends to make households under-estimate health cost in their farm production decision making. It also appears to be a major reason why human health issues (arising from pesticide activities) are given little consideration in farmers' decisions on field activities that they do when they spray pesticides. Most households seem to take into consideration only the cost items in which they incur direct expenses, while they perceive of other non-direct costs as being non-existent.

8.3.3 Factors Affecting the Willingness of Households to Incur Expenses to Treat Pesticide Health Symptoms

Throughout the pesticide spraying season, some households made no expenditures for treatment related to the health costs of pesticide use, while other households reported health symptoms and incurred some costs during the season. In this section, the factors that influence the decision of the household to make expenses on pesticide-related health symptoms are analyzed.

Rather than a health cost function based on the health expenses that households would require to restore their health (i.e. if they had operated under perfect information) the health costs in the present study have been estimated based on the health expenses that households *actually* made. Households are thus divided into two groups: those who reported and incurred health costs during the season and those who did not at all. The dependent variable of the health cost function thus takes a binary form, i.e. 'households that did not invest in human health at all' and 'households that incurred some costs on health'. The regression of dichotomous variables may take the probit or logit functional form. The logit model is often preferred because of its relative simplicity and ease of interpretation (KENNEDY 1992, CHOW 1983). It was chosen in the analysis of this study. The logistic regression describes the relationship between a categorical response variable and a set of explanatory variables that can also be categorical or continuous variables (STOKES et al. 1995). The logistic regression may be extended to a category response variable containing more than two levels of qualitative outcomes. To analyze the factors that explain the decision of households to incur expenses on pesticide-related health symptoms or not, the model in equation (8.2) is specified.

The model was estimated with the aid of the logistic procedure of the SAS analysis software. The empirical model specification of the model is as follows:

$$HTH = f(LOCATION, SEG, CONTACT, QTY, DURATN, PERCEPTION, WTP, PRACTICE) \quad (8.2)$$

Where:

HTH= The dependent binary variable for presence or absence of health costs (1 for households that reported *and* invested in health and 0 for households that did not invest in human health at all).

LOCATION= Dummy for geographical location of the household (1 for long exposure region and 0 otherwise). The theoretical expectation is that health expenses will be higher in the region of longer pesticide use because households in the region cultivate larger cotton fields and use higher quantities of pesticides.

SEG= Socioeconomic group of the household. This variable is a qualitative categorization of households within each village as ‘lower’, ‘middle’ and ‘upper’ class respectively. The categorization is based on several wealth status indicators like the type of house (iron roof or thatched roof), material possessions (radio, bicycle, animal traction implements), size of field, etc. Theoretically, it is expected that richer households would incur greater expenses to mitigate against health symptoms because they are better placed to be able to afford it.

CONTACT= This is a *nominal frequency* of the exposure of applicators to insecticides. The variable is measured as the number of days that pesticide applicators in the household had contact with insecticides while spraying operations during the season. It is the nominal count of the number of times that the household member went out to spray. It must be pointed out that for many households, the variable ‘CONTACT’ is not synonymous with the number of pesticide treatments. This is because many households do not completely cover *all* the area of their cotton fields during each pesticide application regime (see the footnote overleaf for further details). It is expected that investment in health cost will increase as the frequency of human contact that household members have with insecticides increases.

QTY= Total quantity of insecticides that the household sprayed during the season (in liters). Theoretically, health cost will increase with the quantity of insecticides sprayed.

DURATN= Total period (number of hours) that applicators within the households were exposed to insecticide spraying during the agricultural season. It is a cumulative addition of all the time that was spent by pesticide applicators within the household during all the number of times that they had contact with insecticides. The variable DURATN does not have high correlation with CONTACT because CONTACT measures the *qualitative* number of times of spray during the season, while DURATN is the *quantitative* cumulative addition of the duration (in hours) of the exposure to pesticides throughout the spraying season[9]. Health cost is expected to have a positive relationship with DURATN.

PERCEPTION= This is computed as the percentage of the number of times that applicators judge symptoms to be serious (i.e. did something) relative to the total number of times that insecticides were sprayed by household members (CONTACT) during the season. To 'do something' is interpreted in this context to mean the times when applicators incurred direct and indirect mitigation costs or when they took some period off to rest because of health symptoms. The actual health expenses that are made by households are expected to increase with PERCEPTION.

PRACTICE= This is an average index to measure the level of the health risk associated to the field spraying practices of pesticide applicators. The variable is 'field practice risk index'. It provides information on the household's level of knowledge on pesticide-health linkages and the risk of exposure to chemicals. Four exposure indices are used in this study based on the field level practices of applicators during spraying operations. For simplicity, the exposure indices were weighed equally.

Protective clothing: This indicator is scored 1 when the applicator did not wear any protective clothing during insecticide spraying and 0 otherwise.

[9] Each farm year, it is common for households to prepare land for their cotton fields in a staggered manner, i.e. in piece-meals, with some parts of the *same* cotton field being prepared before the others sections. The planting operation follows the same trend accordingly. This staggering of farm operations is often because of the need to prepare land for different crop fields at about the same time, immediately at the onset of the rains. As a result, the cotton crop in some parts of the *same* field attains different stages of growth at any given time. This often requires that the different sections of the same field may be sprayed at different times, i.e. spraying the field more regularly, at shorter intervals but in which only a section of the field and a small quantity of insecticides is sprayed at each time.

Caution of wind: This indicator is scored 1 when applicators did not pay special attention to wind direction before they began to spray and 0 otherwise.

Wind speed: This indicator is scored 1 if wind speed was high when applicator sprayed pesticides and 0 otherwise.

Activity during spray: This indicator is scored 1 if applicator ate, smoked or drank while spraying chemicals.

It follows therefore that a high score on PRACTICE implies that applicators have a high risk to be exposed to pesticides and health symptoms due to their risky field level pesticide spraying practices. The results of the logistic regression on the actual health expenses made by the households are presented in Table 8.10.

Table 8.10: Results of the logistic regression for household's health cost behavior

Variable	Coefficient	Standard Error	Wald Chi-Square	Pr > Chi-Square
INTERCEPT	-1.932	2.306	0.702	0.402
LOCATION	-2.226	1.019	4.775	0.029
SEG	0.387	0.441	0.769	0.381
TRT	0.065	0.108	0.361	0.548
QUANTITY	-0.051	0.044	1.344	0.246
DURATN	0.049	0.035	1.911	0.167
PERCEPTION	0.063	0.025	6.261	0.012
PRACTICE	-0.283	0.083	0.124	0.725

Source: Computed from the analysis of health monitoring data

The results show that two variables are significantly associated with the probability that a household will spend money on health symptoms. These are the time of households using pesticides (i.e. geographical location) and the perception (including the knowledge) of the household on the linkage between pesticide exposure and human health. The significance of PERCEPTION is consistent with theoretical expectation. As the farm workers' perception on pesticide-related health symptoms improves, the proportion of health symptoms that they would evaluate as 'serious' (i.e. beyond stage one) will most probably increase. As a result, the odds are higher that the household will incur more health expenses.

The negative sign of the LOCATION (dummy) variable implies that the probability that a household in the long exposure (LH) region would make (direct) expenses on pesticide health symptoms is significantly lower. As shown in Table 8.11 below, households in the LH region invest considerably lower amounts on pesticide-related health symptoms, even though they use higher quantities of insecticides than households in the less exposed (SH) region.

Table 8.11: Pesticide use and human health cost by geographical location

Health cost and insecticide used	Region		Pr >F	Overall average
	Long exposure region	Short exposure region		
Actual pesticide-related health expenses per household [CFA]	1164	2892	0.0040	2160
Total insecticides applied per household [liters]	35.26	12.32	0.0003	22.06
Cumulative average total active Ingredient used per household [kg]*	9.81	3.18	0.0001	5.99
Actual health cost per active ingredient used [CFA/kg]	264	1302	0.0001	862
Actual health cost per the value of insecticides sprayed [CFA/CFA]	0.02	0.09	0.0001	0.06

* Households in the long exposure region use considerably higher quantities of insecticides because they cultivate bigger and multiple number of cotton fields than the households in the short history region.

Source: Computed from the field monitoring and health expenses data.

The result of the logit model appears puzzling initially because theoretically it would be expected that health expenses should be higher in the long exposure region due to the higher pesticide use. Subject to further examination, the following three hypotheses may be proffered in the interim as possible explanations for the paradox observed in pesticide use and health costs in the study area:

- Households in the long exposure region are less exposed to pesticides because they spend more money on protective clothing. As a result, the households are less affected by health symptoms that are associated with spraying of pesticides, this makes them to incur little health costs, OR
- Households in the long exposure region are less exposed to pesticides because they have learned (through their long experience with pesticide spraying) how to avoid being exposed to the chemicals, OR
- Households in the long exposed region think less of the health symptoms and so do not regard them as a problem. Pesticide applicators pay little or no attention to these symptoms and so they are not regarded as a cost. The households may have developed more home-grown methods to treat pesticide health symptoms given the long experience that they have acquired over the years.

The first hypothesis can be rejected because the bio-medical tests for exposure (Section 8.2) do not suggest that farmers in the long exposure region are less exposed to pesticides. Similarly, the second hypothesis may not be accepted because the results presented in Tables 8.6 and 8.7 respectively show that there is no difference in the level of ‘carefulness’ during pesticide field spraying activities for the applicators across the two regions. A comparison of changes in cholinesterase enzyme across the two regions suggests that on average, enzyme activity is much more significantly reduced for the applicators in the long term region (22.3%) compared to 17.6% in the short term region (Pr > T=0.065). The third hypothesis — i.e. that households tend to accept health symptoms and pay less attention to them — appears to be more plausible to explain the observed differences in health costs across the two regions of the study. Each of the hypotheses is carefully examined and discussed in detail in Section 8.4.

8.3.4 Determinants of the Actual Amount of Pesticide Health Expenses

Further to the previous section which analyzed the decision of households whether to make expenses on health symptoms or not, it is necessary to understand the factors that determine the *amount* of expenditures on pesticide-related health symptoms that households incur during the agricultural season. This task is the main objective of this present sub-chapter. To do this, a regression model was fitted *exclusively* for households that invested in health. A log-linear function was specified as follows:

LnHC = f(LOCATION, SEG, LnTRT, LnQTY, LnDURATN,
LnPERCEPTION, PRACTICE) (8.3)

Where:

Ln HC= Natural log of the amount of health cost that the household actually incurred on pesticide-related health symptoms during the season [CFA].

LOCATION= Dummy for geographical location, as defined above.

SEG= Socioeconomic group of the household, as defined above.

LnCONTACT= Natural log of CONTACT, as defined above

LnQTY= Natural log of QTY, as defined above.

LnDURATN= Natural log of the DURATN variable defined above.

LnPERCEPTION= Natural log of PERCEPTION, as defined above

PRACTICE= As defined above

Table 8.12: Determinants of household expenditures on pesticide health symptoms

Variable	Coefficient	Pr>T
INTERCEPT	0.0440	0.9705
LOCATION	-0.2653	0.4482
SEG	0.0276	0.8385
LNTRT	0.8344	0.0054
LNQTY	-0.4293	0.2997
LNDURATN	0.8318	0.0491
LNPERCEPTION	1.2100	0.0001
PRACTICE	-0.0999	0.6473
F Value= 19.52	**Pr>F = 0.0001**	**R-square = 58%**

Note: The sample used for the above computation consisted of the 106 households where at least one health symptom was reported by pesticide applicators and positive expenses incurred on symptoms during the spraying season.

Source: Computed from the field data

The results indicate that among households that incurred some health expenses, the significant factors that affect the amount of health/medical expenses that households actually made to cure symptoms are as follows: the number of days that a household had contact with insecticide sprays during the season, the duration of exposure to pesticides and the applicators' perceptions on pesticide-related health symptoms. As the frequency with which households have contact with insecticide spraying increases, the amount of health expenses that such households make on symptoms increases significantly. In principle, all the households should have the same number of CONTACT with pesticides because the same prophylactic regimes (six sprays) are recommended for cotton fields in the two study regions. The households that have higher CONTACT with insecticides must be those who sprayed their fields more frequently. They are most likely the households that staggered the insecticide spraying operations in their fields, i.e. those who spray only a part of their cotton fields at each time. For such households, the interval between spraying operations is shorter, and hence applicators are exposed to insecticides more frequently. The practice of spraying only a portion of cotton fields helps farmers to reduce the quantity of chemicals that they use, but it nevertheless increases their health costs. Improvements in the farming systems to ease the pressure of farm labor demand in the crop fields cultivated by the household at the onset of the rain will have a positive effect on reducing the staggering of cotton planting. In turn, it will most likely reduce the present frequent exposure to pesticides, and also reduce pesticide-related health costs.

The results further show that health costs increase in tandem with the total number of hours (DURATN) of exposure to insecticides. Increases in the duration of exposure could be due to the size of cultivated cotton fields and/or from increases in the frequency of application, as explained above. The PERCEPTION of farm workers (i.e. the threshold level of the acceptance level of health symptoms) also significantly affects health costs. The lower the acceptance level, the higher is the likelihood that applicators will quickly regard a health symptom as a 'stage two' case and thus it is more likely that they will make conscious efforts to take care of the symptoms, thereby incurring health costs.

The results also indicate that among households that incurred health expenses, those in the long exposure region spent less on health symptoms than households in the short exposure region. The possible explanations for this have been highlighted earlier and will be discussed in more details in

Section 8.4. Contrary to theoretical expectation, the total quantity of insecticides that households sprayed was not found to affect actual health expenses. Given that households in the long exposure region cultivate larger cotton fields and use more insecticides, the non-significance and the negative sign of QTY may be due to a stronger influence of the attitudinal/behavioral differences among households in the two geographical locations. The results further suggest that expenditures increase together with the socio-economic and wealth status of households. This implies that households that enjoy a certain minimum level of wealth are more likely to give more thought to the expenses related to health symptoms because they can afford them. On the other hand, poorer households tend to give more attention to how they can reduce indebtedness on pesticides rather than health consideration issues. The attitude of the latter group of farmers is concisely summarized in the words of one of the farmers in the study area as follows: "…reading the labels on pesticide containers or issues on pesticide health symptoms are not as important as getting the money to pay for the chemicals". Underlining the linkage between economic status and health impairment aversion, a study in Asia indicates that respondents who consider the price of a commodity as a very important factor in their purchase decision are less willing to pay for lower health risks (FU et al. 1999). The same study also suggests that higher income consumers demand and can afford higher quality (i.e. less health risk) products.

The result of this present study also shows that households whose members engage in more 'risky' pesticide spraying practices spend less on pesticide health symptoms. This result appears surprising because theoretically, one would expect that 'risky' field practices would increase the risk of exposure to chemicals and also increase health costs. The result may signify an information gap among farm households: households who engage in practices that expose them to higher risks are most likely to be the same set of households who have a low level of information and wrong perceptions on pesticides–health symptoms linkages. Such households would include those who give low priority to health considerations because they want to minimize production costs (e.g. farmers who spray when the wind speed is high because they want to reduce the quantity of pesticides that they use). Despite the higher health risks that they face, applicators in such households are most likely to have a higher threshold (higher acceptance level) for health symptoms before they decide to take special care that involve direct expenditure of money. It is most likely that the same factors that make households to be less careful regarding field practices that expose them to health risks will also make them to pay less attention to health expenses that arise from such practices.

8.4 Discussion on Pesticide Exposure and Actual Health Expenses

The pesticide use patterns and results of laboratory and biomedical tests suggest that households in the long exposure (LE) region are *more* exposed to pesticides than their counterparts in the short exposure (SE) region. Similarly, on average, households in the LE region use more than twice the quantity of pesticides used by households in the SE region (see Chapter 7)[10]. Theoretically therefore, the health expenses on pesticide-related symptoms by households in the LE region would be expected to be higher compared to the SE region. Given that there is no evidence to suggest that households in the LE region are less exposed to pesticides, therefore the lower level of the *actual* expenses on pesticide health symptoms by the households in the LE region cannot be attributed to better precautionary measures or better spraying practices by applicators.

The explanations for the low health expenses made by households in the LE region in particular and the whole study area in general are provided below.

- The differences in health costs may be due to the perception and the willingness of households in the two regions to incur actual and direct expenses on pesticide related health problems. As the number of years of pesticide spraying in a region increases, pesticide applicators tend to think less of the health symptoms that are associated with it and so it is not a 'cost' to them. With time, health symptoms are perceived as 'normal occupational hazard problems' that applicators should expect each time they spray pesticides. This raises the threshold of pain (and the duration) that must be associated with a case before the symptom is *perceived* as 'above normal', i.e. from stage one to stage two. This comportment appears not to be exclusive to households in the study area. In a recent study, KISHI et al. (1995: p. 131) report that pesticide applicators in Indonesia "tended to accept (a certain) level of illness as part of the work of farming".

- Farmers in the study area tend to consider only fatal cases and acute symptoms, but they discount chronic effects of pesticides on their health. In

[10] This is essentially because the average cultivated area of cotton field per household is twice as large in Korhogo as in Katiola region.

the KAP survey of this study, farmers reported that there were severe pesticide poisoning cases - including deaths - in the past especially when chemicals were newly introduced, but that severe cases generally decreased over the years[11]. In relative terms, the contemporary acute health symptoms that are associated with pesticides appear to be relatively less serious to some farm workers. A reason for this comportment is because “acute toxic effects are fairly recognized, whereas the effects that result from long-term exposure to low doses are often difficult to distinguish” (WHO 1990: p. 33). A major reason why farmers tend to discount chronic health problems may be due to the inability of farmers to associate pesticide use with the chronic health effects of long term exposure to pesticides. The cause-effect relationship for acute health symptoms appears to be more apparent to farmers than chronic symptoms are (ANTLE, COLE, CRISSMAN 1998). The perception of farm workers regarding pesticide-related health problems has some impact on how they react to illness.

- The elimination of the free distribution of anti-intoxication drugs in the study region makes farmers assume that they are now well enough skilled to avoid health problems when spraying pesticides, even though this is not necessarily true. In the past, anti-intoxication drugs were provided free of charge to pesticide sprayers in the cotton zones to reduce the effects of pesticide poisoning symptoms[12]. A study by RICHARDI (1992: p. 39) on pesticide use in the same study area in Côte d’Ivoire found that “in Korhogo zone of CIDT (i.e. the LE region of this present study), all the stocks of atropine sulphate drugs that were supplied were always exhausted each year”. This is an indication that pesticide poisonings were highly prevalent in the region.

- The long period of intensive use of pesticides has given rise to some home methods for treating pesticide symptoms. Most of the materials used are obtained locally (often within the household). Households generally perceive such materials to be free of charge because they are obtainable

[11] The fatal poisoning cases from pesticides in the past made insecticides to be known locally among farmers as *‘poison’*, a name which it retains still today and which farmers use when they want to distinguish between insecticides and herbicides.

[12] Drugs were supplied in the village health centers from where applicators may collect them whenever a case of pesticide intoxication occurred. This assistance has since been eliminated, but it appears that farmers do not know exactly why.

without making any direct cash expenses. The low cost associated with the home grown cures tend to discourage farmers from seeking ‘costlier’ remedies in formal health centers.

- The knowledge/awareness of farm households on pesticides and health problems can be described as being nominal only because their knowledge is not reflected in the field level practices on pesticides. Although some of the field practices of households suggest that they are aware of possible health effects linked to pesticides but, when they have to make a hard choice between the (indirect) health costs and other direct production costs, farmers tend to sacrifice the former for the latter. Similarly, households attach a greater premium to avoiding financial losses (through direct health expenses) than they do to indirect impact of pesticides on the health of their members. This reason underlines the concerns that farmers mentioned that pesticides currently available are weaker and are not as ‘strong’ as the ones that they used in the past. This concern led to fear that if the households complain too much about pesticide-related health problems, the toxicity of the chemicals may be weakened further. This will force households to use higher quantities of pesticides to protect their crops, i.e. higher production costs for them.

8.5 Summary of Pesticide Use and Human Health

Although the level of awareness of farm households on health impacts of pesticide use is low, this study has established that there are some human health problems associated with pesticide use. Farm households in northern Côte d'Ivoire do incur some direct and indirect health costs. Some of the costs have been estimated but others were only identified qualitatively. Assessing the latter types of cost items will require an improved methodology and more intensive monitoring. This is especially important for cost items for which the level of farmers’ awareness is particularly low.

The field practice of pesticide application is probably the closest indicator of farmers’ level of knowledge on pesticide health issues. Given the low level of awareness on pesticide and health cost among farmers in Côte d’Ivoire, the under-estimation of health costs in production decisions most probably leads to sub-optimal decision-making by the household on the use of pesticides. Thus, the household’s level of awareness and knowledge are key issues that should be addressed by agricultural extension services in the study area to attain optimum pesticide use.

8.6 Conclusions on Pesticide Use and Human Health

This study concludes that the present level of actual expenses on pesticide-related health costs by households is influenced by the information gap and the perception of pesticide symptoms among the farming community. The household's level of knowledge regarding pesticides and health symptoms is indicated by the high percentage of spraying operations that are done by individuals from *within* the households. It is expected that as households increase their knowledge on pesticide-related health issues, the proportion of pesticide spraying activities by household members will most probably decrease while that of non-household members will increase. In addition, an increase in the awareness of households on pesticide-related symptoms will most likely lead to a higher wage rate for pesticide spraying operations to reflect the health risk. The latter situation occurs presently in some countries, like e.g. Thailand (S. PRATANETVATUKUL, personal communication)[13].

Compared to the results obtained in other studies such e.g. in the Philippines (ROLA and PINGALI 1993), the ratio of health cost to pesticide cost that is obtained in this present study is conservative. This is primarily because the computation of health costs in this study is based on the expenses that farmers *actually* incurred based on the current level of knowledge and perception of farmers. It does not refer to the costs to restore farmers' health status completely (i.e., if farmers would have perfect knowledge of pesticide health cost). It is expected that the proportion of health costs to total pesticide costs will increase as the farm households' level of awareness and knowledge of pesticide-related health symptoms increases. Using the health cost per pesticide cost ratio obtained in the Philippines as a reference, the results of this present study may be interpreted as an indicator of the actual perception or the willingness of households to pay (WTP) for health symptoms in northern Côte d'Ivoire. It is also an indicator of the knowledge and awareness of farmers on pesticide health issues.

[13] Presently, the wage rate in Côte d'Ivoire is determined by the level of drudgery associated with a given farm operation and virtually no consideration is given to health issues inherent in the various operations.

9 Conclusions and Recommendations

The main objective of this study is to estimate the marginal product of insecticides in production systems with different levels of crop intensification including the time that chemicals have been used. Secondly, the study seeks to provide answers to the following questions: “Are there human health costs associated with the use of pesticides in agricultural households in Côte d'Ivoire?” If yes, “What are the main health problems and how can their costs be quantified in economic terms?” The third objective is to analyze the current crop protection practices with view to determining the prospects and the constraints to improve crop protection strategies (e.g. the integration of non-pesticide methods) at the farm level in the region.

Some recommendations based on the results of this study have been presented in earlier chapters. In this chapter, succinct conclusions on the results of the study are presented. Technical and policy recommendations to improve the present situation of crop protection in the study area are suggested. Finally, areas for further research are identified.

9.1 Conclusions

9.1.1 Conclusions on Pesticide Productivity

In accordance with previous studies, the marginal value product of insecticides obtained from the Cobb-Douglas and alternative damage functional specifications (except Weibull model) are consistently greater than unity. In a strict economic interpretation, this implies that farmers should use higher quantities of insecticides in their cotton fields than they are doing presently. The Weibull model suggests that farmers are over-using pesticides, but the model does not exhibit a conclusive statistical superiority over the other specification models. It is concluded that changing the functional specification of production models *alone* may not explain *all* the paradox observed in the economic estimates obtained regarding pesticide use at the farm level. However, productivity figures of pesticides obtained from production functions within a (theoretical) framework of inter-temporal degradation of natural biological resources of production systems caused by previous use of pesticides, become comparatively more plausible for economic interpretation.

The alternative specifications of the damage function show a lower marginal product of insecticide use. While the level of insecticides used by cotton farmers is economical, there are indications of a decrease in the effectiveness of insecticides. The regression coefficient for insecticides in the region where these chemicals were used for a longer time was lower compared to the Short History cotton region. The value of cotton production is comparatively *less* responsive to the application of insecticides in the Long History region where chemicals have been used for a longer period of time. The result indicates a gradual build-up of pest resistance to pesticides over time within the cotton production system.

All five alternative model specifications provide consistently higher marginal productivity estimates for insecticides in the production system with a longer history of pesticide use. Two reasons are given to explain why the estimates of insecticide productivity are higher in the Long History region compared to the Short History region. The first is the possibility of a higher yield potential of cotton production in the Long History region. The second is that the insecticide productivity estimates represent a *net effect* of the influence of both the presence of pest resistance and changes in biodiversity over time. While pest resistance tends to reduce the productivity of insecticides, the reduction in biodiversity of the production system leads to an increase in the productivity of insecticides. The results do not yet provide conclusive evidence for the existence of technological path dependence of pesticides in Côte d'Ivoire. The marginal product of other farm inputs (fertilizer and labor) are different across the regions where cotton was cultivated for a different period of time.

9.1.2 Conclusions on Pesticide Health Costs

There is evidence that human health problems are associated with the use of pesticides in agricultural households in the study area. The health costs of pesticides for farm households are multi-dimensional. The costs include damage costs, mitigation costs and avoidance costs. Pesticide applicators are exposed to the risk of acute poisoning that is linked to pesticide spraying activities. Household members who spray pesticides have a four times greater risk of falling sick than an average member within the *same* household. The bio-medical and laboratory tests indicate an exposure to pesticides among pesticide applicators. With the presence of pesticide residues on clothes of applicators and the evidence of a lower cholinesterase enzyme activity among applicators, a 'cause and effect' relationship between pesticide spraying activities and human health symptoms is supported.

Farmers are recognizing pesticides as one important causes of ill health, but over the years, some of the symptoms have been accepted as an 'integrated' part of spraying pesticides. Only in 2% of the cases linked with pesticides do household members visit official health centers for medical consultation or seek formal medical assistance. The official records of pesticide poisoning in the study area are most likely to be under-estimated.

The awareness of pesticide applicators on the potential dangers of pesticides to human health does not appear to have great impact on field practices of pesticides spraying. When farm households are faced with a hard choice between (indirect) human health costs associated with pesticides and (direct) increase in farm production costs, households tend to give greater priority to the latter. Due to the subjective evaluation of human health costs based essentially on the present perception of households, pesticide-related health costs tend to be under-estimated in the decision making. As a result, the amount of farm production that households are ready to forego for human health consideration is quite small. The amount of income that households are willing to forgo (or the expenses that they are willing to incur) for pesticide-related health consideration is also low. Two issues that are important in pesticide health costs among farmers in Côte d'Ivoire are information and low economic status. The negative human health effects of pesticides lower the economic value of chemicals at the household level.

9.1.3 Conclusions on the Situation Analysis of Pesticide Use

The long years of free pesticide distribution have influenced the course of evolution of agriculture in northern Côte d'Ivoire. Some of the long-term structural impacts of the policy on the farming systems still remain. While the free distribution of pesticides has been eliminated (since 1994), the current policy of credit financing of pesticides by the quasi-state cotton agency still tends to reinforce chemical crop protection technology over alternative methods. Cotton remains the pivot around which pesticide use and practices in northern Côte d'Ivoire revolve. For some years to come, the 'Long History' region and the adjoining core of savanna zones will remain the bastion of cotton production and pesticide use in Côte d'Ivoire.

Farmers respond to economic policies in making decisions on pesticide use. There has been a reduction in the quantity of pesticides that they use on all crops since the elimination of direct subsidies on pesticides, i.e. farmers' reaction is price elastic. The level of pesticide mis-use and the cases of unauthorized re-sale of pesticides (which were serious problems in the past) have declined in reaction to higher prices of pesticides.

The long period of free distribution of pesticides and the scope of available information did not allow many farmers to have a reasonable level of awareness about other non-pesticide crop protection methods. As a result, farmers regard pesticides as a ‘reference point’ against which they evaluate other crop protection methods. There are existing opportunities in the study area to integrate other methods (e.g. IPM technology) into the present crop protection strategy. These opportunities include the demonstrated technical feasibility of IPM in several studies that were carried out on major crops grown in the study area. There are also potential opportunities for a mass mobilization of the farming community through the prevailing social system and the existence of farmers’ cooperative groups in almost all the villages. In addition, due to the new pesticide price policy and the present perception of farmers that pesticides are less effective than before, there are indications that the farming community in the region will be more receptive to ‘new’ crop protection methods now than they have been hitherto.

The results of this study show that technical feasibility and superiority of alternative crop protection methods over use of pesticides are necessary conditions, but not sufficient in themselves to persuade farmers to use the new methods. Despite their demonstrated superiority, the failure of previous attempts to encourage farmers in northern Côte d'Ivoire to adopt crop protection practices that are less chemical dependent can be traced to agricultural policy (free distribution of pesticides) that inadvertently discouraged farmers to do so. Economic policy and the relationship between inputs and output prices are two of the principal potential driving forces for the adoption of crop protection practices in northern Côte d’Ivoire.

9.2 Recommendations

The following recommendations are made based on the major results emanating from this study.

- The current official recommendation, requiring that the same standard quantity of farm inputs is used per unit cultivated field across the entire cotton producing region is inappropriate. This policy may lead to allocative inefficiencies of input use in some zones. A more appropriate recommendation would take cognizance of the relative historical period of cotton cultivation and changes in the level of the natural resource capital.
- Biological indicators of pest resistance (e.g. LD50 test) need to be closely monitored in the study region. To be more appropriate, the monitoring

results should be analyzed separately for the different agro-ecosystems (based on the history and intensity of pesticide utilization), rather than being aggregated for all the cotton regions. Time series information on the rate of change of biological indicators across the different agro-ecosystems will be important.

- In addition to biological monitoring, a shift towards crop protection strategies that conserve biological capital resources of the production system should be pursued. This would be necessary to ensure the profitable production of cotton in the region on the long run.
- A mechanism to facilitate a formal documentation of pesticide poisoning cases in the study area should be put in place. This may be done by giving free medical assistance to all applicators that approach medical centers seeking for health assistance on pesticide-related health problems. The costs for the free medical services may be recovered from an appropriate tax imposed on the particular brand(s) of pesticides that is/are responsible for the poisoning cases.
- An inventory and formal documentation of the various indigenous crop protection methods that have been used in the region should be carried out. Research will be important to evaluate indigenous methods on a case-by-case basis, for a possible adaptation and integration into the crop protection strategy for the region.
- The existing crop protection strategies in Côte d'Ivoire should be improved through use of appropriate economic instruments and economic policies.
- The health of household members could be improved by taking advantage of economic instruments in policy making for crop protection in the region. An approach to do this is by implementing a tax on pesticide sales. The funds generated from this could be used to finance research on crop protection technologies that have less negative impacts on farm workers' health.
- Efforts towards the harmonization of pesticide registration and crop protection policies on a larger geographical scale (e.g. sub-regional level covering several related countries) will become increasingly important in the near future[1]. This recommendation is pertinent because at present, the

[1] An example is the *Comité Sahelien de Pesticides* (Committee for Pesticides in the Sahel). This committee is a sub-regional body responsible for the registration of all pesticides in nine countries

success of crop protection policies and pesticide use in a given country is affected by the policies of its neighbors. A large proportion of unofficial cross border trade with pesticides that has occurred in the past could be traced to national policies and institutional mechanisms that are more favorable to pesticides in some countries than in others. Wide pesticide policy differences across neighboring nations will most likely resuscitate unofficial pesticide transactions. Moreover, the integration of national crop protection policies on the sub-regional level would provide the necessary synergy to the participating countries.

9.3 Suggestions for Further Research

It is suggested that in future studies, detailed information about the state of agro-ecosystem that are studied should be collected concurrently with the agro-economic data that are used in the econometric models to estimate the productivity of pesticides. Agro-ecosystem data should include entomological surveys of predators and pest species, LD50 tests, and soil fertility tests in the fields/regions where economic production data were collected. Apart from increasing the explanatory power of the models, the agro-ecosystem data will assist in the interpretation of the estimates obtained from the economic models.

Efforts should be made in future studies to isolate the influence of pest resistance and changes in biodiversity on the productivity of insecticides in the different regions that have been exposed to pesticides for different historical periods.

In future studies, particular attention should be paid to specific issues in the measurement of health costs of pesticides among rural households. The first issue is how to incorporate the cost of chronic health effects of pesticides into the economic evaluation of pesticide use. Presently, some farm households do not take cognizance of the long term health effects of pesticides in making farm production and pesticide use decisions. The second issue is that acute health symptoms are under-reported. In this present study, different groups of applicators have been identified in terms of their reactions to acute health problems. The extent of under-estimation of health costs of acute symptoms will depend on the relative proportion of applicators that belong to each group.

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of West Africa. The participating countries include Chad, Niger, Burkina Faso, Mali, Guinea Bissau, Senegal, Gambia, Cape Verde and Mauritania.

The three groups of farmers are:

- pesticide applicators who reported health symptoms and incurred some costs in the efforts to cure the health problems identified.

- pesticide applicators who did *not* report health problems, because they had incurred some costs in their efforts to mitigate against possible health problems (e.g. by spending money on protective clothing) and so they did not have any health problem;

- pesticide applicators that did *not* report any health symptom, and therefore did not incur health costs either because:
    - there was really no health problem,
    - there were health problems that the applicator should have addressed but did not either because of lack of awareness of the health problem or because of lack of alternatives, i.e. the applicators accept the health symptoms as ‘normal’ effect of pesticide spraying.

The estimation of health costs for the first group is easier and more straightforward. In principle, the estimation of health costs for the second group of applicators appears to be easy with just adding up the purchase costs of the different protective clothing used. As is often the case among farmers however, when a given protective clothing provides a multi-purpose protection for pesticide applicators in the field, the part of the purchase cost that can be attributed uniquely to health protection may become ambiguous. An example is how to impute the cost of a rubber boot that a pesticide applicator wears to protect himself, not only against exposure to chemicals but also against snakes! The methodology to quantitatively estimate human health costs associated with the third group of pesticide applicators in the context of rural households in developing countries needs to be further improved.

10 Summary

In Chapter **one**, the background of this study is presented. The statement of the problem underlining the research and, the objectives of the study are discussed.

The theoretical background of the study is discussed in Chapter **two**. The available literature is reviewed to determine how the productivity of pesticides has been estimated in previous studies. The review highlights the paradox that exists in the results of previous economic studies on pesticide productivity (which indicate that a higher quantity of pesticides should be used than is being done currently) and how these estimates differ from anecdotal observations that suggest that pesticides are already overused. The risk reducing characteristics of pesticides — which are identified in some studies as the reason for the paradox — are reviewed. It was noted that the explanation based on risk factors has not been conclusively supported in the literature. The argument that the paradox in the estimation of pesticide productivity can be explained by modifying the functional specification of production models was discussed. The review of empirical studies that have tested the suggested alternative production models did not conclusively attribute all the paradox to functional specifications alone. Questions on some of the missing links to explain the paradox in the analysis of pesticide productivity are raised.

Some of the ‘missing links’ that were identified include the inadequate consideration of the natural resource degradation effects of pesticides. An explanation is provided on how the change in the natural resource base (i.e. biological capital) of an ecosystem leads to a transformation of the production system. The concept of path dependence is discussed, including an analysis on how inter-temporal production decisions on pesticide use affect the productivity of pesticides in different time periods. The chapter also discusses the impacts of agricultural and price policies on inputs and outputs and how these policies affect the estimation of pesticide productivity. In later sections of the chapter, the conceptual framework that is adopted for this present study is presented. The framework incorporates the implications of natural biological resource degradation into the estimation and the interpretation of pesticide productivity. The chapter also discusses the effects of pesticides on human health. It analyzes how negative health effects of pesticide use lower the economic value of chemicals at the household level.

The role of information and the awareness of farm households of the decisions on pesticide use are analyzed, with particular emphasis on farm households in the developing countries.

In Chapter **three**, an overview of the economic development, and the agricultural policies of Côte d’Ivoire is presented. The agricultural sector plays an important role in the overall economic development of Côte d’Ivoire. The agricultural sector is characterized by small-scale farming. A quasi-specialization in agricultural production exists among the geographical zones in the country. The increases that were recorded in national agricultural production in the past had occurred through the expansion of the cropped area rather than increases in yield productivity. Until recently, economic policies were more favorable for export crop production than for food crops. This study reveals the various price and non-price policies that play a vital role in the evolution of agricultural and crop protection development in particular in the country. The historical antecedents of northern Côte d’Ivoire and the various policies aimed at developing cotton production in the region strongly promote the use of pesticides. These policies created structural impacts on agricultural system, giving rise to mono cropping (i.e. reduced biodiversity) and to current crop protection practices, which are almost exclusively dominated by pesticides.

In Chapter **four**, the sampling technique, the methodology for data collection and the type of data collected are presented. It includes information on the stratification of the cotton growing zones by the historical period of pesticide use. The types of data collected and the procedure for the collection of the same are also presented.

In Chapter **five**, an overview of the geography, socio-cultural and agricultural economy of the study area is presented. It highlights how agricultural and pesticide spraying activities are affected by socio-cultural beliefs and practices of the people. Empirical analysis of households’ structure and characteristics shows that the level of formal schooling is low, and farming is the primary occupation in the study area. Almost all members of the same household share common blood relationship. There is a strong integral reciprocal relationship between the household and the farm, with the former providing almost 90% of all the labor required in the latter. Households cultivate multiple fields that are scattered in different locations. Most of these fields are small in sizes, generally less than five hectares, but on average cash crop fields are bigger than food crop fields. Most households grow both food and cash crops, and cultivate both upland and lowland fields concurrently. There are indications of a gradual reduction in crop diversity in the study area. As an example, only three field crops — cotton, rice and maize — make up about 80% of the total cultivated area in one of the study areas. Cotton that was a mere secondary crop about four decades ago has now emerged to be the most important crop in the present farming structure in the study area.

In Chapter **six,** empirical data on farmers' knowledge, attitude and practices on crop protection and on pesticides are analyzed. The data analyzed include indigenous practices on crop protection and sources (including the scope) of crop protection information available to the farm community. The analysis shows that cotton is the most pesticide intensive crop, with two-thirds of all the herbicides and almost all the insecticides being used on cotton alone. Farmers' field practices on pesticides also diverge from those that were recommended. As a reaction to the increase in pesticide prices, farmers adjusted their crop protection practices, especially by reducing the quantity of pesticides that they use on their crops. Farmers respond sensitively to pesticide prices. There are potential opportunities for the use of economic instruments in crop protection policy in the region. The perception of farmers on some aspects of crop protection differs from the reality. The perception of farmers on yield loss in cotton fields is about two times higher than the actual yield loss obtained in experimental fields in the same geographical area. The existing opportunities for the adoption of alternative crop protection practices in the region are identified. It is concluded that a good information and training program, backed up by conducive economic policies are part of the necessary conditions to improve the existing crop protection strategy to ensure less negative human health impacts.

In Chapter **seven**, the Cobb-Douglas model and alternative functional specifications of the damage function are used to estimate the productivity of pesticides (and other farm inputs) for cotton fields that have been exposed to pesticides for different periods. The Weibull model provides marginal productivity figures for insecticides that are congruent with anecdotal observations and more plausible for economic interpretation. However, statistical tests of this model did not confirm that it is superior to the other functional models. Marginal productivity estimates obtained from the Cobb-Douglas and the alternative specifications of the damage function are greater than unity — i.e. given a strict economic interpretation, the productivity estimates imply that farmers should further increase the level of pesticides they are currently using. Changing the functional specifications of production models *alone* may not explain *all* the paradox observed in the economic estimates obtained regarding pesticide use at the farm level. However, the economic interpretation of the estimates of pesticide productivity becomes less paradoxical if it is done within the dynamic framework of the degradation of natural biological capital resources of production systems that takes place over time. While the level of insecticides used by cotton farmers is economical, there are indications of a decrease in the effectiveness of insecticides. The regression coefficient for insecticides in the region where these chemicals were used for a longer time was lower compared to the Short History cotton region. The value of cotton production is comparatively *less* responsive to the application of insecticides in the Long History region where chemicals have been used for a longer period of time. The result indicates a gradual build-up of pest resistance to pesticides over time in the cotton production system. Comparing the productivity estimates for different production systems, the generic and all the damage function specifications consistently result in lower productivity estimates for the production ecosystems where pesticides have been used for a shorter period. While pest resistance tends to reduce the productivity of insecticides, the reduction of biodiversity in the production system over time leads to an increase in the productivity of insecticides. Insecticide productivity represent a *net effect* of the influence of both the presence of pest resistance and changes over time in the level of biodiversity. There is no conclusive evidence for the existence of technological path dependence on pesticides in the study area. The marginal value product of other farm inputs is also computed.

The empirical analysis of the effects of pesticides on human health and the awareness of farm households about these effects are presented in Chapter **eight**. The results show that farmers generally understand the meaning of some of the warning pictorials on pesticide containers, but their knowledge about other pictorials is poor. The study reveals that there are health risks associated with pesticide spraying activities in the region. The framework to identify pesticide-related health costs shows that the health costs consist of ‘damage’, ‘mitigation’, ‘avoidance’ and ‘unknown’ costs. The actual health expenses incurred by households on pesticide-related health symptoms, including the factors that affect farm workers’ decision to incur expenses on pesticides are computed. Comparative analysis of the reactions of farm workers to pesticide-related health symptoms and other illnesses is presented.

The bio-medical test shows that pesticide applicators have a higher risk of health symptoms than those who are less exposed to the chemicals. The probability to fall sick is four times higher among pesticide applicators than non-applicators who live in the same household. However, the level of awareness to pesticides is low as only in 2% of the actual pesticide poisoning cases do the victims ask for medical assistance in formal health centers. The official records of pesticide poisoning cases in particular (and health symptoms in general) in the study area are most likely to be under-estimated. Some of the practices of farm households suggest that they are aware of the potential health effects linked to pesticides. But when they have to make a hard choice between the (indirect) human health costs of pesticides and the (direct) production costs, farm households tend to accord higher priority to the latter. An information gap and the low level of economic situation are two of the important factors that influence the decision of farm households on pesticide use and human health relationship in the study area.

In Chapter **nine**, the conclusions of this study are presented and the recommendations to improve on the current situation are made.

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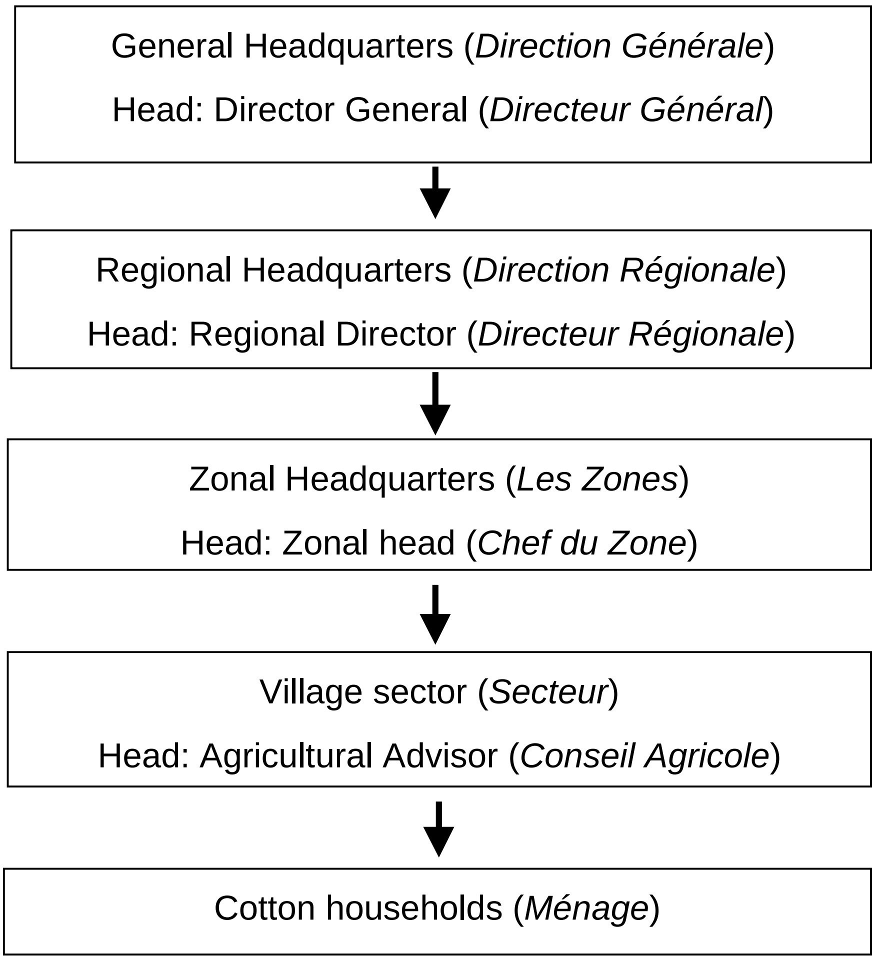
Appendix

Appendix 4.1: Administrative Structure of the Cotton Agency in Côte d'Ivoire



Appendix 5.1: Some Characteristics of Household Members in Northern Côte d'Ivoire

	Korhogo	Katiola	Overall
Level of education of household members	**%**	**%**	**%**
None	84	73	78
Primary school education	12	22	17
Secondary school education	3	4	3
Post secondary education and others	<1	<1	<1
Adult education classes	1	<1	1
Age of head of households	%	%	%
Less than 25 years	17	3	10
26 - 50 years	55	70	63
51 - 75 years	27	26	26
Above 75 years	1	1	1
Mean age of household head	40 years	43 years	41 years
Minimum age	17 years	21 years	17 years
Maximum age	78 years	84 years	84 years
Standard deviation	14 years	13 years	14 years
Primary occupation of household members	**%**	**%**	**%**
Farming	86	63	75
Schooling	6	16	11
Other jobs	1	4	2
None	7	18	12
Number of wives per household	**%**	**%**	**%**
One	53	77	64
Two	36	21	29
Three	11	01	06
Four	-	01	1
Household composition by blood relationship to family head	**%**	**%**	**%**
Nuclear family members	68	73	70
Extended family members	30	26	28
No blood relationship	2	1	2

Location of dwelling place of household members relative to the head of household

	%	%	%
Same dwelling unit, same village	87	91	89
Different dwelling unit, but same village	12	<1	6
Other nearby villages	<1	4	2
Other towns	1	5	3

Note: Except otherwise indicated, all the figures are in percentages

Appendix 5.2: Dependence Ratio among Households in the Study Area by Location of Study and Type of Farm Technology (in %)

Dependence ratio	**Korhogo**	**Katiola**	**Overall**	
1.00 to 1.49	50	25	38	
1.50 to 1.99	23	27	25	
2.00 to 2.49	18	18	18	
2.50 to 2.99	02	16	09	
3.00 to 3.49	06	08	07	
3.50 and above	01	06	03	
Average	1.6	2.0	1.8	
Standard deviation	0.6	0.7	0.7	
Dependence ratio	**Manual**	**Animal**	**Tractor**	**Overall**
1.00 to 1.49	37	40	25	38
1.50 to 1.99	23	27	75	25
2.00 to 2.49	17	21	-	18
2.50 to 2.99	12	03	-	09
3.00 to 3.49	07	06	-	07
3.50 and above	04	03	-	03
Average	1.6	2.0	1.5	1.8
Standard deviation	0.6	0.7	0.1	0.7

Appendix 6.1: Description of the Methods used by Farmers to determine the Direction of the Wind during Pesticide Spraying Operations

“**Plant leaves”** method: farmers observed the direction where the leaves of plants bend to when the wind blows on them.

”Flag/cloth” method: to use this method, farmers tied a piece of cloth or cellophane paper to sticks and install these in different locations in their field and check out for the direction to which the wind blows the cloth or cellophane paper.

”Machine vapor” method: this method is practiced exclusively when electric spraying machine is used and in this method. The farmer activates his equipment first to observe the direction to which the wind blows the fine soluble particles of the pesticide solution.

”Smoke/cigar” method: this is similar to the machine vapor method except that the pesticide applicator blows the fumes of his cigarette to observe the direction of the wind.

”Dust method” method: the pesticide applicator takes a handful of dust from the ground and allows the same to drop off while observing the direction that the fine particles go.

Appendix 6.2: Number of Insecticide Treatments in all the Cotton Producing Regions of Côte d'Ivoire when Insecticides were given free

13 – NOMBRE DE TRAITEMENTS

DIRECTIONS REGIONALES	Ignore le nombre de traitements	Moins de 5 traitements	5 Traitements	6 Traitements	7 Traitements	Plus de 7 Traitements
KATIOLA	1,75	1,75	8,78	50,0	31,58	6,14
BOUAKE **SE**	16,13	3,22	16,13	51,61	9,69	3,22
YAMOUSSOUKRO	0,0	0,0	0,0	12,29	71,92	15,79
BOUAFLE	0,0	14,11	16,66	44,87	20,52	3,84
U.A.C.	2,5	5,0	10,0	41,07	34,29	7,14
MANKONO	0,0	0,0	0,0	50,0	40,28	9,72
SEGUELA	0,0	0,0	5,88	76,47	13,24	4,41
TOUBA	0,0	0,0	10,87	43,48	32,61	13,04
ODIENNE	0,0	43,59	0,0	39,74	16,67	0,0
U.A.O.	0,0	12,88	3,41	52,65	25,0	6,06
BOUNDIALI	0,0	1,72	1,72	44,83	37,93	13,8
KORHOGO **LE**	0,0	0,0	0,0	41,67	55,0	3,33
FERKE	0,0	0,0	0,0	66,67	28,2	5,13
U.A.N.	0,0	0,64	0,63	49,05	42,04	7,64
C.I.D.T.	1,0	7,0	5,42	47,21	32,52	6,85

SE = Region of short exposure to & short use of pesticides

LE = Region of long exposure to & long use of pesticides

Source: Table 13 on page 9 of CIDT (1989)

Appendix 7.1: Formal Derivation of the Marginal Product of Pesticides for various alternative Specifications of the Damage Functions

The calculation of the marginal product of pesticide (X) in a damage function specification has been given in the main text as an implicit expression in equation 7.14. The same equation is written in an explicit equation in equations 7.15 through 7.18. This section of the appendix gives the formal mathematical explanation of how the explicit forms of the equation were derived.

First, if the functional form is specified as a **Pareto function**, then G(x) can be written explicitly as:

$$G(x)= 1-k^{\lambda}X^{-\lambda}$$

It follows that

$$\frac{\partial G(x)}{\partial X} = -k^{\lambda}(-\lambda)\,X^{-\lambda-1}$$

$$= \lambda k^{\lambda}\,X^{-(\lambda+1)}$$

Re-calling the mathematical expression as given in equation 7.15, it is known that:

$$\frac{\partial Q}{\partial X} = \frac{\partial Q}{\partial G(x)} \cdot \frac{\partial G(x)}{\partial x}$$

Substituting for $\partial Q/\partial G(x)$ as obtained from equation 7.13 and expressing G(x) explicitly, the marginal productivity of pesticide $\partial Q/\partial x$ can be calculated directly as:

$$\frac{\partial Q}{\partial X} = \frac{Q\lambda\, k^{\lambda}\, X^{-(\lambda+1)}}{1-k^{\lambda}X^{-\lambda}}$$

PARETO MODEL

On the other hand, if the assumption is made that the **exponential distribution function** is the most appropriate estimation of the contributions of pesticides, then the G(x) will take the explicit form as:

$$G(x)= 1-e^{-\lambda X}$$

This implies that:

$$\frac{\partial G(x)}{\partial X} = - e^{-\lambda X}(-\lambda)$$

$$= \lambda e^{-\lambda X}$$

As established earlier,

$$\frac{\partial Q}{\partial X} = \frac{\partial Q}{\partial G(x)} \cdot \frac{\partial G(x)}{\partial x}$$

Substituting for the value of ∂Q/∂QG(x) and expressing G(x) explicitly, the marginal productivity of pesticide ∂Q/∂x becomes,

$$\frac{\partial Q}{\partial X} = \frac{Q\lambda e^{-\lambda X}}{1- e^{-\lambda X}}$$ **EXPONENTIAL MODEL**

The third option provided for in the literature is to assume that the contributions of pesticides is accurately measured by the **logistic distribution function.** For this distribution, the explicit form of G(x) becomes:

$$\frac{\partial G(x)}{\partial X} = \frac{1}{1+ e^{(\mu - \sigma x)}}$$

If we let $A=1+e^{(\mu - \sigma x)}$,

then G(x) can be re-written as:

$G(x)=1/A$ or A^{-1}

Differentiating G(x) with respect to A, it gives

$$\frac{\partial G(x)}{\partial A} = -A^{-2}$$

$$= -[1+e^{(\mu - \sigma x)}]^{-2}$$

By differentiating A with respect to X, the derivative obtained is

$$\frac{\partial A}{\partial X} = -\sigma e^{(\mu - \sigma x)}$$

Since $\partial G(x)/\partial X$ is a product of $\partial G(x)/\partial A$ and $\partial A/\partial X$, i.e.,

$$\frac{\partial G(x)}{\partial X} = \frac{\partial G(x)}{\partial A} \cdot \frac{\partial A}{\partial X}$$

then making the necessary substitutions, the derivative of G(x) with respect to X can be expressed as:

$$\frac{\partial G(x)}{\partial X} = -[1+e^{(\mu - \sigma x)}]^{-2}[-\sigma e^{(\mu - \sigma x)}]$$

$$= [1+e^{(\mu - \sigma x)}]^{-2}[\sigma e^{(\mu - \sigma x)}]$$

Substituting for the values of $\partial Q/\partial G(x)$ and $\partial G(x)/\partial X$ and multiplying the two, the product is equivalent to $\partial Q/\partial X$

$$\frac{\partial Q}{\partial X} = -[1+e^{(\mu - \sigma x)}]^{-2}[-\sigma e^{(\mu - \sigma x)}]\ [Q/G(x)]$$

Expressing G(x) in its explicit form, $\partial Q/\partial X$ may be written as

$$= \frac{(\sigma e^{(\mu - \sigma x)})\ Q}{1+e^{(\mu - \sigma x)}}$$

Re-arranging the above expression, the marginal productivity of pesticide

$\partial Q/\partial X$ can be written as:

$$\frac{\partial Q}{\partial X} = \frac{Q}{1+ e^{(\mu - \sigma x)}} \bullet \sigma e^{(\mu - \sigma x)} \quad \textbf{EXPONENTIAL MODEL}$$

Finally, assuming that the contribution of pesticides is most appropriately modelled by a **Weibull** distribution function.

Then G(x) takes the form:

$$G(x)= 1-\exp\{-X^{c}\}$$

The derivative of G(X) with respect to X becomes

$$\partial G(x)/\partial X = \exp\{-X^{c}\}\, C\, X^{C-1}$$

$$\frac{\partial Q}{\partial x} = \frac{\partial Q}{\partial G(x)} \cdot \frac{\partial G(x)}{\partial x}$$

By substituting explicitly for the value of $\partial Q/\partial G(x)$ and G(x), the marginal productivity of pesticide $\partial Q/\partial x$ in a Weibull function becomes:

$$\frac{\partial Q}{\partial X} = \frac{Q \,.\, \exp\{-X^{c}\}\, C\, X^{C-1}}{1-\exp\{-X^{c}\}} \quad \textbf{WEIBULL MODEL}$$

Appendix 8.1: Laboratory Procedure for the Extraction of the Pesticides Residues used in Cotton Fields from the Textile Cloth Material

DIRECTION DU LANADA

LABORATOIRE D' ECOLOGIE
BP.42- TEL : 00-225/ 86.07.26
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KORHOGO

KORHOGO /02/03/1998

PROTOCOLE EXPERIMENTAL D'EXTRACTION DES PESTICIDES UTILISES EN CULTURE COTONNIERE DANS LES TISSUS TEXTILES

I. MATERIEL ET METHODES

1. 1 Matériel

Le matériel était constitué de textiles, mélange coton polyester, matériels prélevés sur les paysans après application des produits. Ils sont emballés dans du papier aluminium et acheminés au laboratoire, où ils sont conservés au congélateur à - 20°C . Ensuite ils sont progressivement découpés selon les possibilités d'analyse en petits morceaux de 10 cm de côté soit des coupons de 100 cm^2

2. METHODES

2. 1. *EXTRACTION ET ANALYSE*

Chaque coupon de 100 cm^2 est découpé en petits morceaux et imprégné dans 250 ml d'acétone. La préparation est portée sur une secoueuse rotative pendant 4 heures et l'ensemble est filtré dans un entonnoir sur des ballons de 500 ml. On procède à la réduction du volume sous un flux d'air frais et sec à 100 ml, puis à 1 ml et ce filtra est dilué dans 100 ml d'hexane. Cette dernière préparation est réduite à 10 ml d'hexane et la solution est prête pour l'analyse instrumentale en GC ou en HPLC.

2. 2. *ANALYSE INSTRUMENTALE*

L' analyse instrumentale a été faite sur un gaz chromatographe *SHIMADZU GC - 14 A* split-splitless sur une colonne capillaire DB1 dans les conditions analytiques suivantes:

- injecteur = 250°C
- four = 255°C
- détecteur = 300°C
- gaz vecteur N_2 (azote) = 2 kf/cm^2
- purge = 0,5 kf/cm^2

La confirmation des résultats a été faite en HPLC *SHIMADZU LC - 6A* (chromatographie liquide de haute performance), dans les conditions analytiques suivantes:

- colonne = RP 8
- détecteur UV = 230 nm
- phase mobile = acétone / eau (80/20)
- flux = 0,8 ml/mn

VOIR CHROMATOGRAMME

DIRECTEUR DU LABECO

Dr. DEMBELE ARDJOUMA

Sample Copies of Questionnaires used

Enregistrements et Observations des Travaux aux Champs: INPUTS-OUTPUT

Note important aux enquêteurs: Le but de ce formulaire est pour enregistrer chaque semaine le type de tous les travaux effectués dans les champs cotonniers et rizicoles du paysan. Il faut enregistrer aussi tous les intrants épandus et les revenus/bénéfice obtenues pour la semaine.

Site de recherche:........................ Village: .... Ménage: ....
Code du champ: ..../............ Mois: .... Semaine: ....

7. Main d'œuvre:

Type de travail	Tot travailleurs	Répartition de travailleurs					Heures de travail			Heures effectives par personne	Effectif temps total (heures)					
		Membre de la famille			TR	TP	Début du travail	Fin du travail	Temps de Pause		Membres de la famille			TR	TP	TP (montant payé)
		AM	AF	JN							AM	AF	JN			

Heures totales de travail pendant la semaine: ....

Détails des Intrants utilises ou épandus

Paiement direct	Quantité totale	Coût unité	Coût total
Main d'œuvre	....	....	....
Engrais	....	....	....
Insecticide	....	....	....
Herbicide	....	....	....
Autres.	....	....	....

Payement indirect			
Nourriture	....	....	....
Boissons (vin, bissap)	....	....	....
Cigarette	....	....	....
Autres............	....	....	....

Détails des Productions/Bénéfice:

Produits	Quantité	Prix	Revenu
Récolte	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....

Remarques générales sur la main-d'œuvre, coûts et revenus durant la semaine: ....
....

***Note:** A.M= Adulte masculin A.F=Adulte féminin JN=Jeune (moins 15 ans)
TR= Travail rotatif TP=Travail payé

***Note: Voir au verso pour le guide de codes** Terminer avec remerciement au paysan**

Guide des Codes

1=Défrichessement
2=Pépinière
3=Labour
4=Billonage
5=Buttage
6=Entretien des diguette
7=Semis
8=Re-semis
9=Répiquage
10=Apport d'herbicide
11=Apport d'engrais
12=Démariage
13=Premier désherbage
14=Deuxième désherbage
15=Troisième désherbage
16=Re-billonage
17=Re-buttage
18=Traitement insecticide (premier passage)
19=Traitement insecticide (Deuxième passage)
20=Traitement insecticide (Troisième passage)
21=Traitement insecticide (Quatrième passage)
22=Traitement insecticide (Cinquième passage)
23=Traitement insecticide (Sixième passage)
24=Gardiennage
25=Récolte
26=Stockage
27=Décortiquage
28=Transportation (au village)

PRODUCTION COTON

NOTE: Dans ce formulaire, il s'agit d'information sur l'achat de coton, la production et le choix de coton obtenus dans les champs d'où nous avons accueilli des informations 'inputs-outputs'.

Code du Ménage	Code du Champ	Premier Achat		Deuxième Achat	
		Production totale (en kg)	**Choix:** 1=Premier, 2=Deuxième	Production totale (en kg)	**Choix:** 1=Premier, 2=Deuxième

SOURCES DE PESTICIDES

NOTE: Dans ce formulaire, il s'agit d'information sur la quantité totale des différentes types de pesticides disponible dans chaque ménage pendant la campagne agricole. Il s'agit aussi des sources d'où proviennent ces pesticides.

Code du Ménage	CIDT ou GVC						Amis ou autres paysans		Marché ou Boutique		Restes des années passées	
	*	*	*	*	*		*		*		*	

Pesticides: Toutes Sortes d'Utilisations

Village: ....   Nom du ménage: ....   Code du ménage: ....

Note: Dans cette formulaire , il s'agit de relèvement d'information sur toutes les quantités de pesticides utilisés par chaque ménage, soit dans le champ ou dehors le champ, soit dans le champ commun de la famille ou dans le champ personnel.

Mois	Semaine	Code du champ	No de traitement (T1, T2,...)	Nom de culture ou Type de l'utilisation	Code du culture	Type de champ	Superficie traitée (ha)	Type de pesticide	Nom de pesticide	Code du produit	Quantité épandu (litres)

Note: Type de champs: 1= Champ commun qu' appartient au collective de tous les gens dans le ménage.
2= Champ personnel qu'appartient personnellement aux individus dans le ménage
Type de pesticides: 1= Herbicides, 2= Insecticides.

Traitement de Pesticides: Formulaire d'Observation aux Champs [Partie I]

Importante note aux enquêteurs: Doit être rempli dans les champs en observant les travailleurs

Nom du village: .... Code du ménage: ....

Nom du ménage:... Code du champ: ....

Date de traitement:(mois-jour-année): .... Le numéro de traitement?: ....

1. Nombre total de personnes ayant effectués le traitement:.............

2. L'heure du commencement du travail? ....

3. Superficie traitée ce jour là (en hectare selon le paysan) ....

4. Type de traitement : Herbicides.......... Insecticides...........

5...

6. Spécifiez les détails suivants concernant **ceux qui ont traités** aux pesticides:

Nom de travailleur	No de chargement	Code	Age	Sexe	Habita-tion	Durée d'exposition	Protection porteé	Appareil		Mélange des produits	Activités durant traitmt	Nettoyage	
								Type	Etat			Corps	Veto-ments

<u>Code</u> Mettre le code donné dans le recensement du ménage

<u>Sexe</u> 1=Masculin 2=Féminine

<u>Habitation</u> 1=Dans ménage 2=Hors ménage

<u>Protection</u> 1=Rien 2=chapeau 3=des gants 4=des bottes 5=Mouchoir/nez 6=mouchoir/bouche 7=Vêtements de protection 8=autres

<u>Type d'appareil</u> 1=disque électrique 2=appareil à dos 3=autres

<u>Condition/état</u> 1=Excellent 2=Bon 3=Mauvais- Fuite 4=Mauvais- problème de batteries

<u>Mélange de produits</u> 1=Impliqué 2=Non impliqué

<u>Activités</u> 1=manger 2=fumer 3=boire (de l'eau) 4=autres

<u>Nettoyage</u> 1=Immédiat au champ 2= Immédiat au fleuve 3=Plus tard au village 4=Aucun nettoyage

7. Quels sont les noms des produits chimiques utilisés pour le traitement ce jour-là?

	Nom du produit chimique	Code du produit	Quantité totale épandue (en litres)
a			
b			
c			
d			

8. A part les travailleurs qui traitent les pesticides, combien de personnes étaient présent dans le champ pendant le traitement?

Adulte male:.................. Adulte femelle:....................... Enfant:............

9. Quel type de travail effectues les?

Adulte male:................... Adulte femelle:........................ Enfant:.............

Observation générale

1. Décrivez la méthode de préparation des produits chimiques avant le traitement.

Remuer l'eau et chimique:............ Mélanger avec un bâton: .... Mélange avec un balai: ....
Mélange déjà fait à l'usine: .... Autres (spécifiez): ....

2. Indiquez le lieu de stockage des pesticides avant leurs utilisations aux champs:

Dans la chambre.......... Magasin spécial a la maison.......... Magasin GVC au village: ....
Champs........................ Autres (spécifiez).......

3. Comment les produits chimiques étaient transportés aux champs ce jour-là:

Transporté sur la tête (un adulte): .... Transporté sur la tête (un enfant): ....
Transporté sur une vélo/mobylette (un adulte): .... Transporté sur une vélo/mobylette (un enfant): ....
Dans un sac (adulte):.. Par mains nues (adulte) :...
Par charrette:.. Par burette:..
Autres méthode (spécifiez)..

4. Quel était l'état de l'appareil utilisé pour le traitement?

Excellent........ Fuite......... Problème de batterie......... Problème de bobine: ....
Autres (décrivez).........................

5. Quel était la situation du vent durant le traitement?

Très fort .... Fort:.................... Moyen................ Calme.................

6. Quelle précaution les travailleurs ont-t-ils pris concernant la vitesse et la direction du vent?

Aucun................................... observes des feuilles d'arbres.......... Drapeau/tissu matériel:.................
Observe des poussière............ Fumer: .... Mettre appareil en marche:.........
Autres (décrivez)..

7. Quelle était la situation du climat lorsque le traitement se déroulait?

Sec et ensoleillé .... Humide et nuageux........... Humide/ensoleillé: ....
Soleil/nuageux après:..... Autres (décrivez)................

8. Décrivez le nettoyage d'appareil effectué par les travailleurs après la séance du traitement:

Aucun (non lavé)................................... Lavé immédiat dans le champ...................
Lavé immédiat au fleuve......................... Lavé l'appareil plus tard au village............
Autres (décrivez)..

Traitement de Pesticides: Formulaire d'Observation aux Champs [Partie II]

Note importante aux enquêteurs: Remplir un formulaire pour chaque personne qui a participé à la séance de traitement pesticides, et chaque personne présente dans le champ ce jour là mais qui **n'a pas participés** au traitement.

Village: ....
Nom du ménage:.................................
Code du ménage: ....
Code du champ: ....
Nom du travailleur: ....
Code d'identification:............................

Décrivez tous les problèmes (maladies) que vous avez constaté sur vous pendant le dernier traitement de pesticides ou dans un délai de 24 heures après le traitement.

					NOMBRE DE JOURS			Autre membre de la famille		QUEL TYPE DE SOINS							Maladie résolu mainte-nant?
											Traditionnel			Moderne			
Date de traitement	No de traitement (T..)	Symptômes/ types de maladie	Code	Cause	Resté à la maison	Ennuis en travaillant	Sévérité d'ennuis	Même maladie	Allé au champ ce jour?	Aucun soin pris	Comment a-t-il été effectué ?	Espèces (en cfa)	Autres (en cfa)	Localisa-tion (en Km)	Frais de consultation	Frais des médica-ments	

Note:** ***Voir page 2 pour le guide des codes ☞

***Note: Terminer la séance d'entretien avec le paysan en disant "Merci bien d'avoir répondu à mes questions".**

GUIDE DE CODE

Symptômes/type de la maladie

1=Toux	2=Démangeaison	3=Maux de tête	4=Maux de yeux	5=Maux de cou
6=Empoisonnement/Toxicité	7=Rougeur des yeux	8=Vertige	9=Rougeurs de peau	10=Tremblement des mains/doigts
11=Vomissement	12=Éternuement	13=Pâleur/coloration de la peau		14=Faiblesse générale de corps
15=Catarrhe/bronchite	16=Fièvre	17=Sueur excessive	18=Froid	19=Fossette de peau
20=Rhume	21=Paludisme			

Cause de la maladie (selon paysan)

1=Herbicides	2=Insecticides	3=moustiques/insectes	4=Sorciers	5=Nouriture
6=Boissons (l'eau)	7=Climat	8=autres (spécifiez)		

Sévérité d'ennuis de la maladie en travaillant

1=Beaucoup 2=Moyen 3=Un peu

Même maladie attrapé en même temps par d'autre membre de famille?

1=Non 2=Oui

La personne allé au champ durant le jour de traitement de produit?

1=Non 2=Oui

Comment effectuer le soins traditionnel?

1=Les herbes préparées par le malade lui-même 2=Les herbes préparées par son conjoint/enfant
3=Aller chez le guérisseur local dans le village 4=Aller chez le guérisseur dans autre village

La maladie, a-t-il pris la fin maintenant?

1=Non 2=Oui

Commentaires ici: ....
....
....
....
....

CHOLINESTERASE and HAEMOGLOBIN TEST
(Farm worker sheet)

Nom du village: .... Nom d'Opérateur:.................................
Date de test: ....

Sample no	Nom de travailleur	Menage	Code personnel	Fume now?	No of year	Bois now ?	No of year	Résultats de Test		
								ChE (U/ml blood)	Hgb (g/dL blood)	Hgb corrected ChE (U/g Hgb)

CHOLINESTERASE and HAEMOGLOBIN TEST

(Non - Farm worker data sheet)

Nom du village: .... Nom d’Opérateur:.................................

Date de test: ....

Sample no	Nom de travailleur	Code	Age	Sexe	Profession	Fume now?	No of year	Bois now?	No of years	Résultats de Test		
										ChE (U/ml blood)	Hgb (g/dL blood)	Hgb corrected ChE (U/g Hgb)

La Santé du Ménage: Hebdomadaire Formulaire d'Enquêtes

Une copie de ce formulaire dois être rempli chaque semaine pour chaque ménage en posant des questions suivants les paysans et par observation aussi.

Village: .... Nom du ménage: .... Code du ménage:....................

Introduction: Cette séance s'agit de la santé des membres de votre famille. Y a t-il quelqu'un dans votre ménage qui est/était malade entre ma dernière visite et aujourd'hui. Lequel?

Nom du membre de la famille	Code du person	Trait pest? 1=non 2=oui 3=assist	Age	Malade la semaine passé?	Code du symptômes ou types de la maladie		Cause	Nombre de jours		QUEL TYPE DE SOINS							Maladie fini mainte-nant?
											Traditionnel			Moderne			
					I	II		Durée de la maladie	Resté à la maison	Aucun soin pris	Comment a-t-il été effectué ?	Espèces (en cfa)	Autres (en cfa)	Localisa-tion (Km)	Frais de consultation (cfa)	Frais des médicaments (cfa)	

Note: * Voir au verso pour le guide de codes **** Terminer avec remerciement au paysan**

Guide de codes (révisés) pour les maladies de la fiche „Santé du ménage“

Malade au cours de la semaine passée?

1=Non	2=Oui

Symptôme ou Type de la maladie (I= Première maladie mentionnée II=Deuxième maladie mentionnée)

1=Toux	2=Démangeaison	3=Maux de tête	4=Maux d’œil	5=Maux de cou
6=Empoisonnement/Toxicité	7=Rougeur des yeux	8=Vertige	9=Rougeurs de peau	10=Tremblement des mains/doigts
11=Vomissement	12=Éternuement	13=Pâleur/coloration de la peau		14=Faiblesse générale de corps
15=Catarrhe/bronchite	16=Fièvre	17=Sueur excessive	18=Froid	19=Fossette de peau
20=Rhume	21=Paludisme			
31=Froid	32=Fièvre jaune	33=Général corps chaud	34=Gonflement du corps	35=Diarrhée
36=Maux de gorge	37=Combature/articulation			
50= Maux de dent	51=Maux de cœur	52= Maux d’oreilles		
53= Maux de ventre	54= Maux de pied	55= Epilepthie		
56=Bouton	57=Maux de mains	58=Blessures		
59=Mal de côtes	60= Maux de reins	61=Panarie		
62=Furoncle	63=Bosse	64=Mousure de serpent		
65=Maux de sein	66=Plaie	67=Varicelle		
68=Chaud pisse (Urinal problème)				

Cause de la maladie (selon paysan)

1=Herbicides	2=Insecticides	3=moustiques/insectes	4=Sorciers	5=Nouriture
6=Boissons (l'eau)	7=Climat	8=Des mangues	9=Moustiques	10=Mouches
11=Insectes au champs	12=Poussières	13=Fumée de la cuisine	14=Travail au champ	15=Mauvais rêve
16=Autres (spécifiez)	17=Mystiques/Espirit	18=Velo	19=Grossese	
20=Tombe dans le feu	21=Chien			

La maladie a t-il pris la fin maintenant?

1=Non	2=Oui

Comment effectuer le soins traditionnel?

1=Les herbes préparées par le malade lui-même	2=Les herbes préparées par son conjoint/enfant
3=Aller chez le guérisseur local dans le village	4=Aller chez le guérisseur dans autre village

PESTICIDES: Connaissances, Attitudes et Pratiques des Paysans

Site de recherche:........................ Village: .... Code du ménage:.......................
Ménage: .... Dates d'interview:..

<u>Notes aux Enquêteurs:</u> *(i) Contrairement aux autres formulaires, ce questionnaire est plus grand et il faut le remplir au fur et à mesure jusqu' à la fin de la fiche.*
(ii) Faites des efforts afin d'avoir de bonnes réponses aux questions posées.
(iii) Vous êtes encouragés à faire des commentaires supplémentaires en marge de la page si il est nécessaire.

<u>A. Connaissance de ravageurs</u>

1. A votre avis, tous les <u>insectes</u> qui se trouvent dans vos champs de coton et de riz sont-ils nuisibles (mauvais) aux cultures et au rendement? (*Note: Dans ce sens, une moitie varie entre 40% - 60%*)

<u>Coton:</u> Tous sont nuisibles: .... La plupart sont nuisibles: ....
Une moitié est nuisible:............. Moins d'une moitié est nuisible: ....

<u>Riz:</u> Tous sont nuisibles: .... La plupart sont nuisibles: ....
Une moitié est nuisible:............. Moins d'une moitié est nuisible: ....

2. Comment reconnaissez-vous les mauvais insectes et les insectes avantageux?
Couleur d'insectes: ....
Taille d'insectes: ....
Forme d'insectes : ....
Autres (spécifiez): ....

Veuillez décrire comment ?: ....
....
....
....
....
....

3. Reconnaissez-vous des insectes/organismes suivants? (*Note: Utilisez les noms locaux d'insectes*)

Les chenilles de capsule:	Oui:	Non: ....
Les insectes phyllophages:	Oui:	Non: ....
Les insectes piqueurs/suceurs:	Oui:	Non: ....
Les acariens	Oui:	Non: ....

4. Entre les quatre groupes de ravageurs cités ci-dessus en question 3, quels sont les types d'insectes <u>les plus nombreux</u> dans vos champs (par ordre d'importance)?

	<u>Premier</u>	<u>Deuxième</u>	<u>Troisième</u>	<u>Quatrième</u>
Coton	....	....	....	....
Riz- bas fond	....	....	....	....
Riz- plateau	....	....	....	....

5. Toujours en référence à la question 3, quels sont les types d'insectes qui causent <u>le plus de dégâts</u> aux rendements (en classant par ordre d'importance)?

	<u>Premier</u>	<u>Deuxième</u>	<u>Troisième</u>	<u>Quatrième</u>
Coton	....	....	....	....
Riz- bas fond	....	....	....	....
Riz- plateau	....	....	....	....

6. A part les insectes, est-ce qu'il y a d'autres organismes ravageurs qui posent des problèmes dans vos champs i.e. dégâts aux rendements? Oui: .... Non: ....

Lesquels d'organismes?

Rongeurs:	Oiseaux:	Champignons:	Acariens: ......
Maladies:	Singes:	Bœufs:	Escargots:......
Adventices:	Nématodes:......	Autres (spécifiez):	

7. Quelle proportion de votre rendement perdez vous à cause de ravageurs, les insectes et les autres organismes confondus? (*Note: Perdre dans le sens de réduction en quantité et en qualité*)

1=Très petit (<10%) 2=Moins (10-25%) 3=Assez (26-50%) 4=Grave (51-75%) 5=Très grave (>75%)

	Coton	Riz (Bas Fonds)	Riz (plateau)
Dégât du aux ravageurs	....	....	....

8. Veuillez indiquer la sévérité de chaque groupe de ravageurs selon les pertes causées au rendement ?

(Note: Même code comme question 7 ci-dessus)

Type de ravageur	Coton	Riz (Bas Fonds)	Riz (plateau)
Insectes	....	....	....
Adventices/Mauvaises herbes	....	....	....
Rongeurs	....	....	....
Oiseaux	....	....	....
Champignons	....	....	....
Acariens	....	....	....
Maladies	....	....	....
Singes	....	....	....
Bœufs	....	....	....
Autres ravageurs	....	....	....

9. A votre connaissance, quelle est la relation entre les <u>ravageurs</u> et les <u>maladies</u> des plantes ?

a. Ces sont les même choses: ....
b. Les ravageurs amènent les maladies: ....
c. Les maladies amènent les ravageurs: ....
d. Pas de relation: ....
e. Autres réponses (spécifiez): ....

10. Quelle est la tendance historique du problème d'insectes ravageurs sur vos champs du coton et du riz?

	Pour le coton	Pour le riz
a. Les problèmes ont augmenté gravement	....	....
b. Les problèmes ont augmenté un peu	....	....
c. Pas de changement, il est toujours la même	....	....
d. Les problèmes ont diminué un peu	....	....
e. Les problèmes ont beaucoup diminué	....	....

11. Quelles sont les raisons pour la situation dégradée/améliorée des problèmes des insectes ravageurs?

....
....
....

12. Quel est le niveau du problème d'insectes ravageurs dans votre champ du coton cette année?

Très grave par rapport à d'autres années:...............
Même niveau comme d'autres années:..................
Mieux par rapport à d'autres années:......................

13. Veuillez décrire les types de champs où les problèmes d'insectes ravageurs sont généralement les pires
  a. Les champs situés à côté de la brousse:.......................................
  b. Les champs situés en milieu d'autres champs cultivés:............
  c. Les champs cultivés depuis plusieurs années:..............................
  d. Les champs cultivés récemment (une courte année): ....
  e. Autres (spécifiez):...

B. Perceptions des Paysans des Pesticides

1. Quel est votre constat concernant l'efficacité des pesticides que vous utilisez pour traiter les cultures suivantes?

	Coton	Riz- bas fond	Riz- plateau
Très efficace	....	....	....
Efficace	....	....	....
Un peau efficace	....	....	....
Pas efficace	....	....	....
Ne utilise pas de pesticide	....	....	....

2. Y a-t-il des insectes ou autres ravageurs/herbes que (vous avez remarqué) les pesticides ne contrôlent pas bien?
  Répondre en mettant „OUI" ou „NON"

	Insectes	Adventices	Autres ravageurs
Coton	....	....	....
Riz- bas fond	....	....	....
Riz- plateau	....	....	....

3. Quels types d'insectes ou adventices?
  Coton: ....
  Riz- bas fond: ....
  Riz- plateau: ....

4. Pourquoi cela s'est passé?
  La puissance des pesticides disponibles maintenant est faible: ....
  Les insectes/ravageurs deviennent plus forts qu' auparavant: ....
  Non-conformité aux recommandations d'utilisation de pesticides: ....
  Je ne peux pas utiliser assez de quantité de pesticides à cause du prix élevé: ....
  Autre raison (spécifiez): ....

5. Faites-vous des mélanges de produits pesticides?
  Oui: .... Non: ....
  Si oui, Combien de produits..................... Lesquels?: ....

6. Mélangez-vous les matériels suivants avec les pesticides?
  Essence/Gasoil:........................... Pétrole:.........:.........................
  L'huile:....:.................................. Alcool:.......:...........................
  Autres (spécifiez):.......................

7. Pourquoi faites-vous ces mélanges?
  Pour augmenter l'efficacité des pesticides:.......................
  Pour économiser les pesticides:..
  Parce que les pesticides disponibles sont faibles:.............

8. Vous arrive t'il de <u>sur-doser</u> ou <u>sous-doser</u> les pesticides lorsque vous traitez vos cultures?

Coton:	Sur-doser:	Sous-doser:	Ni: ....
Riz- bf:	Sur-doser:	Sous-doser:	Ni: ....
Riz- plat:	Sur-doser:	Sous-doser:	Ni: ....

9. Pourquoi vous sur-dosez ou sous-dosez?

Pour ceux qui sur-dosent	**Pour ceux qui sous-dosent**
L'efficacité devient faible:	L'efficacité est très forte: ....
Les pesticides sont disponibles abondamment:	Produits pas disponibles à l'heure: ....
Pour réaliser un rendement élevé:	Manque d'argent de payer: ....
Infestation de ravageurs est élevée:	Infestation de ravageurs est faible: ......
Autre(spécifiez):	Autre(spécifiez): ....

10. Pour les trois dernières années, combien de traitement d'insecticides et d'herbicides avez vous effectués dans vos champs?

	INSECTICIDES		HERBICIDES	
Année	Coton	Riz- bas fond	Coton	Riz- bas fond
1996/97	....	....	....	....
1995/96	....	....	....	....
1994/95	....	....	....	....

11. A partir de votre expérience agricole, il faut combien de traitements d'insecticide pour pouvoir obtenir les meilleurs résultats (rendements) aux conditions citées ci-dessous?

	Coton	Riz-bf
Quand la pression de parasites est faible	....	....
Quand la pression de parasites est forte	....	....

12. Entre l'insecticide et l'engrais, lequel contribue le plus au rendement de votre culture de coton et de riz ?

	Coton	Riz-bf	Riz (pl.)
L'insecticide contribue le plus	....	....	....
L'engrais contribue le plus	....	....	....
Les deux contribuent au même niveau	....	....	....

13. Supposons qu' à cause du manque d'argent, vous devez faire un choix en achetant des pesticides ou des engrais pour vos cultures, lequel allez vous choisir?

	Coton	Riz-bf	Riz (pl.)
Je donnerai la priorité aux insecticides	....	....	....
Je donnerai la priorité aux engrais	....	....	....
Je choisirai les deux	....	....	....

14. Que peut-il se passer si vous n'utilisez aucun pesticide sur vos cultures pendant la campagne agricole?

Résultat	Coton	Riz (bf)	Riz (pluvial)
Tous les rendements seront perdus (100%)	....	....	....
Trois quart des rendements seront perdus (75%)	....	....	....
La moitié du rendement sera perdu (50%)	....	....	....
Un quart du rendement sera perdu (25%)	....	....	....
Moins du quart sera perdu (< 25%)	....	....	....

15. Utilisez-vous des herbicides sur votre champs (*Herbicides: les chimiques qui tuent des mauvaises herbes*)

	Coton	Riz (bf)	Riz (pluvial)
Oui, sur toutes les superficies	....	....	....
Oui, sur la plupart des superficies	....	....	....
Oui, sur moins d'une moitie des superficies	....	....	....
Non, pas du tout	....	....	....

16. Si vous n'utilisez pas les herbicides sur toutes les superficies de vos champs, pourquoi?
Le coût d'herbicide est très élevé:..
Pour éviter le problème de crédit:..
L'arrêt de fourniture gratuite des herbicides:..........................
Les herbicides ne sont pas disponibles (à l'heure):.................
Le sarclage est un alternatif et moins cher aux herbicides:.....
Les herbicides sont faibles / pas efficaces maintenant:...........

17. Dans quels types de champs (ou partie d'un champ) utilisez-vous des herbicides?
Les champs qu'on vient de cultiver:..
Les superficies / parties où il y a beaucoup des adventices:............
Les portions où les cultures poussent bien: ....
Les champs cultivés continuellement depuis plusieurs années:.......

18. Veuillez indiquer précisément sont les avantages d'<u>insecticides</u> aux cotonniers?
Tuer les ravageurs nuisibles aux cotons:.............
Rendre plus facile la récolte de coton: ....
Aider les cotonniers à bien pousser: ....
Augmenter le rendement de coton: ....
Autre raison (à spécifier): ....

<u>C. Lutte contre les ravageurs</u>

1. Veuillez faire une liste et décrivez toutes les méthodes de lutte contre les ravageurs que vos aïeux (vos arrières grand parents utilisaient dans cette région autrefois.
....
....
....
....
....
....

2. Est-ce que vous continuez avec ces méthodes actuellement?
Oui: .... Oui, mais partiellement: .... Non, pas du tout: ....

Pourquoi?
....
....
....
....
....

3. Connaissez-vous d'autres méthode de lutte contre les ravageurs à part les produits chimiques?
Oui: .... Non: ....

4. Si vous les connaissez, veuillez faire la liste de ces méthodes de lutte:

a. ....   b. ....

c. ....   d. ....

e. ....   f. ....

5. Si d'autres méthodes alternatives (non chimiques) pour contrôler les ravageurs sont disponibles de nos jours, dans quelles conditions vous allez les adopter/utiliser?

Par rapport aux pesticides, la nouvelle méthode doit:

Avoir le même prix ou être moins cher : ....

Assure le même ou plus niveau de rendement: ....

Adopter par la moitié ou plus des paysans: ....

Avoir même ou plus d'efficacité de tuer les ravageurs: ....

Être au moins aussi simple et aussi facile à manipuler: ....

Être moins toxique pour la santé des hommes: ....

Être moins toxique pour l'environnement: ....

Être aussi ou plus disponible partout: ....

Autres (spécifiez): ....

D. Disponibilité d'information Agricole

1. Quelles sont vos sources d'information générale?

La radio: ....   La télé: ....   Collègues paysans: ....

Amis en villes: ....   Autres (spécifiez): ....

2. En général, combien de fois par mois les encadreurs vous rendent des visites pour vous donner des conseils agricoles ? Nombres de visites par mois: ....

3. En moyenne, chaque visite dure pour combien de temps? Nombre d'heures: ....

4. Quelle est votre source principale actuelle des renseignements concernant la méthode que vous utilisez pour lutter contre les ravageurs de vos cultures?

La CIDT: ....

Les firmes phytosanitaires: ....

Centre de recherche (ADRAO, IDESSA): ....

Sociétés d'encadrement agricole (SODEs): ....

L'OPA: ....

L'ANADER: ....

Les collègues paysans: ....

Autres (Spécifiez): ....

5. Quelles sont les autres sources d'information (en les mettant par ordre)?

La CIDT: ....

Les firmes phytosanitaires: ....

Centre de recherche (ADRAO, IDESSA): ....

Sociétés d'encadrement agricole (SODEs): ....

L'OPA: ....

L'ANADER: ....

Les collègues paysans: ....

Autres (Spécifiez): ....

6. Ces informations sont véhiculées par quels moyens?

Contact personnel, par agents officiels: ....
Contact personnel, par d'autres collègues paysans: ....
Radio et autres audiovisuels: ....
Livrets et autre bulletins: ....
Séances de formations : ....
Autres (Spécifiez): ....

7. Comment vous trouvez des informations concernant le contrôle des ravageurs:

Je prends l'initiative de les chercher moi-même: ....
Je croise les informations par hasard: ....
Les deux façons, mais plus par mon initiative: ....
Les deux façons, mais plus par hasard: ....

8. Avez-vous jamais entendu quelque chose à propos de "La Lutte Intégrée contre les Ravageurs"?

[C'est à dire, un concept qui mélange les différentes méthodes de lutte disponible, en utilisant des produits chimiques avec d'autres matériels dépendant de l'exigence de la pression de ravageurs et aussi, en respectant l'environnement]

Oui: .... Non: ....
Si oui, Quand: .... Où: ....

9. Si „Oui“, quelles sont les contraintes le plus importantes pour la mise en œuvre et la vulgarisation de programme "Lutte Intégrée"?

Les pesticides sont disponibles, moins chers, plus efficaces: ....
Relevés de ravageurs: ....
Connaissance des insectes et leur importance: ....
Main d'œuvre pour effectuer les tâches supplémentaires: ....
Maîtriser la méthode de la "Lutte Intégrée: ....
Autre (spécifiez): ....

10. Pensez vous que des pièges à insectes seraient une solution simple pour vous déterminer le niveau d'infestation de ravageurs? Oui: .... Non: .... Ne connais pas les piège: ....

11. Seriez vous prêts à installer des pièges à insectes comme méthode de lutte? Oui..... Non: ......

12. Pensez vous que l'association de deux cultures peut réduire le nombre d'insectes sur une ou des deux cultures? Oui: .... Non: ....

13. Pour le contrôle des ravageurs, comment comparez vous les pesticides et d'autres méthodes non-chimiques?
(Note: Demandez l'avis de paysans pour tous les thèmes suivants en mettant „OUI“ ou „CONTRAIRE“

Connaissance: Je ne connais pas d'autre méthodes de contrôle à part des pesticides:.........
Disponibilité: Les pesticides sont plus disponibles: ....
Coût: Les pesticides sont moins chers: ....
Efficacité: Les pesticides sont plus efficaces (action immédiat): ....
Effet: Les pesticides donnent le moins effet négatif au long terme:.................................

<u>E. Les effets de l'Utilisation des Pesticides</u>

1. Vous avez travaillé sur le coton depuis combien d'années ?
   Année de commencement: .... Nombres des années: ....

2. Depuis combien d'années utilisez vous (*exposition à*) les pesticides?
   Année de commencement: .... Nombres des années: ....

3. A votre connaissance, quels sont les problèmes qui peuvent arriver à cause d'un forte utilisation de <u>beaucoup de quantité</u> de pesticides pour une <u>période si longue</u>?
   Aucun problème, rien du tout: ....
   Problème de la santé pour les travailleurs: ....
   Problème de l'environnement, fleuves (précisez): ....
   Problème (de toxicité) aux plantes: ....
   Autre problèmes (spécifiez): ....

4. Décrivez précisément, les types de maladies qu'on peut attraper dû à une <u>exposition prolongée</u> aux pesticides:

Toux :...........................	Mort: ....
Démangeaison:	Maux de tête: ....
Maux des yeux:	Empoisonnement: ....
Toxicité:	Rougeur des yeux: ....
Maux de cou:	Vertige: ....
Rougeurs de peau:	Tremblement des mains/doigts: .....
Vomissements:	Pâleur/coloration du peau: ....
Éternuement:	Faiblesse générale de corps: ....
Catarrhe:	Sueur excessive: ....
Fièvre:	Froid: ....
Fossette de peau:	Paludisme: ....
Rhume:	Maux de ventre: ....
Plaie:	Autres (spécifiez) :..........................

5. Depuis votre expérience agricole en utilisant les pesticides, quels problèmes avez <u>vous</u> (ou <u>quel qu'un dans votre famille)</u> eu parmi ceux cités ci-dessous ?

Toux :...........................	Mort: ....
Démangeaison:	Maux de tête: ....
Maux des yeux:	Empoisonnement: ....
Toxicité:	Rougeur des yeux: ....
Maux de cou:	Vertige: ....
Rougeurs de peau:	Tremblement des mains/doigts: .....
Vomissements:	Pâleur/coloration du peau: ....
Éternuement:	Faiblesse générale de corps: ....
Catarrhe:	Sueur excessive: ....
Fièvre:	Froid: ....
Fossette de peau:	Paludisme: ....
Rhume:	Maux de ventre: ....
Plaie:	Autres (spécifiez) :..........................

6. Qu'est-ce que vous faites pour améliorer les problèmes mentionnés?
   Aucune effort, rien du tout: ....
   Je fais les soins moi-même: ....
   Aller au guérisseur dans le village: ....
   Aller au guérisseur dans un autre village: ....
   Aller a l'hôpital/dispensaire: .... Le nom d'hôpital/ dispensaire: ....
   Autres (spécifiez): ....

7. Plus précisément, quels sont les symptômes qui vous permettent de connaître si quel qu'un est affecté par l'intoxication aux pesticides? *(Note: Intoxication= dommages ou troubles causés par les chimiques)*

Toux :...........................	Mort: ....
Démangeaison:	Maux de tête: ....
Maux des yeux:	Empoisonnement: ....
Toxicité:	Rougeur des yeux: ....
Maux de cou:	Vertige: ....
Rougeurs de peau:	Tremblement des mains/doigts: .....
Vomissements:	Pâleur/coloration du peau: ....
Éternuement:	Faiblesse générale de corps: ....
Catarrhe:	Sueur excessive: ....
Fièvre:	Froid: ....
Fossette de peau:	Paludisme: ....
Rhume:	Maux de ventre: ....
Plaie:	Autres (spécifiez) :..........................

8. Y a t-il un guérisseur local ou personne dans ce village ou dans les alentours qui donnent des soins contre l'empoisonnement ou d'autres problèmes liés aux pesticides? Oui: .... Non: ....

9. Décrivez la méthode traditionnelle pour prendre soins d'intoxication dans cette localité
....
....
....
....
....
....

10. Est-ce qu'il y avait un cas de décès ou intoxication dans votre région à cause de pesticides ?

	Précédent période (*10 ans ou plus*)	Récente période (*moins 10 ans*)
Cas d'intoxication	....	....
Cas de décès	....	....

11. En comparant les problèmes de maladie liés aux pesticides que vous avez mentionnés ci-dessus et les avantages de pesticides, quel est votre avis concernant la rentabilité de l'utilisation de ces produits chimiques?

Malgré ses problèmes, les pesticides sont encore beaucoup avantageux: ....
Malgré ses problèmes, les pesticides sont un peu avantageux: ....
Les problèmes et les avantages des pesticides sont au même niveau: ....
En considérant les problèmes, les pesticides sont un peu moins avantageux: ....
En considérant les problèmes, les pesticides sont tellement moins avantageux: ......

F. Connaissance de signes et de symboles d'avertissement aux pesticides

1. Les symboles et figures ci-dessous sont souvent inscrits sur les emballages (boîtes, bouteille, etc) des produits chimiques. Lisez-vous ou tenez-vous compte de leur signification avant de choisir vos pesticides?
(*NOTE: Montrez la page contenant des schémas et des figures aux paysans à ce point*)

Oui, toujours: ....
Oui, parfois: ....
Oui, rarement: ....
Non, pas du tout: ....

Pourquoi? ....

2. Dans l'ensemble, quel est le but principal de ces symboles et figures?

Avertir les utilisateurs contre des dangers: ....
Donner instruction sur le mode d'emploi: ....
Pour les patrons dans l'affaire de pesticides: ....
Aucune importance: ....
Ne pas tenir compte d'eux: ....
Autres (spécifiez) : ....

3. Plus précisément, quelle est la signification des symboles ou figures suivants qui sont écrits/dessinés souvent sur les emballages de pesticides? *(Il faut indiquer le grade de compréhension de paysan aussi)*

a. Sens: .... C: .... T: ......
b. Sens: .... C: .... T: ......
c. Sens: .... C: .... T: ......
d. Sens: .... C: .... T: ......
e. Sens: .... C: .... T: ......
f. Sens: .... C: .... T: ......
g. Sens: .... C: .... T: ......
h. Sens: .... C: .... T: ......
i. Sens: .... C: .... T: ......
j. Sens: .... C: .... T: ......
k. Sens: .... C: .... T: ......
l. Sens: .... C: .... T: ......
m. Sens: .... C: .... T: ......

G. Utilisation des Pesticides

1. Quelle quantité totale de pesticide avez vous utilisée dans vos champs (toutes cultures confondues) pendant la dernière campagne agricole 1995/96?

Quantité en litres: .... Quantité en kg: ....

2. Combien coûtait cette quantité?

Montant total (en CFA): .... Montant total (en coton-grain) :..........................

3. Veuillez donner des informations sur la répartition (par culture) des pesticides que vous avez utilisés pendant la dernière campagne agricole 1995/96?

Culture	Superficie totale (en hectare)	Nombre de traitement: Insecticides	Nombre de traitement: Autres	Quantité par hectare par traitement: Insecticides	Quantité par hectare par traitement: Autres
Coton	....	....	....	....	....
Riz (bas fond)	....	....	....	....	....
Riz (plateau)	....	....	....	....	....
Maïs	....	....	....	....	....
Arachide	....	....	....	....	....
Sorgho	....	....	....	....	....
Soja	....	....	....	....	....
Igname.	....	....	....	....	....
Légumes	....	....	....	....	....

4. Toujours sur l'année 1995/96, quels sont les noms des pesticides que vous avez épandus sur les trois cultures ci-dessous? **(Classez par ordre)**

Culture	INSECTICIDES 1e produit	2e produit	3e produit	HERBICIDES 1e produit	2e produit
Coton	....	....	....	....	....
Riz (bas fond)	....	....	....	....	....
Riz (plateau)	....	....	....	....	....

5. Si vous comparez les quantités totales des pesticides que vous avez épandus sur vos cultures quand les insecticides ont étaient livrés gratuitement et maintenant quand ils sont payants, quelle est la tendance générale pour l'utilisation de pesticides sur chaque culture? (Note: C=Croissant D=Décroissant)

Culture	**Insecticides***		**Herbicides***	
Coton	..C..	..D..	..C..	..D..
Riz (bas fond)	..C..	..D..	..C..	..D..
Riz (plateau)	..C..	..D..	..C..	..D..
Maïs	..C..	..D..	..C..	..D..
Arachide	..C..	..D..	..C..	..D..
Sorgho	..C..	..D..	..C..	..D..
Soja	..C..	..D..	..C..	..D..
Igname	..C..	..D..	..C..	..D..
Légumes	..C..	..D..	..C..	..D..

** Note: Pour la tendance de pesticides, entourer la bonne réponse d'un cercle.*

6. Pour le coton et le riz, quelles sont les raisons pour expliquer ces tendances mentionnées ci-dessus?

Pour ceux qui disent qu'il y a des décroissances des insecticides ou herbicides épandus, indiquez leurs raisons:

Des raisons	Coton	Riz: BF	Coton	Riz: BF
Arrêt de la fourniture gratuite des insecticides	....	....	....	....
Manque d'argent	....	....	....	....
Les prix des pesticides sont devenus très élevés	....	....	....	....
Non disponibilité des pesticides à l'heure	....	....	....	....
Je tiens compte des effets négatifs des pesticides	....	....	....	....
L'utilisation des pesticides n'est pas rentable encore	....	....	....	....
Le prix des produits agricoles se décroît	....	....	....	....
La superficie des cultures diminuent	....	....	....	....
Autres (spécifiez)	....	....	....	....

Pour ceux qui disent qu'il y a des croissances des insecticides ou herbicides répandus, indiquez leurs raisons:

Des raisons	Coton	Riz: BF	Coton	Riz:BF
Disponibilité des gammes des différentes pesticides	....	....	....	....
Croissance des superficies cultivées	....	....	....	....
L'efficacité des pesticides devenant faible	....	....	....	....
Fourniture des pesticides au crédit	....	....	....	....
Le prix de produits agricoles s'accroît	....	....	....	....
L'utilisation des pesticides est toujours rentable	....	....	....	....
Les superficies des cultures augmentent	....	....	....	....
Autres (spécifiez)	....	....	....	....

7. Quels sont précisément les avantages provenant de l'utilisation des pesticides?

Eviter des pertes des rendements: ....
Tuer les insectes/adventices: ....
Augmentation de rendement (comme des engrais): ....
Assurance contre le risque de destruction des cultures: ....
Utilisation des pesticides est directement proportionnelle à la rentabilité:.......
Pesticides améliore le sol: ....
Autres (spécifiez): ....
Autres (spécifiez): ....

8. Au contraire, quels sont les problèmes dérivés de l'utilisation des pesticides?

Rien du tout: ....
Problème de la santé humaine: ....
Dangereux aux travailleurs: ....
Problème de toxicité aux plantes: ....
Autres (spécifiez): ....

9. En général, quel utilisation faites-vous des pesticides?

Utilisation	Pourcentage
Pulvérisation sur les cultures (toutes confondues)	....
Autre utilisation, non culture (toutes confondues)	....

10. A part la pulvérisation sur vos cultures, quels autres usages vous ou les autres paysans faites-vous des pesticides? *** (NOTE: Mettez „Oui“ ou „Non“ sous la colonne „Usage“)*

Autres utilisations	Usage**	Proportion utilisé (%)
Traitement/préservation des denrées stockées	....	....
Tuer les moustiques	....	....
Traitement de bois	....	....
Désinfecter des greniers et des lieux de stockage	....	....
Traitement des semences avant de planter	....	....
Tuer les poux ou autres insectes organismes de corps	....	....
Tuer les animaux de brousse (agouti, etc)	....	....
Dans l'eau pour tuer des poissons	....	....
Premiers soins pour des blessures humaines/animales	....	....
Parfois vendre, s' il y a manque d'argent	....	....
Autres (spécifiez)	....	....

11. Quel est le <u>nombre de passages</u> de traitements que vous effectuez sur vos cultures pendant l'époque les insecticides étaient fournis gratuitement, et maintenant qu'ils sont payants?

	Gratuite	Payant
Coton	....	....
Riz (bas fond)	....	....
Riz (plateau)	....	....

12. Quels critères choisissez-vous pour commencer le programme de traitement phytosanitaire?

Calendrier/prophylaxie: ....
Observation de la pression parasitaire: ....
Apparition des boutons floraux: ....
Apparition des fleurs: ....
Aussi immédiat qu'on voit des insectes dans le champ: ....
N'importe, quand les produits chimiques sont disponibles: ....
Quand on a le temps pour le faire: ....
Autres (spécifiez): ....

13. Quels critères choisissez-vous pour arrêter le traitement phytosanitaire?
Calendrier/prophylaxie: ....
Disparition des ravageurs/insectes: ....
Arrêt de la production de feuilles: ....
Arrêt de la production de fleurs: ....
Manque de produits pesticides: ....
Autre (spécifiez): ....

14. Basé sur votre expérience agricole, qu'est-ce que vous avez remarqué concernant l'efficacité des pesticides *(„efficacité“ dans le sens de tuer des insectes/adventices)* ?
Les pesticides de nos jours ne sont pas aussi efficaces comme ceux d'avant: ....
Pas de changement d'efficacité entre les pesticides de nos jours et ceux d'avant: ....
Les pesticides de nos jours sont plus efficaces que ceux d'avant: ....

15. Supposons qu' une situation arrive que vous deviez supprimer un traitement, lequel allez vous supprimer?
Le 1er: ...... Le 2eme: ...... Le 3eme: ...... Le 4eme: ...... Le 5eme: ...... Le 6eme: ......

16. Si vous deviez supprimer un autre traitement encore, lequel allez vous supprimer?
Le 1er: ...... Le 2eme: ...... Le 3eme: ...... Le 4eme: .... Le 5eme: .... Le 6eme: ....
(Le premier traitement, Traitement au milieu, Dernier traitement)

17. Pourquoi allez vous supprimer ces traitements?
Ce ne sont pas très utiles au rendement: ....
J'ai beaucoup de travaux à ces périodes: ....
La pression parasitaire est faible pendant ces périodes: ....
Très peu ou absence d'insectes pendant ces périodes: ....
Autre raison (spécifiez): ....
Autre raison (spécifiez): ....

18. Est-ce que les travaux sur d'autres cultures ont des influences sur le **nombre** et le **temps** de traitement que vous effectuez sur le coton et le riz ? *(Répondez en mettant Beaucoup; Un peu; Non du tout)*
Oui, beaucoup: .... Oui, mais un peu:............. Non, pas du tout: ....

19. *Si oui*, quel est le nom de la culture la plus importante qui influence le traitement de coton et de riz?

	Coton	**Riz-bf**
Fréquence ou Nombre	....	....
Temps de traitement	....	....

20. Dans quelle condition du climat préférez vous traiter vos cultures?
Quand il est sec et ensoleillé ..... Humide et nuageux...........
Pendant la matinée:................... Pendant le soirée:..............
Autres (décrivez)..

21. Dans quelle situation du vent préférez vous traiter vos cultures?
Quand le vent est très fort:........... Quand le vent est moyen fort:..... Quand le vent est calme:......

22. Pourquoi préférez vous ces conditions?
Le vent nous aide à mieux épandre les pesticides:..............................
Pour économiser les quantités épandues:...
Pour m'aider à travailler plus vite:...
Les conditions sont plus convenables:...
Pour éviter la présence de beaucoup de personnes dans le champ:......
Autres raisons (Spécifiez):..

23. Après le traitement d'un champ, combien de jours attendez vous avant de rentrer dans le même champ?
Nombre du jours: ....

24. Faites vous d'autres types de travaux dans autres champs le même jour après que vous ayez effectué le traitement d'un champ?
Oui, toujours:................. Oui, parfois:..................... Non, je me repose:............

H. Fourniture de pesticides

1. Qui sont vos fournisseurs de pesticides?

	Source	Insecticides(%)	Herbicides et autres (%)
Coton:	CIDT	....	....
	GVC	....	....
	COOPAGCI	....	....
	CEACI	....	....
	Magasin commercial en ville	....	....
	Les autres paysans dans le village	....	....
	Autres (spécifiez)	....	....
Riz:	CIDT	....	....
	GVC	....	....
	COOPAGCI	....	....
	CEACI	....	....
	Magasin commercial en ville	....	....
	Les autres paysans dans le village	....	....
	Autres (spécifiez)	....	....

2. Quelles sont les modalités actuelle de la fourniture de vos pesticides?

	Source	Insecticides (%)	Herbicides et autres (%)
Coton:	Payant en espèces	....	....
	A crédit	....	....
	Autres (spécifiez)	....	....

	Source	Insecticides(%)	Herbicides et autres (%)
Riz:	Payant en espèces	....	....
	A crédit	....	....
	Autres (spécifiez)	....	....

3. Dans le cas de fourniture en crédit, quel est le taux d'intérêt que vous payez?
Le taux d'intérêt: .... Je ne sais pas: ....

4. Dans le cas de fourniture à crédit, quand est-ce que vous devez le repayez ?
Après récolte: ....
Pendant l'achat du coton: ....
Autres (spécifiez): ....

5. A quel moment êtes-vous informé sur le taux d'intérêt à payer sur le crédit des pesticides chaque campagne?

	Insecticides	Herbicides
Très tôt dans la campagne, avant de recevoir des pesticides	....	....
A la réception des pesticides	....	....
Durant la campagne, après avoir reçu des pesticides	....	....
A la fin de la campagne, durant la commercialisation	....	....
Je ne sais pas, les gens coupent le montant qu'ils veulent	....	....

6. Quelle est votre opinion concernant le montant coupé (taux d'intérêt) ?
Très haut: .... Haut: .... Modéré: .... Bas: ...... Très bas: ....

7. Basé sur les résultats économiques de campagne de ces quelques années passées, supposons que vous avez connu l'intérêt à payer des pesticides très tôt, quel est la quantité que vous auriez demandé ou utilisé?

Même quantité de pesticides: ....
Moins de quantité de pesticides: ....
Plus quantité de pesticides: ....

8. En général, quand est-ce que les pesticides vous sont-ils livrés?

	Insecticides	Herbicides
Pendant la préparation du terrain	....	....
Pendant le semis	....	....
Un mois après le semis	....	....
Deux mois après le semis	....	....
Autres (spécifiez)	....	....

9. Suite à la cessation de la fourniture gratuite des insecticides pour le coton, quelle est votre réaction?

Diminué le dosage d'insecticide (quantité épandue pour chaque traitement): ....
Diminué la superficie de coton: ....
Diminué le nombre de traitement: ....
Abandon de la culture de coton complètement: ....
Il n' a aucun effet: ....
Autres (spécifiez) : ....

10. Supposons que le prix d'achat du coton augmente, comment réagisserez-vous par rapport à l'utilisation des pesticides et la superficie du coton (*mettez votre réactions par ordre*)?

Augmenter la superficie de coton: ....
Augmenter le dosage d'insecticide (quantité épandue pour chaque traitement): ...
Augmenter le nombre de traitement par campagne: ....
Il n' y aura aucun effet: ....
Autres (spécifiez) : ....

11. Depuis la fourniture payante des pesticides (1994/95 campagne), il y a trois ans. Combien d'années parmi les trois avez vous été déclaré comme „*impayé*" à la fin d'achat du coton? Nombre d'années: ....

12. Quelle est votre évaluation du problème de l'*impayé*, maintenant et avant (quand pesticides étaient gratuits)?

Pire qu'avant:......................
Même qu'avant :.................
Mieux qu'avant :.................

I. Appareil de Protection et Traitement de Pesticides

1. Quel appareil de protection portez-vous quand vous traitez vos champs?

Rien du tout: ....
Mouchoir pour couvrir le nez: ....
Vêtements protectifs: ....
Des bottes: ....
Mouchoir pour couvrir la bouche: ....
Le chapeau/casquette pour couvrir la tête...........
Des gants : ....
Autres (spécifiez) : ....

2. *Pour ceux qui ne portent aucun appareil de protection,* pourquoi vous ne portez pas des appareils de protection?

Ce n'est pas utile: ....
Ce n'est pas disponible chez nous: ....
Manque d'information de leur existence: ....
Il retarde l'efficacité du travail: ....
Le travail se déroula lentement: ....
C'est utile, mais c'est très cher: .....
Il me fait trop chaud: ....
C'est trop lourd à porter: ....
C'est difficile à manipuler: ....
Autres (spécifiez) : ....

3. *Les questions 3 à 5 concernent ceux qui portent un ou l'autre appareil de protection,* Comment vous avez obtenu votre appareil de protection?

Un cadeau de la part du gouvernement/encadreurs: ..... Acheter moi-même: ......
Emprunter (à louer) des autres paysans : .... Location du GVC: ....
Autres (spécifiez) : ....

4. Depuis quand est-ce que vous utilisiez ce même appareil de protection? Nombres des années: ....

5. Pour quels ouvriers mettez-vous à leur disposition ces appareils de protection?

Tous les travailleurs qui font le traitement: .... Moi seule: ....

6. En général, qui fait le traitement de vos champs (classez par ordre)?

Le chef du ménage: .... Fils du ménage: ....
Autres membre s de la famille: .... Ouvriers (permanent): ....
Autres producteurs/paysans................ Ouvriers: ....

7. Y a t-il un changement de ces personnes au cours de la campagne ou chaque année?

<u>Au cours de la campagne</u>	Changement	Pas de changement.........
<u>D'une année à l'autre</u>	Changement	Pas de changement.........

8. Pourquoi?

....
....
....
....

9. Quel type de pulvérisateur utilisez-vous pour le traitement des pesticides?

	Herbicides	Insecticides: (végétatif)	Insecticides (Fructifère)
Appareil à dos	....	....	....
Appareil à pile	....	....	....
Autre (spécifiez)	....	....	....

10. Quels autres usages faites-vous de cet appareil?

Traitement d'autres cultures vivrières: ....
Arrosage des légumes: ....
Autre (spécifiez): ....

11. Achetez vous cette appareil ou vous l'empruntez de quel qu'un? Acheter:...... Emprunter: ....

Si acheté personnellement, quand est-ce que vous avez payé cet appareil? ....

12. En général, pour combien de fois l'appareil tombe en panne pendant une campagne agricole? Nombre: .....

13. Que faites-vous quand l'appareil n'est pas en bonne forme?
Rien, utiliser le dans la même condition: ....
Réparer moi-même: ....
Réparer par le technicien: ....
Emprunter celui de quel qu'un d'autre: ....
Acheter un nouveau appareil: ....
Autre (spécifiez): ....

14. Y a t-il un centre ou un paysan formé dans ce village ou dans les alentours spécifiquement pour la métiers de la réparation/entretien d'appareil de traitement?

	Dans le village	Autour du village
Centre de réparation/entretien	....	....
Paysan formé formellement dans ce métier	....	....
Rien du tout!	....	....

J. Stockage de Pesticides et Évacuation d'Emballages Vides

1. Où est-ce que vous faites le stockage des pesticides?
Chez moi dans la maison: .... Chez moi dans un magasin spécial séparé de la maison: ....
Aux champs: .... Au magasin commun dans le village:.....................................
Autres (spécifiez) : ....

2. En général, le stockage dure combien de temps? Nombre de mois: ....

3. Qu'est-ce que vous faites avec les emballages vides?
Jeter dans le champ: .... Jeter plus loin du champ:..........
Bien laver et vendre: .... Incendier: ....
Bien laver et utiliser (e.g. à la maison): ...... Enterrer dans le sol: ....
Autres (spécifiez) : ....

K. Fourniture des médicaments contre l'intoxication

1. Receviez-vous des médicaments contre les intoxications de pesticides au par avant? Oui: ... Non: .....
2. Qui sont/étaient les fournisseurs de ces médicaments: ....
3. Quelles sont/étaient les conditions de livraisons des médicaments? Gratuits: .... Payants: .....
4. Les médicaments sont toujours disponibles pour vous comme au par avant? Oui: ..... Non: ....
5. *Si la réponse est NON à la question 4*, quelle est la dernière année d'un livraison? L'année 19.............
6. *Si la réponse est NON à la question 4*, pourquoi les livraisons se sont-ils arrêtées? ....
....
....

L. La Relation entre le Type de Travail et la Santé

1. A partir de votre expérience agricole, lequel de ces types d'opérations agricoles semble vous donner <u>le plus de fatigue</u> (En mettant en rang) ?

Opération dans le champ	1er	2eme	3eme	4eme	5eme
Préparation du sol	....	....	....	....	....
Semis	....	....	....	....	....
Désherbage	....	....	....	....	....
Pulvérisation de pesticides	....	....	....	....	....
Récolte	....	....	....	....	....

2. Toujours basé sur votre expérience agricole, lequel de ces types d'opérations agricoles semble vous donner le plus de maladie (En mettant en rang) ?

Opérations agricoles	1er	2eme	3eme	4eme	5eme
Préparation du sol	....	....	....	....	....
Semis	....	....	....	....	....
Désherbage	....	....	....	....	....
Pulvérisation de pesticides	....	....	....	....	....
Récolte	....	....	....	....	....

3. A votre connaissance, quelle est la saison/période la plus favorable à l'apparition des maladies dans votre région?

La saison sèche: ....
La saison pluvieuse: ....
Autres (spécifiez) : ....

4. Quel est la/les raison(s) pour ça?

....
....
....

5. En se référent à la question 3 dessus, quel est le type d'opération agricole qui se déroule durant cette période aux plateaux et aux bas fonds?

Type d'opération agricole	Plateaux	Bas-fonds
Préparation du terrain	....	....
Semis	....	....
Désherbage	....	....
Pulvérisation de pesticides	....	....
Récolte	....	....
Autres (spécifiez) :	....	....

M. Fermes, Revenu agricole

1. Veuillez nous indiquer (dans l'ordre) combien de champs votre ménage possède t-il actuellement?

Culture	Nombre de parcelles	Superficies totales des fermes (ha)	Tendance de la superficie pour les cinq dernières années (note *)
Coton	....	....	..C.. ..D..
Riz (bas fond)	....	....	..C.. ..D..
Riz (plateau)	....	....	..C.. ..D..
Maïs	....	....	..C.. ..D..
Arachide	....	....	..C.. ..D..
Sorgho et Mil	....	....	..C.. ..D..
Soja	....	....	..C.. ..D..
Igname	....	....	..C.. ..D..
Légumes (tous)	....	....	..C.. ..D..
Anacarde	....	....	..C.. ..D..
Patate douce	....	....	..C.. ..D..
Autres cultures (a spécifier)			
....	....	....	..C.. ..D..
....	....	....	..C.. ..D..

** Note: Pour la tendance de superficie, entourer la bonne réponse d'un cercle.* [C= Croissant, D=Décroissant]

2. Pourquoi avez vous augmenté / diminué les superficies semées par votre ménage pendant les cinq dernières années?

Coton: ....
....
....
Riz: ....
....
....
Autres cultures (spécifiez): ....
....
....

3. Quelles sont vos raisons principales (vendre ou auto-consommation) en faisant des cultures ci-dessous?
Note: Si le paysan ne peux pas donner le pourcentage exact, mettez sa réponse en classe comme ci-dessous:
1 =(<10%), 2=(10-40%), 3=(41-60%), 4=(61-90%), 5= (>91%)

Culture	vendre (%)	Vivres (%)
Coton	....	....
Riz (bas fond)	....	....
Riz (plateau)	....	....
Maïs	....	....
Arachide	....	....
Sorgho	....	....
Soja	....	....
Igname	....	....
Légumes	....	....
Anacarde	....	....
Autres cultures (spécifiez)		
....	....	....
....	....	....
....	....	....
....	....	....

4. Quels étaient les rendements (kg/ha) de coton et de riz que vous avez obtenu pour les trois dernières années?

Année	C o t o n	Riz- bas fond	Riz- plateau
1996/97	....	....	....
1995/96	....	....	....
1994/95	....	....	....

5a. Pouvez vous nous indiquer votre revenu agricole total (toutes cultures confondues) pour la dernière campagne? Le montant en CFA: ....

5b. Quel était la répartition de ce montant total par cultures?

Note: Le paysan peut donner sa réponse en CFA, nous allons calculer le pourcentage nous-même après.

Culture	Revenu (en CFA)	(en %)
Coton	....	....
Riz (bas fond)	....	....
Riz (plateau)	....	....
Maïs	....	....
Arachide	....	....
Sorgho	....	....
Soja	....	....
Igname	....	....
Légumes	....	....
Anacarde	....	....
Autres cultures (toutes confondues)	....	....

6. Pendant la dernière année, quel était le montant total généré par les activités?

Note: Mettez comme ceux-ci: <10.000 cfa, 10.000-50.000, 51.000-100.000, 101.000-200.000, >200.000

a. Activités non agricole (enseignement arabe, activités artisanales, commerce, guérison locale, loisirs)?

Montant en CFA: ....

b. Cadeaux monétaires de vos relations (en ville ou pays extérieurs)

Montant en CFA: ....

N. Système Foncier

1. Quel est votre statut de possession des terres de vos champs?

Note: STATUT: *PP= possession personnelle, PC= possession commune, PL= ou propriété louée*

Note: Si PP, comment: *AC=achat, HE=héritage, CA=cadeau, AU=autres*

Note: „Durée de loyer“ *dans le sens du nombre d'années que le paysan peut utiliser la terre.*

Culture	Statut	*Si PP*, comment	*Si PL*, durée de loyer	*Si PL*, loyer payé par an
Coton	....	....	....	....
Riz (plat.)	....	....	....	....
Riz (bf)	....	....	....	....
Arachide	....	....	....	....
Maïs	....	....	....	....
Sorgho/Mil	....	....	....	....
Soja	....	....	....	....
Igname	....	....	....	....
Légume	....	....	....	....
Anacarde	....	....	....	....
Autres cultures	....	....	....	....

2. Pour la possession commune ou louée, êtes vous permis d'effectuer des améliorations permanente (e.g. amélioration du sol) ou de semer/récolter des plantes vivaces sur les terres?

Oui, toujours: .... Oui, parfois: .... Pas souvent: .... Pas du tout: ....

O. Accès aux informations

1. Combien d'années d'éducation scolaire avez vous passé depuis votre naissance?

Éducation formelle (occidentale), nombres d'années: ....

Éducation informelle (arabique), nombres d'années: ....

Éducation adulte, nombres d'années: ....

2. Quel diplôme académique le plus avancé avez vous obtenu ? ....

3. Est-ce que vous êtes un membre d'une coopérative agricole (GVC ou COOPAGCI ou CEACI) ? ....

4. Si oui, depuis combien de temps (nombre d'année)? ....

5. Est-ce que vous appartenez à d'autres associations du village ou autour du village?
Oui: .... Non: ....

6. *Si oui*, combien d'associations? ....

7. Etes-vous titulaire d'une position spéciale (traditionnelle, social, agricole) dans ce village ou autour du village?
Oui: .... Non: ....
Si oui, quel est le titre: .... Depuis quand? ....

8. Avez-vous eu l'opportunité d'assister aux cours de formations agricoles depuis les dix dernières années?
Oui: .... Non: ....

Si oui, indiquez les détails suivants:

Thème	No. de jours	Organisateurs	Lieu
a.	....	....	....
b.	....	....	....
c...	....	....	....
d...	....	....	....
e...	....	....	....

P. Autres Informations Générales

1. Au départ, quelles raisons vous ont amené à cultiver le coton ?
Fourniture gratuite des insecticides : ....
Fourniture gratuite des autres intrants (semence, engrais, etc) : ....
Fourniture gratuite d'encadrements et d'autres services techniques:.......
Fourniture à crédit de bœufs et autres outils:..
Le prix élevé d'achat de coton ou coton-grain : ....
Manque d'autre cultures de rente dans notre région :...............................
Les avantages du coton sur les culture vivrières : ....
L'héritage de champs de coton : ....
Autres (spécifiez) : ....

2. Y a-t-il des paysans dans ce village ou dans les alentours qui ont abandonnés le coton depuis la suppression de la fourniture gratuite des insecticides?
Oui: .... Pourcentage des paysans: ....% Non: ....

3. En général, quelle est la relation entre le coton et les cultures vivrières, surtout le riz?

Main d'ouvre du ménage:	Avantageux:.......	Désavantageux:.........	Néant: ....
Superficie de champ:	Avantageux:.......	Désavantageux:.........	Néant: ....
Rendement/revenu:	Avantageux:.......	Désavantageux:.........	Néant: ....

4. Veuillez expliquer?
....
....
....
....
....

5. A quelle période de l'année situez vous le moment le plus difficile de manque d'argent?

Pendant la préparation du terrain: ....
Pendant le semis: ....
Pendant le désherbage: ....
Pendant la récolte du coton: ....
Pendant la récolte d'autres cultures: ....
Pendant les grandes fêtes/cérémonies (spécifiez):.........................
Autres (spécifiez): ....

6. *Note aux enquêteurs: Catégorisez chaque répondant* <u>*vous-même*</u> *à partir de vos connaissances des paysans*.
Quelle position <u>économique</u> (richesse) occupe le paysan par rapport aux autres paysans du village?

Parmi le tiers le plus riche: .... Parmi le tiers du milieu: .... Parmi le tiers le plus pauvre: ......

NOTE: Terminer chaque séance d'entretien avec le paysan avec beaucoup de remerciements.

GTZ/University of Hannover PESTICIDE POLICY PUBLICATION SERIES:

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Summaries of the publications and other project related information are also available at:

http://www.pesticide-policy-project.de