New Biotechnology and Competitiveness The Case of Cocoa

Guidelines for Assessing the Potential Economic Impact of Future Biotechnology Developments on National Cocoa Production

Thomas Braunschweig
Department of Agricultural Economics
Swiss Federal Institute of Technology
Zurich, Switzerland

and

Nikolaus Gotsch
Institute of Agricultural Policy & Market Research
Justus-Liebig-University
Giessen, Germany

A Study Prepared for
International Service for National Agricultural Research (ISNAR)
The Hague, The Netherlands

April 1995

"The major reason for actors to reorganize their activities - to change their routines - originates from the competitive forces that they are subjected to. Actors who fail to respond to competitive challenges - threats or opportunities - will find themselves on the loser side. Actors who opt to the wrong strategy may face the same fate or may be subject to takeover raids. Although a proper response to competitive challenges is of vital importance, three major categories of causes for weak performance may occur:

1. *Actors are not aware of the challenge or alarmingly poor performance.*
2. *Actors are aware of the challenge, but do not know the proper strategy to follow.*
3. *Actors are aware of the challenge and know the proper response, but are unable to implement the proper strategy.*

The first two cases are information gap problems."

Kamann and Nijkamp, 1991

Contents

Figures

Tables

Chapter 1

Introduction

1.1 Objectives of the Study

The purpose of this study is to provide information as well as a methodological tool for national policymakers and research managers who must determine a strategy, in the context of future developments in cocoa biotechnology taking into consideration the strengthening of the competitive position of the national cocoa sector. Therefore, the objective of the study is twofold.

First, it is intended to provide a comprehensive framework by which the potential economic impact of new biotechnology can be assessed. This framework consists of a wide range of determinants with respect to competitiveness. The developments of modern cocoa biotechnology and the international cocoa market over time are crucial factors also discussed in the study.

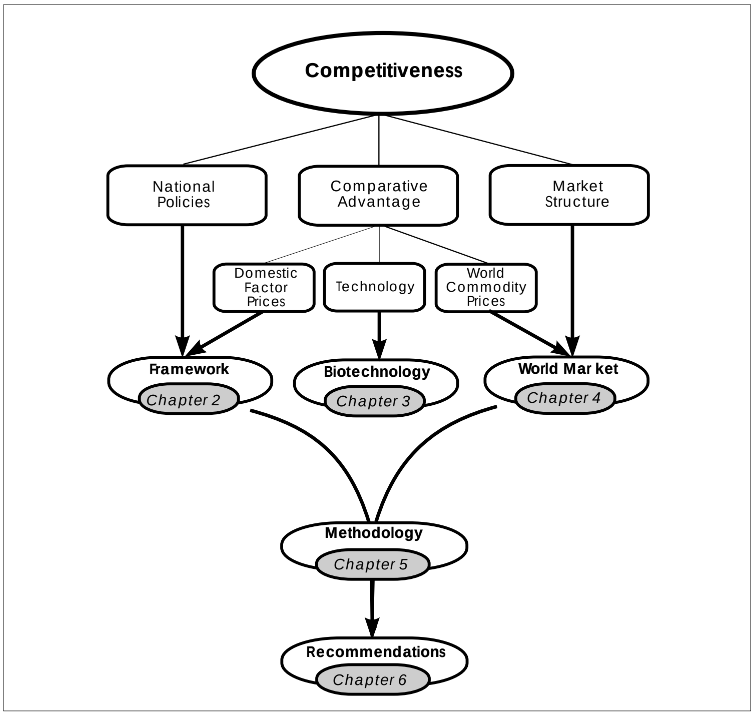
Second, the study provides an instrument to analyse the potential effects of these new technologies on the competitiveness of national cocoa production. This includes instructions on the kind of national data and information which have to be gathered by decision makers. The methodological tool presented here should enable the user not only to assess the impact on competitiveness but also to analyse the influence of national policy and the allocation of resources.

1.2 Background and Outline of the Study

Development and adoption of new technology are essential to enhance productivity of an agricultural production system. Under the condition of sustainability an increased productivity, i.e. a more efficient employment of production factors, may lead to increased competitiveness. However, the competitive situation of a production system not only depends on the technology currently used. Consequently, an analysis of changing technologies on competitiveness has also to take into account other relevant factors. This is even more necessary as some of these factors influence primarily technological change and only indirectly competitiveness.

The major elements determining competitiveness summarised in the schematic outline of the study. In Figure 1.1 the three determinants of competitiveness which are 'National Policies', 'Comparative Advantage', and 'Market Structure' are shown on the top. Comparative advantage on its part is influenced by three factors and can be understood as the potential competitiveness of a production system. 'Potential' because this would be the prevailing competitive situation if no distortions caused by government policies and/or market failures have existed. The three factors which could alter the comparative advantage of a country or a production system among a country are the domestic factor prices, world commodity prices, and technology (see Figure 1.1). While the domestic resources and their price determination are discussed in Chapter 2, the world market price of cocoa is treated in Chapter 4. Chapter 3 deals with technological change in general and developments in biotechnology in particular.

Figure 1.1: *Schematic outline of the study*



In *Chapter 2* the national framework for assessing biotechnology and competitiveness is presented. It consists of two categories of factors, those which can be influenced by national policies (defined as ‘endogenous’) and those that cannot (defined as ‘exogenous’). The first group is further divided into regulatory and policy issues. After a brief discussion of policy objectives the potential influence of the regulatory framework is pointed out. The part on the policy instruments emphasises the considerable direct influence they have on competitiveness but also via other factors as, for instance, the provision of infrastructure facilities. In addition, the strong effects of policies - macroeconomic as well as sectorspecific ones - on technological innovation is discussed. Finally, the third section is devoted to the exogenous factors such as international agreements and regulations, international research and development.

Before assessing the effects of biotechnology on the competitiveness of cocoa production, information on possible future technological developments in cocoa research and production has to be obtained. This information are given in *Chapter 3*. Section 3.2 briefly illustrates important biotic constraints for cocoa production and improvement. Section 3.3 defines biotechnology for the purpose of this study. Based on a written expert survey, Section 3.4 outlines present activities and goals of cocoa research and their expected potential impacts on research and cocoa production. Furthermore, this section describes constraints which limit research progress.

Chapter 4 focuses on the international cocoa market where the actual competition takes place and the price - without doubt the crucial determinant - is formed. Factors influencing the determination of the price are primarily the behaviour of demand and supply which on their part are influenced by further factors. Price fixing mechanism, cocoa butter equivalents or the distribution of processing facilities are other determinants. The chapter consists of three parts. Some structural features and their consequences with respect to national cocoa sectors are outlined in the first part. Issues are: the strong price instability, past and actual agreements, production structure and systems, consumption behaviour, trade patterns, and the situation in processing. The second part highlights the actual situation concerning production, consumption and prices. Past and actual growth rates of area and yield in the different production regions are discussed. The third part depicts projections made by different international organisations. This outlook should assist decision makers in carrying out a strategy for future developments in cocoa biotechnology.

In *Chapter 5* a methodological tool to analyse the economic impact of technological change is presented. After a brief discussion on the theoretical background with special emphasis on efficiency and nonefficiency objectives of an economy, the chapter turns to the instrument in question called PAM (Policy Analysis Matrix). Although this approach was mainly developed in order to analyse distortions caused by government interventions and market failures, it may perfectly be used to quantify the impact of technological change. Moreover, this methodological tool allows the analyst to isolate the economic effects of technological innovations from the above-mentioned distortions. This means, that the potential (undistorted) as well as the real impact on competitiveness can be analysed. In addition, the change in factor proportions allows a better understanding of the socioeconomic implications of the technological change. These outcomes enable policymakers to formulate an appropriate policy in order to optimise the performance of new biotechnologies. To do so, the third part of the chapter provides guidelines for the empirical application of this approach.

The conclusions based on previous chapters are summarised in *Chapter 6*.

1.3 Limitations of the Study

The issue of biotechnology in the context of competitiveness consists of complex interactions between various determinants as noted above. For the analytical as well as the methodological purpose there is a need to make assumptions and simplifications in order to tackle the constraints. These should be taken into account by interpreting the recommendations of the study.

The major restriction of the study concerns the fact that it is an *ex ante* analysis. That is, the potential impact of emerging biotechnology is a forecast for the next century. However, the developments of biotechnology and of the numerous other factors involved may partly be very uncertain for that time frame. Thus, the results should be carefully interpreted and supplemented by sensitivity analysis. This is also inevitable as earlier predictions regarding the time frame for the commercialisation of plant biotechnologies have not been accurate (Brenner and Goldin, 1993).

A clear limitation of the study is the investigated type of biotechnology. It deals exclusively with cocoa production technologies and does neither take into account the processing technology nor the technological developments with respect to cocoa alternatives. A challenge in that context seems to come from fermentation technology which tries to improve cheap cocoa of lower quality and therefore to make it more competitive (van Roozendaal, 1992). Future innovations in biotechnology for other crops which are in competition with cocoa for domestic factors are also excluded.

Another shortcoming has to do with the comparative static feature of the methodological approach which means that this kind of analysis represents snapshots of the state of the market at single points in time and any trace of the pace or speed of adjustment is missing.

Finally, the present study does not calculate the competitiveness of national cocoa production systems but provides a general guidance to do so. More detailed and defined technical instructions concerning data collection and updating can be found in some basic references, some of which are listed in the bibliography.

Chapter 2

The Framework for Competitive National Cocoa Production

In this chapter the wide range of determinants and constraints influencing the competitiveness of national cocoa production is discussed. The complex interactions of these factors are analysed. Special emphasis is given to the various policy instruments affecting the cocoa sector, directly and indirectly. The reaction of the producers to these policies is crucial for the competitiveness of a country's cocoa production.

Figure 2.1 on the next page provides a schematic summery of the chapter. In that diagram an attempt is made to depict the main issues of this chapter which may be classified as endogenous and exogenous factors and have a major impact on the economics of the cocoa sector. The arrows indicate this direct and indirect influence which the different elements have on competitiveness. The middle section of the diagram shows the real scope of the study. The 'Competitiveness of National Cocoa Production' is located in the centre and directly determined by the 'International Cocoa Market' and its elements respectively on the one hand and influenced by the 'Biotechnology' through 'Adoption and Diffusion' processes on the other hand.

Concerning competitiveness some general remarks were made in Chapter 1 whereas the theoretical framework as well as the basis for its calculation are presented in Chapter 5. The features of the international cocoa market with its peculiarities and projections of future developments are highlighted in Chapter 4. Comments on the price-setting power of a developing country ('large' country) were made in Chapter 5. Moreover, this point will be further discussed in the context of the policy instruments (see 2.2.2).

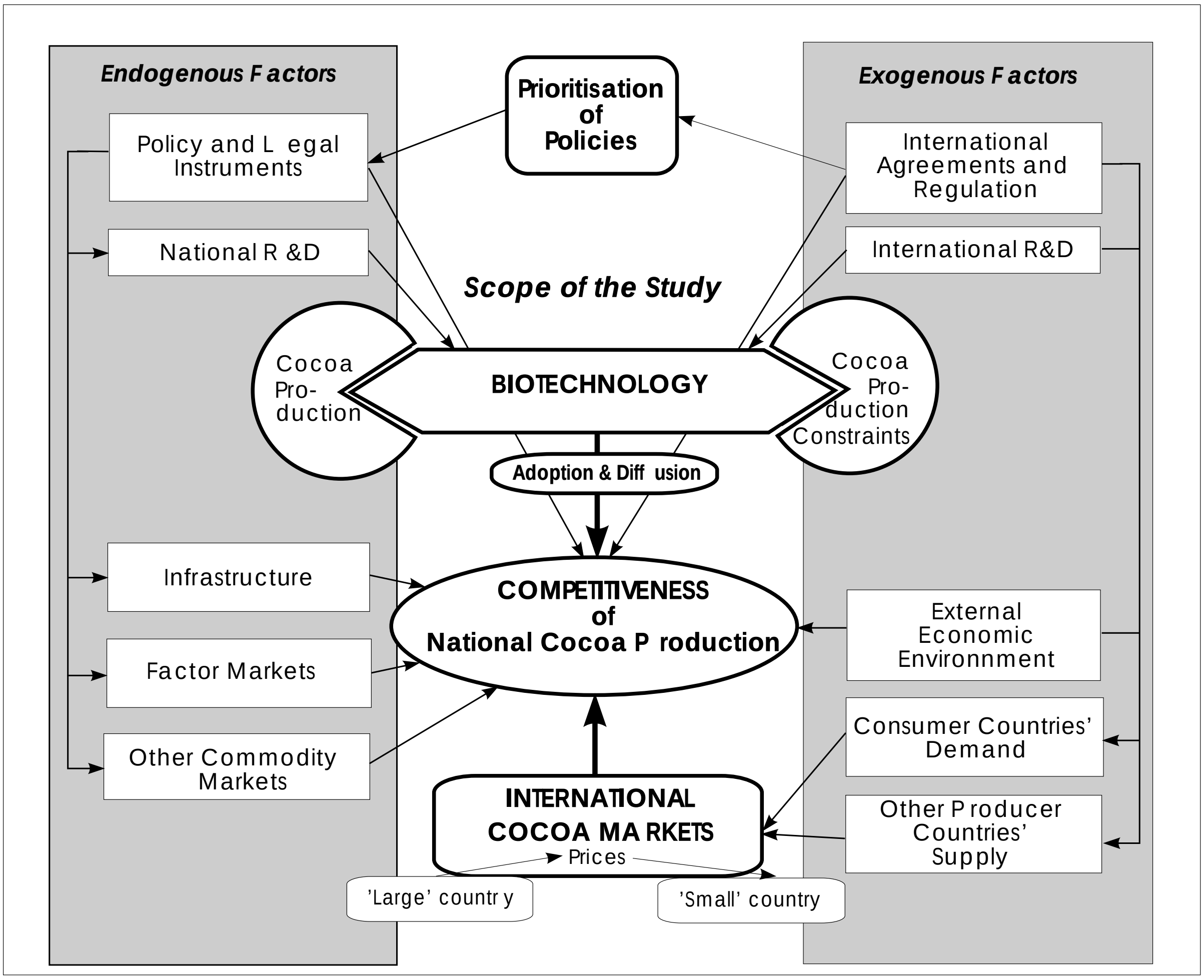
The present state as well as the most likely developments of biotechnology in cocoa are dealt with in Chapter 3. Research issues and the crucial role of the adoption and diffusion processes regarding new technologies is also pointed out in that chapter. These three elements (research, technology, and adoption/diffusion) constitute a "national innovation system" as described in a recent OECD study carried out by Brenner and Komen (1994).

A special remark is in order with respect to the terms: 'Cocoa Production' and 'Cocoa Production Constraints' in Figure 2.1. A basic aim of biotechnology is to overcome physical production constraints. For instance, a innovation in the field of modern biotechnology may overcome a particular constraint, such as soil moisture through the development of a new drought tolerant variety of cocoa. In this situation, the basically exogenous factor (too low soil moisture) still remains the same but an important constraint to production has been overcome through technological innovation improving the existing production system ('Cocoa Production' as an endogenous factor). This dynamic interrelationship between 'Cocoa Production' and 'Cocoa Production Constraints' represents a key element of biotechnology innovations. The process, however, is significantly influenced by the other factors listed in Figure 2.1, directly or indirectly.

These other factors are divided into two groups - endogenous and exogenous. In the present context 'endogenous' refers to the possibility of the cocoa producing countries to influence these factors whereas 'exogenous' are factors out of the sphere of influence of the country in question. The endogenous factors, in particular the policy and legal instruments, are basically determined by the explicit or implicit prioritisation of policies undertaken by the country. Section 2.1 is devoted to policy objectives associated with the priority setting. In the first part of Section 2.2 the regulatory framework is discussed. The second part highlights the policy instruments and their impact on the different economic levels which finally influence the competitiveness of national cocoa production. The potential effects of various exogenous factors is pointed out in Section 2.3. Mainly, they form the prevailing international conditions and should be taken into account even though these factors, by definition, cannot be influenced.

The main focus of the study is on future ~~biotechnological~~ developments of biotechnology. So, the time frame for the analysis extends on to the next century. This implies that the policy objectives and instruments as well as the international situation could alter considerably. For the evaluation of policy objectives, in particular, these could have consequences as sustainability, gender issues or environmental concerns, to mention but a few, seem to become increasingly important. One should keep in mind these trends by assessing the potential impact of future biotechnologies on them.

Figure 2.1: *The framework for biotechnology~~biotechnological~~ contributions to competitiveness of cocoa production*



2.1 Prioritisation of Policies

Determinants of a competitive cocoa system are defined or strongly influenced by the prevailing regulatory framework as well as the policy instruments employed. These regulations and policies are established in order to meet objectives and their priority setting, respectively laid down in a political process. At least, this may apply to a consistent policy framework backed by society. Unfortunately, "more often, policies respond to the desires of special interest groups within or outside agriculture." (Monke and Pearson, 1989, p.6). However, this problem is beyond the scope of this study but is discussed in the vast political economy literature. Furthermore, the elaboration of national policies is increasingly influenced by international agreements and regulations as indicated in Figure 2.1 by the arrow.

Analysing the determinants of a particular system requires a definition of its objectives. For the purpose of this study it appears reasonable to adopt the development objectives of the agricultural sector. Basically, it can be divided into efficiency and nonefficiency objectives. The former aims to establish an optimal resource allocation in order to reach a maximisation of aggregate income i.e. to improve the competitive situation of a domestically produced commodity, in this case cocoa. The latter can be grouped as social, security and environmental objectives.

Social Objectives

Income distribution is often the major nonefficiency objective. It concerns the distribution of income between the different target groups (consumers, producers, taxpayer) but also among these groups (e.g. small and large farmer, rural and urban consumer, etc.). In this context, a special reference has to made concerning the gender issue which is rapidly gaining ground in the development debate.

Another objective can be employment creation in order to realise the right for work and to prevent the state from the establishment of expensive social programmes. An important aim in this context is also to combat the rural-urban migration which may create serious and costly problems.

Security Objectives

Another group of objectives affects security for individuals on the one hand and for the state on the other. In particular producers of export crops are faced with high income risk due to variability in both production and price. A stable income would significantly raise their livelihood security.

The second point concerns the security need on a national level. Food security and self-reliance are often mentioned as reasons for government interventions in order to promote domestic production.

Environmental Objectives

This category is increasing in importance, particularly after the 'Earth Summit' held at Rio in 1992. There is a big challenge for agriculture to attain a more sustainable level of production without degrading the resource base. In agriculture, it is cash crops like cocoa which has often expanded at the expense of rain forest and, therefore, will be affected by the growing emphasis on this objective. In addition, developments of biotechnology~~ical developments~~ could - in a negative and/or positive way - be associated with restrictions warranted by environmental goals.

There is an obvious trade-off between efficiency and nonefficiency objectives in the sense, that any policy to achieve the above mentioned objectives involves a smaller or larger sacrifice of economic efficiency[1]. As a result, the pursuing of nonefficiency objectives influences the competitiveness of a country. Therefore, it is essential for actors in the field of cocoa biotechnology to have a clear understanding of the process of prioritising of all national objectives.

2.2 Endogenous Factors

For the present purpose, endogenous factors are defined as opportunities for national governments to influence the competitiveness of national cocoa production through appropriate policies. In the wider sense, this encompasses the broad range of measures in order to establish an appropriate environment for the economy, to work out a regulatory framework, and to build up the necessary infrastructure. For biotechnology the required infrastructure includes research, development and innovation diffusion capacities and extension services. Beside this specific infrastructure to influence developments of biotechnology~~ical developments~~ and therefore the competitive performance of cocoa production, there are other important factors which are influenced by national regulations

[1] For a comprehensive theoretical analysis of the economic costs of agricultural policy interventions in order to achieve any particular objective see for instance Gardner (1990).

and policy instruments. The impact of these factors may even be more powerful in determining cocoa competitiveness of a country.

2.2.1 Regulatory Framework

With respect to biotechnology the most binding regulations concern biosafety and intellectual property rights. Other regulatory systems relevant for competitiveness affect factor markets (land tenure, capital restrictions, labour law) and infrastructure (marketing boards, credit system, competition law).

Biosafety

The urgent need of such safety regulation for the competitiveness of a country is expressed in a research report about biosafety by Persley *et al.* (1993, p.1): "The constitution of a national biosafety system is important both to foster the development of modern biotechnology within a country and to ensure access to modern biotechnology products generated elsewhere. The absence of a regulatory framework for biotechnology makes it difficult for development agencies and private companies not only to invest in biotechnology but also to make the products of biotechnology available in that country. Thus, a safe and efficient regulatory process is in itself a comparative advantage in biotechnology (...)."

Comprehensive guidelines for laboratory practices and field trials have been developed by the Organisation for Economic Cooperation and Development (OECD). Additional efforts for international harmonisation of the regulatory system concerning biotechnology in order to protect public health and to guarantee environmental safety have been carried out by other international organisations mainly initiated by developed countries. The above-mentioned report provides detailed guidelines for developing countries to introduce safety regulation which are in line with the international standard. These guidelines include also risk-assessment procedures for genetically modified plants.

Intellectual Property Rights

Intellectual property rights (IPR) are commonly defined as "rights protecting innovation, creativity, or goodwill created in the marketplace. They indirectly protect investment. (...) In essence, IPRs provide exclusive rights allowing a rightholder to exclude others from using the protected information. They provide a defensive monopoly right, mostly limited in duration" (Cottier, 1994, p.1/2).

Similar to the case of biosafety, several international initiatives try to harmonise the regulation regarding intellectual property rights of innovations of biotechnology. But only recently they succeeded with the GATT agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs).[2] This gives evidence to an increasing insight from developing countries that an adequate protection of IPRs is required to promote local innovation, foreign investment, and technology cooperation. Nevertheless, IPRs are only a necessary, but not sufficient, condition and it remains to be seen to what extend these promises become reality. So far, only limited evidence exists concerning the contribution of stronger IPRs to a country's welfare and development. This is especially true for countries with a weak technology base (van Wijk *et al.*, 1993).

Cottier (1994) advocates with respect to IPRs for a revaluation of traditional genetic resources. He suggests to link the discussion for IPRs with that of biodiversity and consequently to "search for mechanisms and instruments to create returns for the owners. (...) The concept of so called farmers rights, currently under examination in FAO and part of Agenda 21, focuses on creating a new type of intellectual or cultural property right which no longer depends on criteria of novelty, but tradition" (p.7). This approach is consistent with the principle of IPR and could smooth the way for cooperation agreements with biodiversity prospectors and biotechnology research based on mutual interests.

---

[2] For the outline and implication of this agreement see Bhat (1994) and van Wijk *et al.* (1993); the changing attitudes of developing countries during TRIPs-negotiation and their reasons are described in Cottier (1994), with further references.

Other Regulatory Systems

Just in the context of IPRs the need for a strong competition law is evident in order to prevent the abuse of dominant market position achieved through enhanced protection. Moreover, this regulation can be useful to guarantee an efficient cocoa production, processing, transportation and marketing by strengthen the competitiveness on all these levels.

As land is the most important production factor for agricultural activities, the national land tenure legislation plays a crucial role for competitiveness. For instance, Côte d'Ivoire has an extremely liberal land law and therefore access to land is either free or of small monetary costs. However, in the rural areas, traditional laws regulate access to land which seems to be accepted by the government (Affou, 1993). The very low price of land is, on the one hand, a competitive advantage for Ivorian farmers but results, on the other, in less pressure for productivity enhancement and therefore in a technological trade-off to other producers elsewhere.

Labour legislation is also an important factor with respect to a competitive cocoa sector. Less restrictive laws concerning minimal wages, health and safety regulation, average working hour, or immigration positively influence the comparative advantage of a cocoa producer country. Again, Côte d'Ivoire is a good example for a country with a "ultra-liberal immigration law" (Affou, 1993). This tends to lower the wage rates but at the same time holds the risk that in case of a change in immigration policy cocoa production will struggle.

Environmental concerns become more and more important - not in developed countries only. Consequently, stricter regulations regarding deforestation, soil and water protection or the use of pesticides will increase production costs and, therefore, potentially lower the competitiveness - at least in the short run.[3]

2.2.2 Policy Instruments

There exists a range of policy instruments used by governments for interventions in order to achieve the objectives stated in Section 2.1. Basically, it can be distinguished between macroeconomic and sectorspecific policy whereas, according to the definition, the latter refers to the agricultural or other economic sectors as a whole or to individual commodity markets. Macroeconomic policies comprise mainly fiscal and monetary policy, exchange rate policy, and trade policy. Sectorspecific policies embody mainly pricing policy for commodities and inputs.

Sectorspecific policies correspond to direct interventions and macroeconomic policies to indirect interventions. There is clear evidence from a lot of different case studies that the effects of indirect interventions outweigh those of direct intervention (e.g. Bautista and Valdés, 1993; Krueger *et al.*, 1991; Diakosavvas and Kirkpatrick, 1990). These findings have consequences for the analysis of competitiveness as "... attempts to provide incentives to agriculture with commodity policies can be overwhelmed by negating macroeconomic policy that transfers resources away from agriculture and the rural economy" (Monke and Pearson, 1989, p.75).

---

[3] An early adoption of an environmentally friendly production could also result in a commodity price premium depending on the consumer preferences. Furthermore, an realignment towards a ecologically more harmless production could - in the medium or long run - become more competitive thanks to a lead in technology.

***Figure 2.2**: Policies affecting competitiveness*

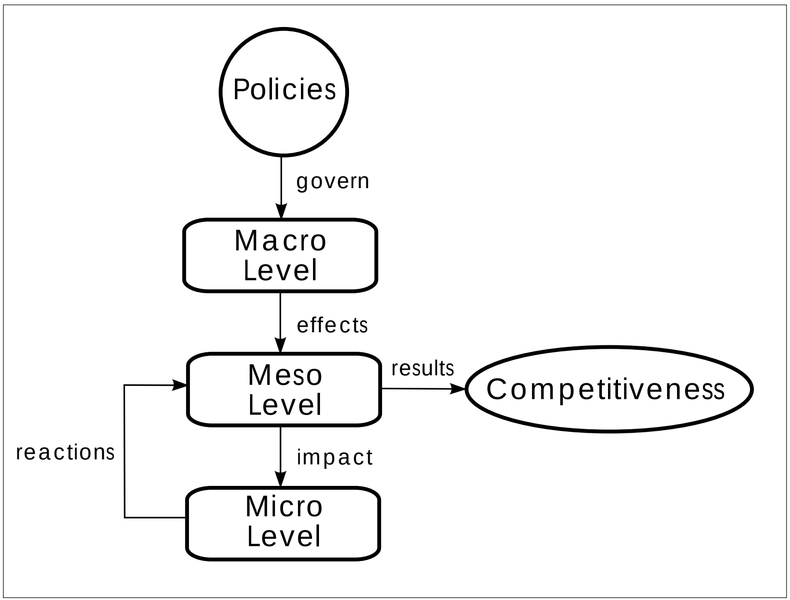


Figure 2.2 shows how policies influence competitiveness. The arrows indicate the direction in which these effects are transmitted. To link the macro level which is governed by the different policies[4] with the micro level of households and enterprises it is necessary to establish a meso level. This level comprises markets (both commodity and factor) and infrastructure and can also be found in Figure 2.1[5]. So, the policies are affecting the farm level through effects on the meso level which have impact on the micro level. These mesoeconomic linkages are crucial as the reactions of individuals (e.g. adopting a new technology or not) concern this meso level and finally result in a changing competitiveness. However, "economic policies can always be found that will effectively eliminate any degree of comparative advantage achieved through technological progress" (Gnaegy and Anderson, 1991, p.116). Following that, it is claimed to first check that the current policies allow existing comparative advantages to be exploited before supporting an improvement in productivity through research.

There are good reasons for policy interventions, especially in the context of nonefficiency objectives. One of these is the high variability of world cocoa prices as it is pointed out in Chapter 4. Stryker (1991) analysed the effect of government intervention on the variability of cocoa prices in Ghana and found a clear reduction in price instability.

In the remainder of this chapter the most important policies affecting the agricultural sector in general and the cocoa sector in particular are briefly discussed with emphasis on their impact on production level and subsequently on competitiveness.

Exchange Rate Policy

Basically, the (real) exchange rate is a measure of competitiveness of domestically produced goods in relation to goods produced in the rest of the world. However, most developing countries use fixed exchange rate regimes resulting in a gap between real and nominal exchange rate. That is, the domestic currency is often overvalued in these countries because of direct manipulation of nominal exchange rate, foreign borrowing and the government's fiscal and monetary policies (e.g. tariffs on industrial imports).[6]

---

[4] Although sectorspecific policies are not macroeconomic and therefore should described more accurately as meso level policies the ultimate impact is the same. For further explications see World Bank (1990).

[5] The meso level in this figure consistes of infrastructure, factor and other commodity markets. Although research and development is part of the infrastructure it is noted separatly because of the major role for biotechnology.

[6] For a detailed discussion on reasons for an overvalued currency see Bautista and Valdés (1993). A comprehensive treatment of the definition and measurement of different exchange rates as well as the effects on production incentives in agriculture is provided in Diakosavvas and Kirkpatrick, 1990 or Tsakok, 1990.

There is broad consensus among economists on the key role that country's exchange rate policy in particular plays on incentives to agricultural producers of export crops. An overvaluation of the currency undermines exports by creating a negative price effect resulting in an inefficient allocation of resources and therefore deteriorating the competitiveness. This affects the balance of payments negatively which further causes overvaluation. In that situation, relief can be come from a devaluation as it is pointed out by Stryker (1991) using as example the cocoa sector in Ghana during the early eighties. Simulation results on Côte d'Ivoire and Cameroon seem to confirm the positive effect on the performance of the cocoa sector from devaluation of domestic currency (Coleman *et al.,* 1993).

Fiscal and Monetary Policy

Financing deficits often involves the use of monetary policy i.e. the debt will be financed by increasing the money supply. Usually, such a policy affects inflation and interest rate and indirectly wage rates. All these variables have a strong impact on prices and thus production incentives which finally determine resource allocation for economic activities.

Fiscal policy and public spending in particular is very important for infrastructural requirements which form a crucial part of the meso economy. From there, it will have a decisive impact on the micro level. In the transportation sector a reduction in investments on physical infrastructure, for instance roads, will affect farm profitability and thus the competitiveness of the cocoa sector. On the other hand, the improvement of the financial system will increase farmers' response and therefore efficiency.

A major infrastructure in the agricultural sector is research and development. This will lead to enhanced technology and international comparative advantages and competitiveness according to the agricultural price policy (see Chapter 5). Lack of financial resources was cited as a major constraint in a survey of the development of agricultural biotechnology programmes in several developing countries. The authors also noted that this constraint concerns agricultural research in general and not only biotechnology. However, technical progress not only depends on investments in agricultural research systems but also on a wide range of other conditions as human resources, private-sector involvement, international collaboration, access to information or a consistent regulatory framework (Komen and Persley, 1993). Some of these conditions, in turn, are strongly linked to infrastructural facilities induced by public investment. Binswanger (1992) analysed and calculated the impact of infrastructure on agricultural production. This impact has long been ignored particularly in Sub-Saharan Africa, which might explain part of the reasons for their weak performance of the agricultural sector.

Trade policy

Trade policies encompass measures directed toward imports and exports. Similar to exchange rate policy they play a major role for domestic agricultural production. These two macroeconomic policies are highly interrelated and should be used in an integrated manner for the desired impact. Taxes on exports and imports strongly affect the competitiveness of the cocoa sector by influencing the producer price and the production costs. Conversely, they often represent the most important source of government revenue and their elimination would, therefore, create negative fiscal effect in the short run (Bautista and Valdés, 1993).

Another important remark has to be made with respect to trade policy. According to trade theory, 'large' countries, defined as producers capable of influencing the world market price with the help of their export share, can improve their overall welfare by imposing an optimal export tax on the corresponding commodity (see e.g. Gardener, 1990). For cocoa, Côte d'Ivoire could - theoretically - play this role and therefore increase its export revenue.[7]

---

[7] However, reality is much more complex and it is therefore questionable if this trade strategy works. First, the country in discussion needs sufficient storage capacities as well as some working capital to pay the producer. Second, the huge stock in cocoa will prevent an increase in world market prices. Third, strong substitutional effects in production and consumption would prevent such a strategy in the long run (see also section 5.3.3).

Sectorspecific Policy

This policy encompasses measures to influence prices both of products and inputs in the defined economic sector. Although the main focus lies on agricultural policy one has to be aware of the effect of other sector policies. For instance, a strong influence is brought about by the protection of domestic industry, which increase prices of farmers' input above the world market level (Krueger *et al.*, 1991). In addition, factor prices such as wage rates in the industrial sector will highly affect agricultural production as the intersectoral income differential is a major determinant of the rate of rural-urban migration (Bautista and Valdés, 1993). For instance, Malaysia's transition to a semi-industrialised country has increased labour cost in the cocoa sector resulting in a deterioration of its competitive situation (Bloomfield and Lass, 1992).

A favoured measure to influence producer prices of cocoa was the establishing of marketing boards, particularly in African countries. As a result of the recent liberalisation of export marketing many of these commodity boards have been abolished resulting in less deteriorated producer prices. However, UNCTAD (1994) has pointed out that, even from a pure efficiency perspective, not all the impacts of liberalisation have been positive.

Another widely used measure to support agricultural protection concerns subsidies for inputs. Several countries used or still use this instrument to promote cocoa production and/or technology adoption, respectively. Generally, this policy does not lead to an efficient cocoa sector as the factor price does not reflect the scarcity of that particular input. On the contrary, it creates informal markets, rent-seeking behaviour, corruption and hampers private sector initiatives and therefore wastes scarce resources. A good example for this misguided policy is the subsidy on credits. Depending on the domestic inflation the real rate of interest can easily become negative where credit is subsidised.

Finally, earnings from export taxes are an important revenue for the government but lower the producer price. In the longer run, this could hurt the competitiveness of the national cocoa sector as "...farmers will adopt new technologies and purchase the physical inputs that embody them only if they expect their income to improve. That is, price incentives also influence the diffusion of agricultural technology and the level of productivity" (Bautista and Valdés, 1993, p.12).

2.3 Exogenous Factors

The most important determinants of competitiveness that are outside government's influence are indicated on the right hand side in Figure 2.1. The arrows show the direction of influences from the different factors on competitiveness, direct and indirect. These factors are 'International Agreements and Regulation', 'International R&D', and the general 'External Economic Environment' as well as 'Consumer Countries' Demand' and 'Other Producer Countries' Supply' which are an integral part of the cocoa market. Although decision makers can hardly influence these factors they should take into account their potential impact on the competitiveness of a cocoa sector. Therefore, the terms are briefly discussed with respect to their influence on competitiveness.

International Agreements and Regulation

International regulations stemming from the Uruguay Round of the 'General Agreement on Tariffs and Trade' (GATT) or from the 'International Cocoa Agreement' (ICCA) can have an indirect impact on the cocoa sector. The competitiveness of producer countries may be influenced, to varying extends, by the requirement to adapt the national regulatory framework or by production controls.

Competitiveness is definitely affected if changes in national legislation is necessitated by bilateral trade negotiation. This happened when industrialised countries pressed developing countries to adopt stronger intellectual property rights legislation.

The GATT negotiations have brought into discussion the requirement for antidumping rules tied to ecological and social issues. It can be expected that future trade agreements will result in more such regulations.

International R&D

There is a growing number of international initiatives in agricultural biotechnology consisting of projects, programmes, and networks as reported in an IBS survey (1994). The results of such activities, partly financed by bilateral or multilateral donor organisations and often executed by IARCs, may provide a considerable input for a national cocoa system and lead to an improvement of its competitiveness. At the same time, competitors can also profit from these initiatives. Moreover, decision makers should be aware of the fact that international programmes are mostly funded on a short-term basis whereas the whole process of development, adoption and diffusion of a new technology is very complex and consequently long-term (Brenner and Komen, 1994).

External Economic Environment

Without doubt, the global situation influences the cocoa economy. Again, cocoa producing countries are affected differently by international developments of interest rates, main currencies, raw material prices or political disturbances and population growth. Accordingly, the impact on their competitiveness may vary. The same goes for consuming countries which, on their part, have a considerable influence.

Consumer Countries' Demand

Consumer countries' behaviour is crucial for the performance of national cocoa sectors. Their trade barriers, food regulations, consuming habits, and economic situations affect individual producer countries' competitiveness and future developments in these areas should be taken into account. Good examples are the substitution of vegetable oil for cocoa butter or the trends in concentration of the processing industry mentioned in Chapter 4.

Other Producer Countries' Supply

Finally, considerations on competitiveness have to include the quantitative and qualitative supply from other cocoa producing countries. These encompass the technological level of production and processing, trends in factor prices and their availability as well as the production structure with respect to the age of the trees or the use of hybrids. The possibility of newly emerging cocoa producer should also be taken into account.

2.4 Summary

In this chapter, the regulatory, economic, and political framework of competitiveness are presented. The interrelationship between different factors and their impact on biotechnology as well as their influence on the national cocoa sector are highlighted. Priority setting with respect to efficiency and nonefficiency objectives is described as repeating political process. National regulation is identified as an important determinant of competitiveness which is particularly true for legislation affecting biotechnology.

A crucial impact in the context of a competitive cocoa sector is coming from the various political instruments among them the macroeconomic ones are without doubt the most effective. Sectorspecific policies also influence decisions of cocoa farmers and have, therefore, a major effect on the adoption and diffusion of new technologies. Finally, some major exogenous factors which influence competitiveness are briefly discussed.

Chapter 3

Biotechnology and Cocoa[8]

3.1 Introduction

This chapter presents the state of cocoa research, its goals and activities, its expected results and impacts as well as information on technological and social constraints and prospects influencing research progress. The results have been gathered with the help of an expert survey. It should provide information to policy makers on the expected developments in cocoa biotechnology. The rationale to base forecasts of future technological developments for cocoa production on actual research activities is the long term perspective of perennial crop improvement described in the following section which deals with the technological key constraints limiting progress in cocoa production and crop improvement.

Section 3.2 briefly discusses basic production and technological constraints for coca to demonstrate the incentive for cocoa research and the development of improved production systems.

Section 3.3 defines biotechnology to provide a common basis of interpretation of the findings of this study.

Section 3.4 presents the state of cocoa research, its goals, prospects and limitations.

Finally, Section 3.5 outlines the conclusions of this chapter.

3.2 Basic Production and Technological Constraints for Cocoa

The most serious production constraints are caused by pathogens. Table 3.1 shows the important diseases and pests in cocoa, their geographic location and the estimated annual loss in affected regions.

---

8 Certain authors make a distinction between 'cacao' as referring to the tree of the genus *Theobroma* and his products and 'cocoa' as the drink made from its seeds. On the other hand, standard literature for this crop (e.g. Wood *et al*., 1985), and international commodity literature (e.g. FAO) refer to both categories as 'cocoa'. The latter terminology is used in this report.

Table 3.1: *Major diseases and pests of cocoa and their estimated loss*

Common name	Scientific name	Geographic distribution	Estimated annual loss in affected regions
‘Black pod’, ‘*Phytophthora* pod rot’	*Phytophthora spp.*	World-wide	5-90%
‘Witches’ broom’	*Crinipellis perniciosa*	W.Brazil, Columbia, Ecuador, Peru, Venezuela, Trinidad, Panama	10-90%
‘Soft rot’, ‘*Monilia* disease’, ‘*Moniliophthora* pod rot’	*Monilia roreri*	Amazon, Columbia, Ecuador, Peru, Venezuela, Central America to Costa Rica	10-65%
‘Vascular streak dieback’	*Oncobasidium theobromae*	Papua New Guinea, Malaysia, Indonesia, India, Philippines	10-50%
‘Swollen shoot’	Cocoa swollen shoot virus (CSSV)	Nigeria, Ghana, Côte d'Ivoire, Sierra Leone, Togo	100% of infected trees killed
‘Cocoa moth’, ‘cocoa pod borer’	*Conopomorpha cramerella*	Philippines, Malaysia, Indonesia, the Moluccas	Up to 50%
‘Mirids’, ‘capsids’	*Helopeltis spp., Monalonian spp.*	Cameroon, Nigeria, Ghana, Côte d'Ivoire, Togo South and Central America	20% 5%

Source: Adapted from Larson (1986), and completed from Bloomfield and Lass (1992) and Söndahl (1994)

A restriction inherent to breeding progress for all perennial crops is the long term perspective for improvement: For cocoa, e.g., first bean yield can be expected at the age of two years (hybrid varieties) to four years (traditional varieties) (UNCTAD, 1991). A tree must be at least five years old before the number of pods available is adequate to permit any yield assessment in the field (Bloomfield and Lass, 1992). The release of non-segregating seeds will take a minimal of 24 years for six cycles of crossing and selection (Söndahl, 1994).

Cocoa has a complex incompatibility system and so, plants close to each other with incompatible genes will bear very few fruits (Söndahl, 1994). The existence of incompatible genes poses additional difficulty to introgress wild genes into cultivated clones. Cocoa yields can be further improved by the proper exploitation of the hybrid vigour. Hybrids between the Upper Amazon types and the Amelonado or Trinitario genotypes produce hybrid plants that outperform the parental types with respect to early vigour, ease of establishment, and precocious production (Söndahl, 1994). But these Amazon parental lines are highly heterogeneous which creates great variability among the resulting F1 hybrid population. The creation of homozygous Amazon lines for hybrid seed production or the vegetative propagation of the elite hybrids would bring enormous gains in cocoa plantations.

3.3 Biotechnology and Genetic Engineering Defined

Biotechnology has been defined in many different ways. Definitions range from very narrow ones, which comprise only the latest developments in genetic engineering, to very wide and comprehensive ones, which include long established, and widely used techniques, which are based on the commercial use of microbes and other living organisms, through to the more complex and strategic methods of genetic engineering of plants and animals. Broadly defined, biotechnology includes „the application of scientific and engineering principles to the processing of materials by biological agents to provide goods and services“ (Bull *et al*., 1982, p.21).

Modern biotechnology comprises a body of knowledge and techniques involving the integrated use of biochemistry, microbiology, genetics and engineering sciences to achieve the technological application of the capabilities of living organisms such as micro-organisms, cultured tissue cells and parts thereof but also plants and animals. This definition stresses the multidisciplinary nature and strong scientific foundation of modern biotechnology. According to Orsenigo (1989), these features constitute the distinctive character of modern biotechnology whereas traditional biotechnology had an empirical, rather than scientific, foundation up to the second half of the last century.

According to Persley (1990) the combination of recombinant DNA technology, monoclonal antibody production and cell and tissue culture forms the basis of genetic engineering of microbes, plants and animals. The key components of genetic engineering are

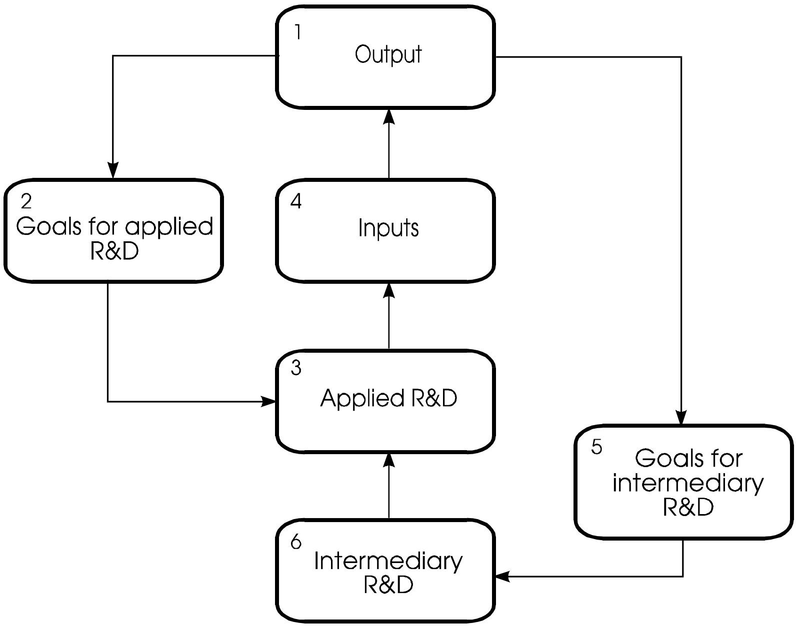
1. identification and isolation of suitable genes to transfer
2. delivery systems to introduce the desired gene into the recipient cells
3. expression of the new genetic information in the recipient cell.

In this study agricultural biotechnology is interpreted in the broad sense on the basis of Bull *et al*. (1982) including modern biotechnology and genetic engineering as defined above but also the wide range of tools, agents, and knowledge to influence the productivity of crop plants and farm animals. This includes traditional breeding of crops and animals, biological and microbial control of pathogens, integrated management of pests and diseases, and the modification, regulation and management of agricultural production systems by agronomic means to obtain improved and more stable yields of the desired system's output. This is an adequate definition because many substitutional and complementary possibilities exist to improve the productivity of agricultural systems, to modify the quantity and quality of its outputs and the necessary inputs.

3.4 Cocoa Biotechnology: Status, Goals, Prospects and Limitations

This section presents the status, constraints and potential of cocoa biotechnology research and development (R&D). It is based on a written expert investigation. Information on this survey and a list of participating experts is included in the appendix. to facilitate a systematic discussion, the results of the survey are discussed with the help of Figure 3.1. Our analysis starts with the box 'Output' (1) on the top.

Figure 3.1: *Interactions between cocoa production, research, and inputs*



A primary driving force for research and technological progress is inadequate output of production systems and technological shortcomings of the inputs required to obtain this output, respectively. Output must be understood in a comprehensive way, including the quantity and quality of the requested products, but also undesirable side-effects of the production such as ecological damage.

These inadequacies cause the re-formulation of the 'Goals for applied R&D' (2) in the political process. Besides goals for R&D, there are further classes of goals such as social, political, and economic which direct the re-formulation of goals for R&D. For cocoa, the following goals for applied R&D are designated:

- Reduced yield losses caused by
  - diseases
  - pests
  - environmental stress
- Improved crop quality with respect to
  - flavour, e.g. alkaloids (theobromine contents) and protein storage
  - plant lipid biochemistry and biosynthesis to regulate fat content (total butter production) and fatty acid composition
  - improved morphological characteristics (e.g. bean size)
  - reduced pesticide residues and heavy metal contamination in the beans
- Improved crop production systems
  - reducing requirements for non-renewable inputs per hectare (pesticides, fertiliser)
  - reducing land and labour requirements to produce a given cocoa quantity
  - providing modified planting, pruning and rehabilitation systems (e.g. planting of different resistant lines, optimised canopy architecture to reduce water stress or disease and pest attack)
  - reducing environmental pollution and degradation caused by cocoa production (e.g. pesticide contamination and soil degradation, deforestation of primary forests)
- Improved nutrient assimilation capacity, availability and partitioning

- Increased yield.

'Applied R&D' (3) provides improved inputs and refined methodologies for the application of newly developed and already existing inputs, respectively. The tools for applied R&D are:

- Practical crop breeding (e.g. to improve resistance to diseases and pest, and environmental stress, to enhance quality and yield, to promote precocity and to improve management characteristics of the trees)
- Disease and pest control
  - Biological and microbial control
  - Methods for the integrated management of diseases and pests
- Epidemiology
- Plant pathology and agricultural entomology for the screening of the host range and pathogenicity and the analysis of host-pathogen interactions
- Crop physiology to investigate yield and quality formation
- Agronomy to improve e.g. cropping systems, and crop rehabilitation and replanting
- Crop system analysis and modelling.

As a result of this research, improved 'Inputs' (4) such as new planting materials and pesticides but also refined cultural practices through the application of new management knowledge are available to produce more of the desired outputs. However, practical experience sufficiently illustrates that their success for perennial crops is limited for various reasons (see Section 3.2.). To improve their efficiency - and consequently the output of the production system - it is necessary to fulfil certain 'Goals for intermediary R&D' (5) which are:

- Improved knowledge of the crop
- More efficient practical crop breeding thanks to
  - systematically improved selection criteria
  - faster, earlier and more effective field selection
- Faster planting material multiplication and production
- Conservation of genetic resources
- Improved knowledge and understanding of diseases and pests.

These goals for intermediary R&D are not new. But only in the last few years, technological innovation allowed the development of 'Intermediary R&D' (6) which mainly includes techniques and methodologies of modern biotechnology. The tools of intermediary R&D are:

- Cocoa germplasm characterisation, conservation, and management
  - with the help of the complete plant or parts of it
    - Morphological characterisation using botanical descriptors
    - Agronomic and technological characterisation and evaluation
    - Database management/(electronic) documentation
  - Genetic characterisation using
    - biochemical markers
    - molecular marker technology
- Genetic characterisation of the pathogens using molecular marker technology
- *In vitro* techniques
  - Plant regeneration and micropropagation
  - Germplasm preservation and conservation
- Genetic engineering.

In the next section, an overview on the importance of various R&D fields and goals is given followed by a section describing the status and potential of intermediary R&D in more detail, and a section analysing the role and prospects of applied R&D under the new perspectives of efficient intermediary R&D and by an overview on factors constraining cocoa research.

3.4.1 Importance of Specific Research and Development Fields and Goals

Figure 3.2 is based upon the classification of R&D fields and goals discussed in the previous section. Goals for intermediary and applied R&D are listed on the horizontal. The importance of specific fields of intermediary and applied R&D is depicted on the vertical. The first eight items listed in the figure's caption are fields of applied R&D according to the definition in the previous section. The remaining four items are elements of what we defined as fields of intermediary R&D. The total length of a bar reflects the overall importance of all R&D fields for the achievement of the belonging R&D goal. A bar is the aggregate of those R&D fields relevant to achieve the belonging R&D goal. Each sub-unit of a bar represents a specific R&D field and its length reflects the importance measured by the number of times that the experts declared this field to contribute to the accomplishment of the belonging R&D goal. The bars are arranged in descending order.

From the figure it can be seen that the three most important R&D goals are goals for intermediary R&D which are: Improved knowledge of the crop (first bar) followed by more efficient crop breeding thanks to faster and more effective field selection (second bar), and more efficient crop breeding thanks to improved selection criteria (third bar). Furthermore, it can be seen from the figure that germplasm characterisation with the help of the complete plant and genetic characterisation (first two sub-units of the bars) are the most prominent R&D fields to achieve these goals. Further important fields to obtain these three R&D goals - in varying order- are *in vitro* techniques, plant pathology and agricultural entomology, agronomy, and crop physiology.

A next group R&D goals includes three goals classified in the previous section as goals for applied R&D. These include reduced yield losses caused by diseases (fourth bar), improved production systems through reduced use of non-renewable inputs (fifth bar) and increased yield (sixth bar). These goals will be achieved through a combined effort in various intermediary and applied fields for R&D, in particular integrated management of diseases and pests, agronomy, practical crop breeding - in particular resistance breeding - and biological and microbial control of pests and diseases.

The importance of various R&D fields to achieve the remaining R&D goals depicted in Figure 3.2 is not further discussed here. It is only referred to the significant role of *in vitro* techniques to achieve faster planting material multiplication and production (eighth bar).

Figure 3.2 has to be relativized in the sense that it purely sums the number of times the experts mention specific R&D fields to contribute to the achievement of a particular R&D goal. However, this type of analysis neither takes into account the amount of funding or the number or quality of scientific staff available nor does it provide information on the chances for a successful achievement of a specific R&D.

3.4.2 Intermediary R&D

General Aspects

Intermediary R&D includes the development and application of methods for the cocoa germplasm characterisation, conservation, and management with the help of the complete plant or parts of it, research on marker-based genetic characterisation of cocoa and of pathogens infesting the crop, and the development of systems for the *in vitro* regeneration, multiplication, and conservation of cocoa. They provide better knowledge of the crop with respect to its genetic, physiological and breeding characteristics, and disclose biological, physiological, technological, phytopathological and agronomic characteristics. Furthermore, they assist to the systematic improvement of practical crop breeding providing refined criteria for the selection of crossparents in the breeding process, and a more effective and faster selection of clones with valuable characteristics followed by an accelerated propagation of planting material from these clones.

The importance which is granted to the improvement of intermediary R&D can be seen from the fact that 25 out of the 44 participating experts (57%) describe research projects developing one or several of these methodologies or techniques. Many institutions are simultaneously active in several fields - several mainly publicly financed large bodies in the three most important fields cocoa germplasm characterisation, conservation, and management with the help of the complete plant or parts of it, genetic characterisation, and *in vitro* techniques.

Cocoa Germplasm Characterisation, Conservation, and Management with the Help of the Complete Plant or Parts of it

Management of cocoa germplasm by means of morphological characterisation using botanical descriptors and agronomic and technological characterisation and evaluation are not newly developed tools of intermediary R&D. They have ever been a prerequisite for the successful development of applied research, in particular for crop breeding. However, the new prospects and possibilities in the fields of modern biotechnology included in intermediary R&D confer increased weight and significance and a primary and strategic importance to the management, improvement and conservation of the crop and allow a more systematic approach. 11 out of the 44 participating experts describe research activities in this field.

A central role in this field plays the phenetic characterisation of the roughly 2500 accessions of the International Cocoa Genebank of the Cocoa Research Unit at the University of the West Indies, Trinidad, managing germplasm from South and Central America, and various other countries. This project started in 1990. It will facilitate the utilisation of the available genetic resources for the international cocoa community through the international cocoa germplasm database located at the University of Reading, U.K. In addition to the activities in Trinidad, further projects are described by experts from CATIE in Costa Rica, CEPLAC/CEPEC, in Itabuna, Brazil, and at the USDA National Germplasm Repository in Miami (genetic characterisation).

The accessions are described for, e.g., agronomically and economically important traits such as parameters contributing to pod index (the number of pods to produce one kilogram of dried beans), yield quality (e.g. total cocoa butter content), and resistance to *Phytophthora* pod rot and witches' broom.

This research assists the development of an efficient cocoa germplasm core collection, and also aims on the standardisation of characterisation methodology. It provides essential botanical and agronomic information for plant breeders. Analysis of the data could lead to the identification of associated characteristics and facilitate the detection of mislabelled accessions and duplicates. It will help to improve cocoa breeding efficiency world-wide allowing, e.g., a better choice among hybrids parents.

Furthermore, wild cocoa materials are collected, analysed, described and evaluated, e.g. Guianese and Malaysian wild cocoa.

The experts describing projects in this field expect valuable results to be available within the next four to nine years.

Genetic Characterisation

12 out of 44 answering experts describe research projects for the genetic characterisation of cocoa; five of them are also involved in the morphological and agronomic characterisation and the conservation and management of complete plants or parts of it. This illustrates the importance and interdependence of these fields. One project is related to the genetic characterisation of the cocoa witches' broom pathogen.

Biochemical markers (isozyms or proteins) or molecular marker technology such as restriction fragment length polymorphism (RFLP) and random amplified polymorphic DNA (RAPD) are used to produce genetic linkage maps and for quantitative trait loci (QTL) analyses. With the help of these methods, genomic regions are tagged which are associated with yield components (podweight, pod index, seed weight, self-incompatibility), formation of yield and crop physiology (dry matter partitioning, light interception, canopy architecture), heritability of the resistance to diseases (*Phytophthora* and *Moniliophthora* pod rot, and witches' broom), fat content and quality (fatty acid profile), and flavour characteristics (alkaloids, protein storage). Information on the number of genetic factors expressing a character, their localisation on the chromosomes and the relative contribution of a given factor in the factor expression can be evaluated.

With the help of these tools, cocoa breeding could be speeded, using marker-assisted selection. For the end user (processors) these methods represent a strategic tool providing information on raw material characteristics and - in combination with the possibility of long term *in vitro* preservation of genetic resources and rapid micropropagation - a competitive advantage for product innovation.

Again - as for the morphological and agronomic characterisation and conservation and management of complete plants or parts of it - the experts expect project goals to be achieved within two to ten years.

In Vitro Techniques

Several *in vitro* techniques are developed:

- *In vitro* regeneration and micropropagation:
  - Axillary bud culture
  - Regeneration of somatic embryos of non-zygotic origin
  - Protoplast culture
  - Micropropagation in liquid culture
- Germplasm preservation and conservation by means of cryopreservation or in liquid cultures

11 experts (25%) describe research activities in this field. All of them are involved in the development and improvement of *in vitro* plant regeneration. This demonstrates that still

considerable efforts have to be made to obtain reliable and efficient protocols for the regeneration and propagation of cocoa plants from cells. The applied aspects of plant and tissue culture play an important role. Due to the recalcitrant plant, several groups are developing different systems to get an appropriate protocol for plant propagation from somatic embryos and to develop systems for the regeneration of protoplasts. Improved methodology will speed crop breeding and assist crop selection and multiplication and opens new opportunities for genetic engineering rendering crop improvement more efficient.

Research institutions of two participants are engaged in the long term *in vitro* preservation and conservation of genetic resources. It will allow an easier conservation and exchange of genetic resources

The knowledge gained with molecular marker technology and *in vitro* techniques allows a faster and more flexible reaction to the requirements of processors allowing accelerated product innovation and thus a more rapid reaction to changes in consumers' demand and economic and legal environments. The practical realisation of the new prospects opened by these modern tools will be influenced much more by the economic (production costs) and legal (food legislation) environment and consumers acceptance of these products than by technological restrictions.

Genetic Engineering

Only two participants describe research projects involving genetic engineering. This may be due to the only recent success of the *in vitro* regeneration of cocoa which is a prerequisite for the application of genetic engineering. One project tries to genetically transform cocoa for the eventual purpose of introducing foreign genes conferring resistance to fungal pathogens and insect pests into cocoa. The scientists want to obtain transgenic somatic embryos with test genes by using *Agrobacterium tumefaciens* and biolistics, then to regenerate transgenic plants from these embryos. However, for the moment being, the frequency of genetic transformation of cocoa cells is very low. Nevertheless, first transgenic plants are expected to be regenerated in 1996, first field tests of transgenic disease or insect resistant cocoa in the year 2000. The other project does not list specific possibilities for genetic transformation but mentions the application of genetic engineering as to offer possibilities in many fields after the successful development of more efficient *in vitro* techniques.

3.4.3 Applied Research and Development

The Importance of Different Tools for Applied Research and Development

The most important tool for applied (R&D) is crop breeding (including one project describing the use of mutation breeding). 14 of the 44 participating experts describe activities in this field, seven of them breeding for enhanced resistance or tolerance to pathogens as the most important goal. Seven of those experts applying or improving crop breeding for cocoa describe also activities in the development of intermediary R&D discussed above. This shows the importance of intermediary R&D to render applied cocoa R&D more efficient - in particular breeding.

Nine experts mention activities in the field of disease and pest control (outside of resistance breeding), four of them being active in the development of methods for the biological and microbial control of cocoa pathogens, seven developing improved methods of integrated pest and disease management.

Not only the integration of intermediary R&D for the improvement of tools for applied R&D is of central importance but also a co-operation among applied disciplines. This can be illustrated with the fact that eight experts who describe agronomy as a tool for the improvement of cropping systems and crop rehabilitation apply crop breeding in their research activities too.

The Importance of Various Goals for Applied Research and Development

From the experts' answers also the overall importance of various goals for applied R&D can be evaluated. The most important are reduced requirements for non-renewable inputs (pesticides, fertiliser), reduced yield losses caused by diseases, and again - as already for the intermediary R&D - improved knowledge of the cocoa crop, and yield increase.

In general, the application of tools for applied R&D will result in increased cocoa productivity (e.g. yield per hectare or yield per hour of labour input) and changed production intensity (hence, the ratio of two inputs, e.g., more labour per hectare due to increased yield or reduced pesticide input per hectare caused by more resistant crops).

For cocoa breeding, particularly, primary goals are the reduction of yield losses caused by diseases, followed by reduced requirements of non-renewable inputs and increased yield. The same three goals have highest priority for experts describing projects in the field of disease and pest control (biological and microbial control plus integrated management of diseases and pests) and for experts improving production systems by means of agronomy.

The rehabilitation and replanting of old cocoa is an important integrated research goal mentioned by several experts. Various intermediary and applied tools will have to interact to achieve this goal and to stop cocoa production unsustainably drawing on the forest capital and consuming primary forests through new cocoa planting as a pioneer crop.

Even though post-harvest processing is not explicitly included in this survey, several projects deal with post-harvest quality monitoring and improvement, e.g. during cocoa fermentation and drying but also during chocolate manufacturing where modern biotechnology (e.g. with the help of enzyme technology) can also play a significant role. Improved and new innovative chocolate products could increase consumers' demand and thus raise cocoa world market price.

There is one project dealing with cocoa by-product development which could have positive results for the environment and create additional income to African small peasant farmers.

3.4.4 Factors Constraining the Success of Cocoa Research and Development

The emphasis on intermediary R&D in cocoa research reflects the continuing lack of basic knowledge on genetic diversity and on the qualities and characteristics of cocoa germplasm - also with respect to the value of clones for practical breeding. The systematic development and application of intermediary R&D in cocoa research is still emerging. Their reliability and efficiency is still lacking and must be validated with the help of tools for applied R&D such as breeding. Also basic knowledge on the ecobiology of pests and diseases is still very rare.

Many experts blame a lack of continuity and research co-ordination for cocoa. The lacking long term continuity increases the turnover of scientists and prevents the creation of a stock of qualified scientists. This is a necessary prerequisite not only for basic sciences but also for practical field research (e.g. collection and evaluation of genetic resources) and for research on smallholders' level, all time consuming and complicated long term tasks, and therefore difficult to be continuously financed.

From the point of view of international research, the establishment of an international centre for cocoa research is considered essential by various experts. This institution could internationally co-ordinate and structure long term research and should efficiently establish the necessary additional funding for research and provide more well-trained scientists and better equipped research institutes.

In general, a lack of inter-institutional collaboration and exchange of experience and information is felt. Also the international exchange of germplasm is impeded by quarantine regulations and a lacking legal framework for exchange of breeding material.

Persistently low cocoa prices curtail further projects - in particular commodity funded-ones- by local institutions and corporations. Or they restrict the implementation of research results in cocoa production because of too high costs in relation to the low commodity price level (e.g. integrated control of the cocoa pod borer).

In particular, the research of some scientists from producer countries is impeded by budgetary restrictions of national governments and relatively expensive hard currency imports. This becomes manifest in short laboratory equipment-such as microscopes and computers - and chemicals, or lacking equipment for field research. Also short funding to employ more staff and low salaries often prevent research progress specially in these countries.

'Field people' such as practical breeders still doubt the contribution of modern biotechnologies to the improvement of conventional breeding methods. Some of them perceive an over-reliance on genetic resources and an under-emphasis of genetic principles. Scientists from applied fields of R&D fear that research on modern biotechnology is conducted at the expense of applied research. This would hinder the necessary evaluation of modern biotechnology with the help of applied methods and their integration into the methodological building of applied research such as practical breeding. The application of modern biotechnology should be the most cost-effective way of overcoming constraints and be complementary rather than competitive with practical breeding. Practical breeders and agronomists feel that they are best placed to identify and prioritise the biotechnologies as tools in strategic research, but - according to them - the decisions on research investments are often taken by donors.

3.5 Conclusions

Thanks to the development of intermediary R&D, the following research progress can be expected within the next ten years:

- Better knowledge of the cocoa tree with respect to its morphology, botany, agronomy, genetics, physiology and quality characteristics
- Improved systems for the *in vitro* regeneration and micropropagation of cocoa, and long term *in vitro* conservation of genetic resources
- Development of a system for the production of transgenic cocoa
- More efficient and faster breeding and propagation of cocoa
- Better understanding and control of cocoa production systems and improved systems for the rehabilitation of old cocoa plantings.

The speed and direction of research progress will mainly depend on a better integrated cocoa research policy and organisation and the level of long-term research fund.

For cocoa production, technological progress may offer the following prospects within the next 20 to 30 years:

- From the point of view of technology it may be possible to reduce yield losses caused by the economically most important diseases and pests, in particular *Phytophthora* pod rot and witches' broom but also to *Moniliophthora* pod rot, vascular streak dieback, the cocoa pod borer and the cocoa swollen shoot virus. These reductions may be achieved by a combined application of various intermediary and applied research tools.
- Improved resistance to pathogens and improved cultivation systems may result in a reduction of pesticide application in cocoa. Regional differentiation (or a differentiation with respect to labour costs) is necessary. Research aiming on the improvement of cocoa as an estate crop tries to increase the productivity of land and labour whereas a reduction of the requirements of non-renewable inputs may not be a primary goal in these production systems. Reduced input requirements for non-renewable inputs such as expensive pesticides are of primary importance for smallholders' production systems.
- Enhanced productivity will most probably also change the quality and quantity of inputs required to realise the yield potential, in particular the quality of land, and the amounts of fertiliser, water and labour.
- It can be expected that the combination of various technological tools will allow an improved rehabilitation of old cocoa plantings and thus to reduce deforestation of primary forests for new cocoa plantings thanks to a better productivity of rehabilitated plantings.
- The knowledge gained with molecular marker technology and *in vitro* techniques allows a faster and more flexible reaction to the requirements of processors permitting an accelerated product innovation and thus a more rapid reaction to changes in consumers' demand and in changing economic and legal environments.

- The practical realisation of modern biotecnologies in cocoa production - such as *in vitro* techniques - will be influenced much more by the economic (production costs, cocoa productivity and profitability) and legal (food legislation) environment, and consumers' acceptance for these products than by technological restrictions.
- Transfer of genetic information responsible for the production of cocoa yield components in crops other than cocoa (e.g. oil crops such as soybean) has not been mentioned by the experts. For the moment being, such developments can neither be assumed nor entirely rejected.
- The interactions between the impacts of future cocoa biotechnology in production (e.g. through changing production costs, yield quantity, stability and quality), and demand of the industry and consumers can not be predicted at the moment. However, it will influence the direction and intensity of future cocoa research.
- Cocoa biotechnology will broaden the range of new cocoa varieties. In addition, their development, propagation and market introduction will accelerate thanks to the development of improved intermediary R&D and more efficient cocoa breeding. Hence, adequate and timely information of the producers with respect to new biotechnological innovations will be crucial. Furthermore, producers must be able to adopt and implement new technology and the necessary complementary inputs. Technical support from extension services and the promotion of information diffusion will be essential for the provision of an optimal performance of new biotechnology in the context of increased international competition.

Chapter 4

The International Cocoa Market

As mentioned in the introduction and shown in Figure 2.1 the international cocoa market is the most important determinant of the competitiveness of national cocoa production systems. Theoretically, the international cocoa market equilibrates supply and demand to define a price. The international price and the competitors facing the producer in question have a crucial influence on competitiveness. Furthermore, the structural aspects of the market such as the prevailing trading conditions, actors or binding agreements play an important role. These structural features of the cocoa market are described in the following section. In Sections 4.2 and 4.3, economic parameters of importance for the analysis of the future competitive situation of producer countries are discussed. Besides information with respect to overall prices and quantities, the data concerning yields, separate shares of quantities produced and consumed, stock, growth rates and variations of them are presented. In Section 4.2 the actual situation is considered, whereas in Section 4.3 forecasts made by different organisations are discussed.

4.1 Structural Features

To meet the objectives of this study, one has to be aware of the major characteristics concerning the international cocoa market. In the present section this basic information is given under the following key words: general aspects, production, consumption, and trade.

4.1.1 General Aspects

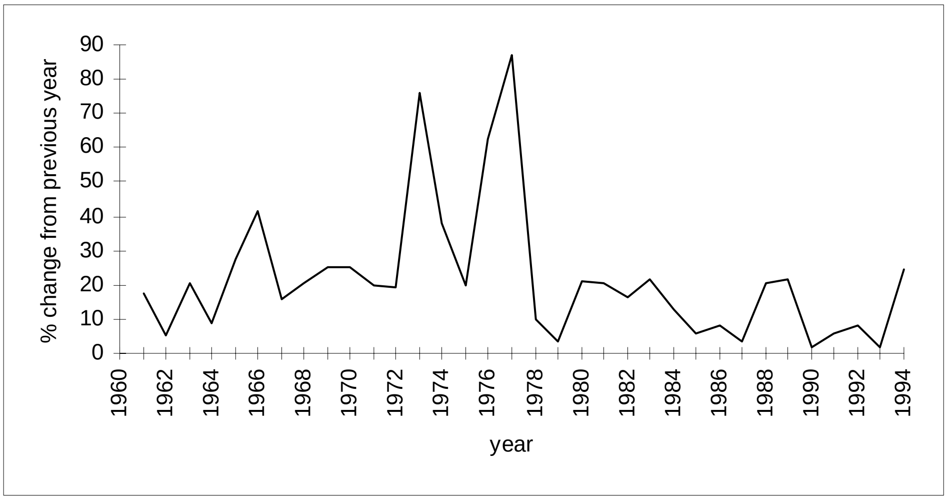
Compared to other important commodity markets, the cocoa market has a modest volume. The world production of cocoa amounted to about 2.4 million tonnes in 1993 whereas coffee production reached more than twice that level - 5.8 million tonnes - and sugar cane 104 million tonnes (FAO, 1994).

A major feature of the international cocoa market is the observed price instability. This instability is associated with fluctuations in supply and the inherent inelastic demand[9]. Although, similar commodities exhibit this phenomena, according to Amin (1993) cocoa has the highest index of price instability. Figure 4.1 shows the annual fluctuations of the world cocoa price for the last 30 years.

---

[9] A commodity is called price inelastic if the ratio of the relative change in quantity to the relative change in price is less than |1|. For instance, if a decrease in the cocoa price of 10% causes an increase in the quantity demanded of 7%, the elasticity (of demand) is -0.7.

Figure 4.1: *Year-to-year percentage change in world cocoa price*[a]



[a]Average of daily prices, New York/London, 3 month futures, US cents/lb.
Source: calculated from UNCTAD, Monthly commodity price bulletin, various issues

There are two main international organisations concerned with cocoa: the 'Cocoa Producers Alliance' (CPA) and the 'International Cocoa Organisation' (ICCO). The CPA was founded in 1962 following severe consecutive years of poor cocoa prices. At that time, it was only the second producers' organisation from developing countries (after OPEC). Their goals were the exchange of technical and scientific information, improvement of the relations among producers, regulation of cocoa supply to obtain higher prices, and the promotion of consumption. Today, the influence of this alliance is quite limited because major producers such as Malaysia are not members. it represents only 77 percent of the global exports (Hanisch and Jakobeit, 1991). The ICCO was established in the context of the first International Cocoa Agreement (ICCA). The main task of the organisation was the accomplishment and supervision of the four agreements which came into force over the years 1972,1975, 1980, and 1986. The purpose of these agreements was always to stabilise the world cocoa price - with no success as Herrmann *et al.* (1993) stated in a thorough assessment of the last two agreements. The newest attempt for a co-ordinated action is the recently concluded International Cocoa Agreement, 1993, which does not incorporate any measures for price-stabilisation. Instead of a market intervention mechanism, the new agreement intends to implement a 'production-management plan' targeting a long-term balance between supply and demand.[10]

4.1.2 Production

Cocoa production takes place on an area of 5.4 million hectares located 10 degrees on either side of the equator. The main producer countries are Brazil and Ecuador in Latin America, Cameroon, Côte d'Ivoire, Ghana, Nigeria in Africa and Indonesia together with Malaysia in Asia. Africa provides virtually 50% of the world's cocoa production. The other half comes in equal proportions from Latin America and Asia. Côte d'Ivoire is the world biggest producer and holds a share of almost 30% of the world market (FAO, 1993a). That gives the country a market power which - at least in the short run - allows it to influence the world market price. For large cocoa producing countries like Côte d'Ivoire this fact has to be taken into account for the calculation of competitiveness (see Section 5.3).

The structure of cocoa production can roughly be divided into smallholders and estates.[11] Bloomfield and Lass (1992) estimated that around 80 to 85% of the cocoa is grown by smallholders cultivating less than 5 hectares of cocoa. They also associate the two production types with the different regions by stating that in "...the four West African

---

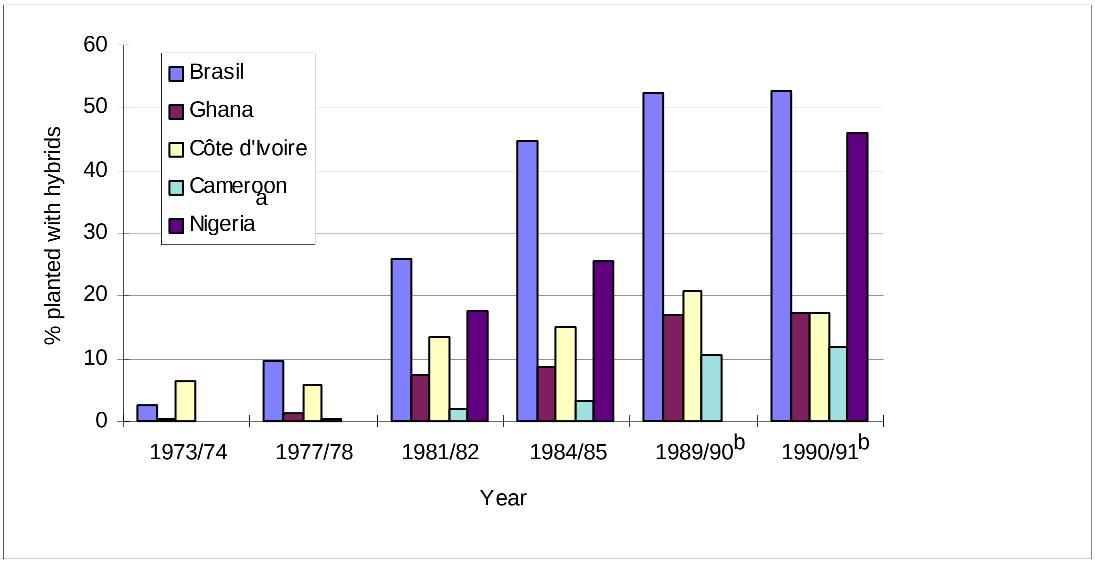
[10] See Brewer (1993) for a comprehensive discussion of this ‘production-management plan’;

[11] In fact, there exists more production types. An example for Malaysia’s different cocoa production systems is provided by Jarrige (1993).

countries cocoa is cultivated almost exclusively by small-scale farmers, in contrast to Indonesia, Brazil and particularly Malaysia, where a significant portion of the crop is grown on large plantations" (p.81). And concerning the consequences which should be drawn from that fact, they continue: "This is an important distinction with respect to the financing of research and the ability to target extension services and transfer developments in research." (p.45). The same point is mentioned in the report of UNCTAD (1991), additionally stressing the result for the use of production factors (p.22): "Estates usually have greater access to credit and other inputs, such as research findings and technologies, as well as chemicals and fertilisers, which enables them to maintain higher yields, while smallholders using family labour might face fewer labour constraints and are much less vulnerable to a fall in selling prices."

Another aspect of production structure concerns the use of traditional varieties and hybrids. According to UNCTAD (1991) the area planted with traditional varieties is decreasing. Whereas the Asian producers use only hybrids, the area planted with hybrids is gradually increasing in the major producing countries of Africa and in Brazil as well (see Figure 4.2).

Figure 4.2: *Percentage of area planted with hybrids for selected countries*



[a] No values available for 1973/74, 1977/78 and 1989/90;
[b] Estimations

Source: ICCO quoted in Hanisch and Jakobeit, 1991

To measure the yield of cocoa trees is a difficult task, because it is influenced by a range of factors. Firstly, a cocoa tree can have a lifetime of many decades and an associated theoretical yield profile according to the variety. The UNCTAD report (1991) provides an overview of estimated yield profiles for traditional varieties and hybrids in different countries. Secondly, cocoa yields depend heavily on the maintenance and input supply. Thirdly, average yield per area may fluctuate due to mixed cultivation. Fourthly, because of the different age of the trees, the yield per area is structurally altering. Taking into account all these factors, the yield can vary from as low as 200 or 300 kg/ha to 1'500 kg/ha or more.

4.1.3 Consumption

Whereas cocoa production takes place exclusively in developing countries, the consumption of cocoa products is more or less limited to the developed world. Only around 10% of global consumption is allotted to the producer countries. Western Europe consumes 35%, the USA 27% and Eastern Europe 17%. The bulk of cocoa in the third world is consumed in Latin America (80%), while consumption in Africa is virtually non-existent (Hanisch and Jakobeit, 1991).

Cocoa is consumed mainly as Chocolate in its various forms and only for a small part as beverage. Table 4.1 shows the leading cocoa-consuming countries according to their total and per capita consumption, respectively.

Table 4.1: *Leading cocoa-consuming countries in total and per capita terms*[a]

Ranking	Country	Total ('000 tonnes)	Country	Per capita (kilos)
1	United States	582.3	Belgium/Lux.[c]	4.87
2	Germany	268.3	Switzerland	4.69
3	United Kingdom	184.0	Iceland	3.80
4	France	157.8	Austria	3.37
5	Japan	110.4	Germany	3.33
6	Brazil	75.3	United Kingdom	3.18
7	Italy	69.9	Norway	2.81
8	USSR[b]	68.1	France	2.75
9	Spain	56.6	Netherlands	2.62
10	Belgium/Lux.[c]	50.7	Denmark	2.47

[a] Average consumption in beans equivalent during the three-year period 1990/91 - 1992/93;
[b] Average of 1991/92 and 92/93 for the Russian Federation;
[c] Average of 1990/91 and 1991/92;
Source: ICCO, 1994b

There is a strong positive correlation in low-income countries between per capita chocolate consumption and per capita income. But growing incomes, on the other hand, lead also to a shift in consumption towards confectionery containing smaller shares of cocoa.

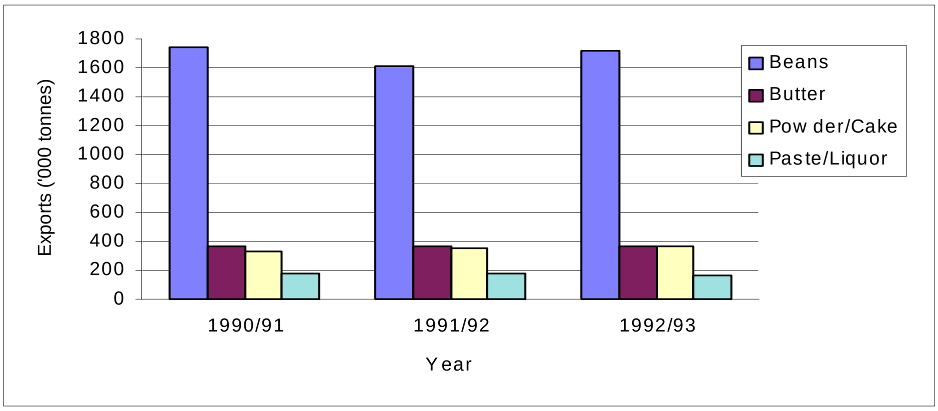
Another development influencing cocoa consumption is the substitution of vegetable oil for cocoa butter. The use of cocoa butter equivalents (CBEs) is of great interest for the manufacturer of chocolate products because the prices of CBEs are much lower than that of cocoa butter (CIRAD, 1990). The incentives to use CBEs is particularly strong in periods of high cocoa prices. In the European Union, for instance, the potential of CBEs is 135'000 - 160'000 tonnes of beans equivalents. This amount corresponds to around 15% of EU consumption (ICCO, 1993a). Actually, the use of CBEs in the EU is - except for Great Britain, Denmark and Ireland - not legally permitted. But legislative initiatives try regularly to implement regulation for the use of CBEs up to a 5% limit of the weight of the chocolate products (Keunecke, 1995). In addition, future (bio-)technological developments in this area could significantly widen the application of CBEs.

4.1.4 Trade

Globally, cocoa products are traded as beans, butter, powder, cake, and paste/liquor.[12] The shares of each product for the crop years 1990/91-1992/93 is presented in Figure 4.3.

[12] A detailed flow chart of cocoa processing including the various resulting products is presented in CIRAD (1990).

Figure 4.3: *Exports of cocoa products from 1990/91 to 1992/93*[a]



[a]Cocoa year: 1 October to 30 September

Source: ICCO, 1994b

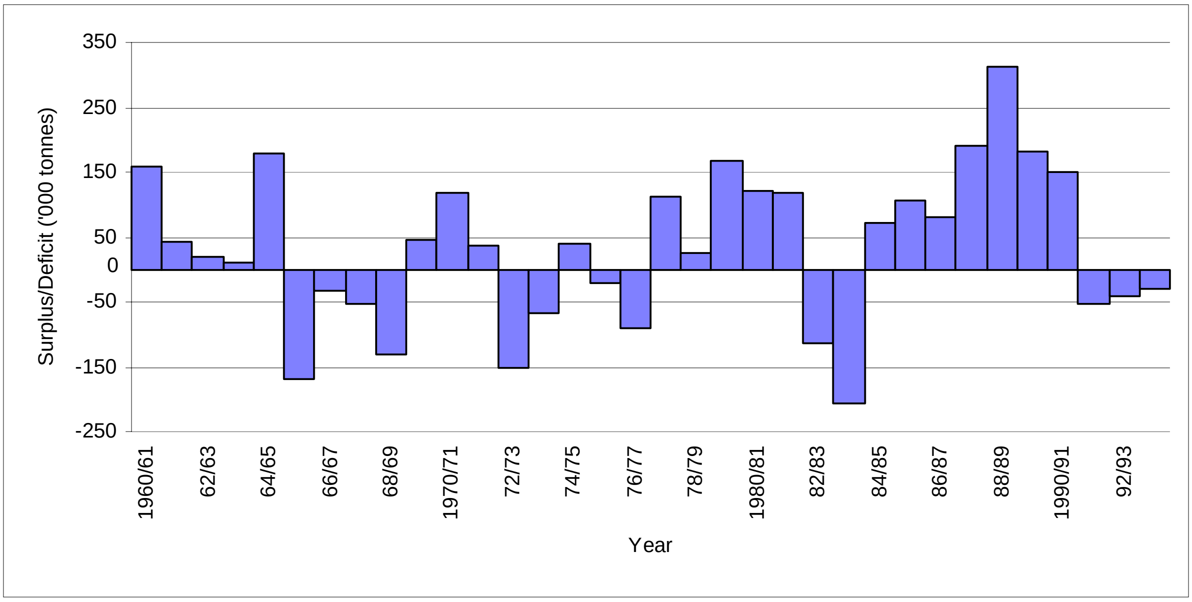
Cocoa is primarily traded in the form of beans as the above figure indicates. In the last few years, the individual shares of the different categories only have marginally altered. Furthermore, the data reveals that, virtually two thirds of the world cocoa production is exported as beans and therefore processed in the consuming countries. The Netherlands are the largest single exporter of butter and powder/cake (approx. 30%) whereas Côte d'Ivoire is the main single supplier of paste/liquor (approx. 25%).

Mainly three marketing systems are prevailing in the major cocoa producing countries: marketing boards, 'caisse de stabilisation', and free market systems. Marketing boards as well as caisse de stabilisation are run by governments which guarantee a fixed producer price to their farmer. The former is dominant in English-speaking cocoa areas of Africa, whereas the latter is common in francophone Africa. Due to market liberalisation enhanced by structural adjustment programmes, the influence of the government in the cocoa sector was cut back by reforming or even eliminating the respective marketing systems. In Latin America and Asia, the private sector is most influential in the export of cocoa. Nevertheless, the governments have a more or less strict controlling systems mainly concerning quality standards (UNCTAD, 1991).

The above-mentioned marketing systems, particularly the former two, play an important role in providing incentives to cocoa producers by determining the producer price. Unfortunately, the governments price policy has often pursued many other goals than keeping the world cocoa economy in balance. These distorted price policies were still boosted by the excessive intervention prices of the international cocoa agreements. According to Herrmann *et al.* (1993) there is no doubt about the consequences of such a situation: "The fact that there was hardly any link between world market prices and producer prices in major producing countries was a major fact behind the persistence of the situation of oversupply." (p.220).

Indeed, the figure below shows a clear picture. Particularly in the eighties, considerable surpluses prevailed on the cocoa market.

Figure 4.4: *Surplus/Deficit[a] on the cocoa world market from 1960/61 to 1993/94*



[a]calculated as current world crop minus grindings (which are frequently used as a proxy for consumption);
Source: ICCO, 1994b

There are other possible causes for the oversupply on the cocoa market. One is the lag in production response to the price change. This fact becomes also apparent by analysing the price elasticity of the supply[13] and seems to be typical of perennial crops. Other reasons are the massive planting of hybrids (see above) and the high price period in the seventies resulting in a huge expansion of production particularly in Malaysia and Indonesia.

Besides falling prices, the accumulated surpluses led to a substantial increase in world cocoa stocks. In 1990/91 they reached two third of the global cocoa consumption and are actually at 50% of that level. The current share of the ICCO cocoa buffer stock counts for roughly one seventh of total stock and will be liquidated at an annual rate of 50'000 tonnes, e.g. within four years (ICCO, 1994a).

There is not just one price for cocoa beans, but different price premiums and discounts according to the quality including flavour, defects and purity. Ghanaian cocoa fetches a price premium up to 20% as compared to cocoa from Indonesia. The quality issue is not a question of planting material but "...is a function first of farmers' preparation, and second of an infrastructure to monitor and evaluate the quality and consistency of cocoa shipments." (Bloomfield and Lass, 1992; p.33). For the second aspect, the above-mentioned marketing systems play an eminent role by providing an efficient quality control system.[14]

Some large companies directly purchase the cocoa in the producer countries. But usually, the link between private or government exporters and processors in the consuming countries are the traders. Some of these traders are not at all interested in the physical commodity but in making profit from buying and selling cocoa contracts trying to take advantage of the different price expectations. These speculators participate in the Commodity Futures Markets in New York and London where the volume of cocoa traded is ten times the annual world production. The speculative activity is an important factor in the determination of the international cocoa price based mainly on expectations about future cocoa supply and demand, but also on price developments of other commodities, exchange rate as well as inflation fluctuations or the political and social situation of major producing countries. Amin

[13] The short term elasticity of the supply is small that is, the immediate reaction to price changes is very limited. On the other hand, different estimates for the long term elasticitiy of cocoa supply show values well over 1 indicating that, producers react appropriatly at given price changes. For a thorough discussion of this issue see, for instance, UNCTAD (1991).

[14] Bloomfield and Lass discuss the disbandment of the Nigerian Cocoa Board (NCB) which resulted in a rapid decline in the quality of cocoa.

(1993), who tried to analyse and isolate the influence of this speculation on price determination, describes the role of this activity as follows (p.4): "Speculation is seen, within the functioning of the world's economic system, as a necessary and essential activity to the survival of the system itself. The speculator is considered as key piece in this process. He is a 'risk taker' and is always willing to invest in the option that would bring him the fastest and highest return of the market."

As discussed above, the processing of cocoa takes place mainly in the consuming countries, where the major leading firms in cocoa and chocolate industry is located.[15] According to FAO (1994), the high degree of vertical integration of these companies is a main reason for the lack of processing capacity in producing countries. However, the crucial point for the social profitability of cocoa processing is the price ratio of beans to intermediate products (this ratio is not constant at all over time). The world's largest processing countries are the United States, Germany, and The Netherlands with around 300'000 tonnes each. Brazil as a producer country is fourth with 230'000 tonnes (ICCO, 1994b).

A final remark is noteworthy with respect to cocoa trade. It is the concern about the considerable deterioration of the terms of trade for agricultural commodities in general and for cocoa in particular (the worst after coffee). Table 4.2 presents the variations of terms of trade - calculated in three different ways - and of yields and productions for cocoa, coffee and tea.

Table 4.2: *Variations of yield and production and different terms of trade for the period 1979/81 to 1990/92[a] (in %)*

Product	Variation of yield	Variation of production	Variation of terms of trade		
			Commodity[b]	Single factoral[c]	Income[d]
Cocoa	18	42	-66	-60	-52
Coffee	3	14	-66	-65	-61
Tea	27	36	-28	-8	-2

[a] Three-year averages;
[b] Export prices (of agricultural products) corrected in function of import prices (of manufacture products and oil);
[c] Commodity-terms of trade corrected in function of variation of productivity;
[d] export revenue corrected in function of import prices;

Source: FAO, 1993b

For cocoa (and coffee too) the increase in production is completely offset by the worsening of the terms of trade during the eighties. Contrary to that, the terms of trade for cocoa have more than doubled in the period 1977/78 to 1979/81, which confirms the above discussed aspect of price instability for cocoa and point at the huge difficulty in predicting commodity prices.

4.2 Actual situation

In this section the actual situation on the world cocoa market is considered. Developments in production, consumption and prices are discussed. Furthermore, overall yields and areas planted as well as the figures associated to single regions and the corresponding growth rates are presented.

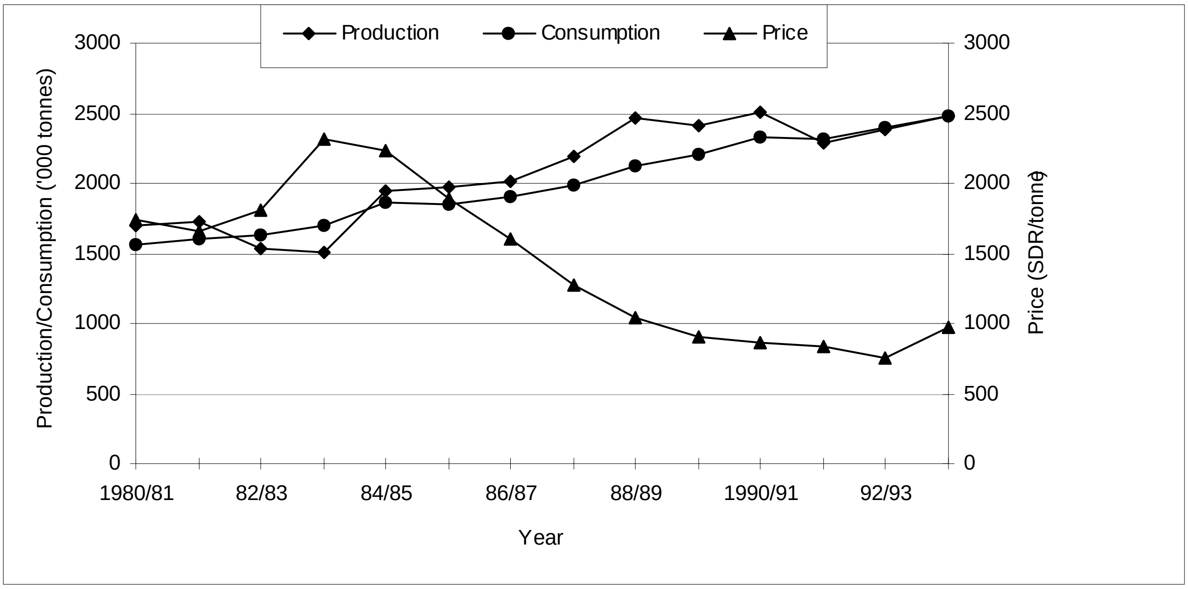
4.2.1 Production, Consumption and Prices

Figure 4.5 presents, in graphical form, the developments in production, consumption and prices in the period 1980/81 to 1993/94. The price fluctuations are in accordance with the surplus/deficit situation. In particular, the period between 1984/85 and 1991/92, where the consumption is steadily below production, the prices decreased by an average annual rate of

[15] A comprehensive discussion of the processing industry as well as a list of the leading firms in this sector is given in Hanisch and Jakobeit (1991).

9% and, in real terms, resulted in an all time low in 1992/93. The cocoa price recovered in the last production year partly because of the third consecutive production deficit (see Figure 4.4). In the period shown in Figure 4.5, production grew at an average rate of 3.3% per annum whereas the corresponding value for consumption was 4.6%. The growth rate for consumption in 1993/94 reached 6.4%

Figure 4.5: *Developments in cocoa production* [a]*, consumption* [b] *and prices* [c]



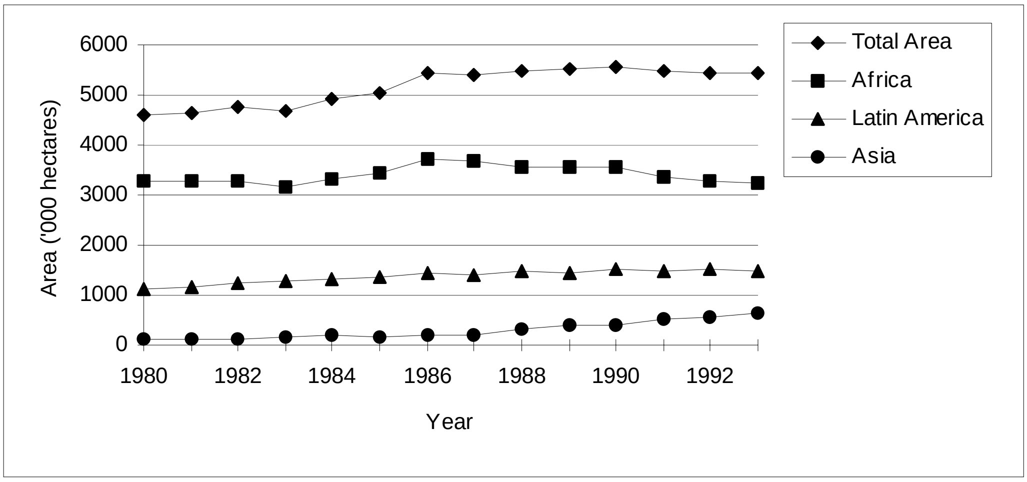
[a]Gross crop as measure for production;
[b]Grindings as measure for consumption;
[c]Annual average of daily Now York and London prices converted from US-dollar into SDR (Special Drawing Right), right hand scale;

Source: ICCO, 1994b

4.2.2 Area

Figure 4.6 shows the total cocoa area planted and the proportion of each region. More than 85% of this area is situated in the seven major producer countries (Brazil and Ecuador in Latin America, Cameroon, Côte d'Ivoire, Ghana, Nigeria in Africa, Indonesia and Malaysia in Asia). The average growth rate of the global area is 1.4% per annum for the period referred to in the figure below. But there is a huge difference between the single regions. The growth rate for Africa was even negative (-0.1% annually), whereas Latin America's area grew with a modest rate of 2.4% per annum. A big jump in cocoa production took place in Asia which increased its area planted at an annual rate of 38.8%, i.e. multiplied by six. Although Africa's area is more than five times that of Asia, its output is not even three times that of Asia's producer. The reason for that is the different yields achieved in the two regions. The next paragraph is, therefore, dedicated to this issue.

Figure 4.6: *Area*[a] *planted with cocoa as world total and by region from 1980 to 1993*

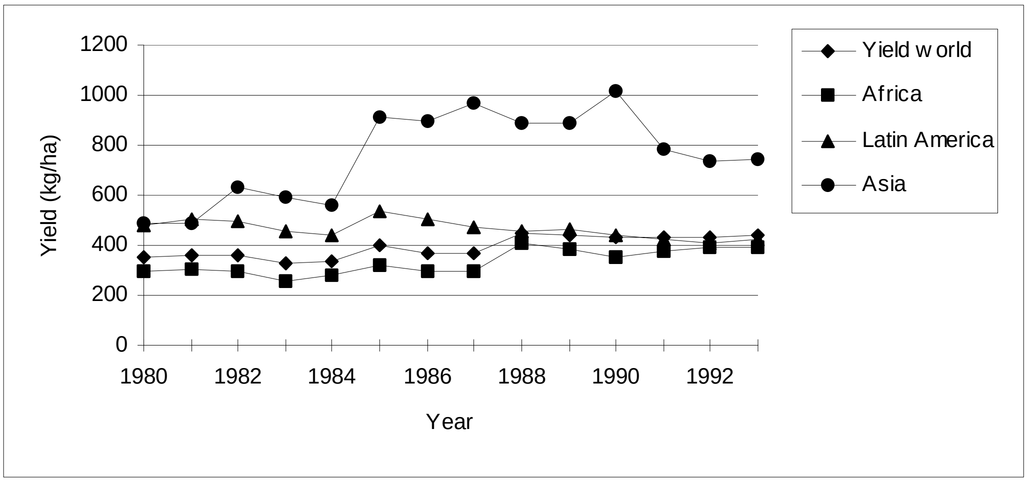


[a]FAO estimate where not official country statistics available;

Source: FAO, Production Yearbook, various issues

4.2.3 Yield

Figure 4.7: *Cocoa yields as global average and by region from 1980 to 1993*



Source: FAO, Production Yearbook, various issues

Since the FAO's calculations of cocoa yields are based on areas which are not available from certain countries (and therefore have to be estimated), one has to be careful for the interpretation of the above figures. However, the picture seems quite clear. While the average cocoa yields in Africa and Latin America converged during the last decade (at about 400 kg/ha), the yields in Malaysia and Indonesia almost doubled (reaching 750 kg/ha) mainly because the hybrids, planted earlier, came into full production. The drop in yield after 1990 in this region is due to Indonesia's' heavy expansion of its coca area which is still not in full production. At the same time, some of the larger plantation companies in Malaysia started to pull out cocoa trees with yields under 1'500 kg/ha due to low world cocoa prices and high production costs, respectively (Bloomfield and Lass, 1992). So, for the eighties the average growth rate per annum was 4.1 for Asia, 2.5 for Africa and -0.9 for Latin America. World-wide, the yield grew in this period at a rate of 2.1% annually.

4.3 Outlook

This section is dedicated to forecasts of the world cocoa market. Prospects of prices, production and consumption of cocoa are discussed. These forecasts are carried out by the International Cocoa Organisation (ICCO), the United Nations Conference on Trade and Development (UNCTAD), and the Food and Agriculture Organisation of the United Nations (FAO). Since there are neither homogenous assumptions nor the same period of the forecasts taken by the single Organisations, the results cannot be depicted in a similar manner. Forecasts are always restricted by underlying assumptions, which are a crucial issue in this business. As the detailed discussion of these assumptions would be beyond the scope of this study, the reader is advised to take them into account by consulting the original sources before seizing actions based on these forecasts.

4.3.1 Prices

ICCO (1993a) projected the future prices in the world cocoa market up to the year 2000 by using econometric modelling[16]. In addition, they simulated the development under the assumed implementation of the 'production-management plan' referred to in Section 4.1. These price forecasts are made under two distinct scenarios and cover the period up to the production year 1997/98. The results of the price projections are summarised in Table 4.3.

Table 4.3: *ICCO-forecasts of world cocoa prices for different scenarios*

Scenario	Price Projections in SDRs/tonne in constant 1993 terms						
	1994/95	1995/96	1996/97	1997/98	1998/99	1999/2000	2000/01
Scenario under a decreasing stock/grindings ratio	1'011			1'059			1'203
Production-management plan							
Scenario I: Production reduction of between 1% and 5%	1'200	1'471	1'521	1'526			
Scenario II: Production reduction of between 2% and 10%	1'328	1'790	1'947	2'057			

Source: ICCO, 1993a

The scenario depicting an introduction of the production-management plan reveal a considerable increase in cocoa prices of 9% and 18% per anum, respectively . The implementation in practice and the real impact on production still remains to be seen. The other scenario indicates an increase in constant prices under the condition of a decreasing stocks-to-grindings ratio. This points at the strong inverse relationship between those two variables.

UNCTAD (1991) also estimated the likely prices of cocoa up to the production year 2005/06. They formulated several assumptions for future cocoa price trends, which are based on World Bank price projections ('Baseline Scenario'). The low and high price scenario assume a level 20% lower and higher, respectively, than that scenario. The estimated prices for each scenario are shown in Table 4.4.

[16] The presented projections are from the quoted source which have revised and actualised the study 'The World Cocoa Market: An Analysis of recent Trends and of Prospects to the Year 2000' carried out by the ICCO Secretariat (1993b).

Table 4.4: *UNCTADs' assumptions of world cocoa prices for different scenarios*

Scenario	Price trends in US$/tonne in constant 1985 terms											
	1994/95	1995/96	1996/97	1997/98	1998/99	1999/2000	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06
Baseline	740	760	850	950	1'020	1'100	1'130	1'130	1'100	1'020	950	850
Low price	592	608	680	760	816	880	904	904	880	816	760	680
High price	888	912	1'020	1'140	1'224	1'320	1'356	1'356	1'320	1'224	1'140	1'020

Source: UNCTAD,1991

UNCTADs' price estimates confirm the upward trend in constant prices up to the end of this century. This is also in line with the latest World Bank projections which show an annual growth rate of 2% for this period (World Bank, 1994). However, for the beginning of the next century (2000 to 2005) the World Bank forecasts no increase in constant prices at all whereas UNCTAD projects even a decrease of more than 4% per annum.

Estimations of price trends are very difficult for cocoa because of its price instability. The long time lag between production decisions and their results with respect to output aggravates this instability. A further factor for these large price fluctuations seems to be the speculative activity in Commodity Future Markets, as prices are linked to expectations of developments of economic variables which have nothing to do with the cocoa sector or the producing country (MaBean and Nguyen, 1987).

4.3.2 Production

All the studies indicate that, cocoa production will further grow during the current decade. However, the extent of the predicted rate differs from one source to the other. ICCO estimated an annual average growth rate of 1.1% from 1992/93 to 2000/01, whereas UNCTAD projects - for the period 1993/94 to 2001/02 - growth rates of 3.1% to 5.1% according to the different scenarios (see Table 4.5). In contrast to this large increase for the nineties, the forecast for the years 2001/02 to 2005/06 is for negative growth. As Table 4.5 indicates, the average growth rate in cocoa production, for the entire period, is expected to be between 1% and 2% per annum. The production projections made by FAO (1994) show an average annual rate of increase of 1.8% from the year 1988 to 2000. This is almost half the observed growth rate for the previous decade.

Table 4.5: *Average annual rate of production increase*

Scenario	Average annual growth rate of global cocoa production (%)		
	1993/94 - 2001/02	2001/02 - 2005/06	1993/94 - 2005/06
Baseline	4.9	-3.9	1.4
Low price	3.1	-4.3	1.1
High price	5.1	-3.4	1.8

Source: calculated from UNCTAD,1991

Another important development relates to the change in the regional distribution of cocoa production. Although the extent of production shifts varies according to the different sources, there is no doubt about the trend. ICCO (1993a), for instance, forecasts a shift in world production shares from Africa and Latin America towards Asia. For the period 1992/93 to 2000/01 the share of Africa is estimated to decline from 54.9% to 48.1%, that of Latin America from 24.2% to 20.4%. Meanwhile Asia's share is forecast to increase from 20.9% to 31.6%. The ranking of the individual producer countries will - at least in accordance with ICCO's projections - considerably change by the end of the decade. Indonesia will replace Brazil as the world's second largest producer and Malaysia is struggling together with Brazil and Ghana for the third place. Côte d'Ivoire is expected to remain the leading cocoa producer.

4.3.3 Demand

Table 4.6 shows the annual consumption rates for different periods and scenarios as projected by UNCTAD. The value of the baseline scenario for the period 1993 to 2001 virtually coincides with the forecasts of ICCO. These estimates predict an average annual growth rate for cocoa consumption of 1.0% for the years 1992/93 to 2000/01 which is also in accordance with calculations made by the FAO if converted into the same period. Furthermore, the FAO forecasts the increase between 1988 and 2000 to 4.3% annually for developing countries and 1.8% for developed countries.

Table 4.6: *Average annual rate of consumption increase*

Scenario	Average annual growth rate of global cocoa consumption (%)		
	1993 - 2001	2001 - 2005	1993 - 2001
Baseline	0.9	1.3	1.5
Low price	2.2	3.5	2.8
High price	0.3	1.8	0.8

Source: calculated from UNCTAD,1991

Table 4.6 also gives evidence of the accelerated consumption growth for the period 2001 to 2005 for all scenarios. The rate of increase is highest for the low price scenario. For the historical price scenario the growth rate is three times larger in the first period than in the second one. The market projections from UNCTAD, at least concerning the baseline and low price scenario correspond with conclusions drown by ICCO, that the world cocoa economy is developing towards a phase of structural production deficits.

To analyse the potential for future growth in demand, the actual per capita consumption as well as the price and income elasticities have to be revised. The very high consumption level of major European countries (averaged at almost 2.5 kg/person and year) and the small price and income elasticities (Hanisch and Jakobeit, 1991) indicate the narrow limits for a further increase in this region. However, there are large cocoa consuming countries with a huge consumption potential as their per capita figures are very small, like for instance Russia (0.2 kg/year), Mexico (0.3), China (0.01), Japan (0.9) but also cocoa producer countries like Brazil (0.5), Ecuador (0.2), Malaysia (0.2) and Indonesia (0.1) (ICCO, 1994b). In addition, most of these countries show a considerably higher value for price and income elasticity. So, the major determinants for a future per capita consumption growth are the cocoa price and the income development in these countries. In addition to these economic parameters, the overall cocoa consumption is influenced by trends in national population growth.

4.4 Summary

This chapter highlighted the market conditions as major determinants of competitiveness. In particular, the crucial role of the cocoa price and its determinants was discussed. Several international cocoa agreements did not lower the characteristically high degree of price instability entailed by unelastic demand, cocoa supply fluctuations which are inherent in the system and speculation. Quality premium can have a considerable impact on producers' income and is partly determined by the prevailing marketing system in the producer country. Trade structure includes factors which may influence the world cocoa price. While the effect of speculation on the price level is not clear, the increasing concentration on the demand side - as a result of mergers and take-overs - is leading to an oligopsonistic structure and, therefore, unpredictable consequences for prices. Quantitatively, beans are the main cocoa product in international trade because major processing facilities are located in the consuming countries.

On the supply side, the prevailing production structures - small scale farmers and estates - were identified. Developments in production, area and yield as well as their determinants were revealed. Special attention was given to the existing yield profile indicating that the full potential of cocoa output is far from being reached.

On the demand side, leading consumer countries as well as the huge difference in per capita consumption were noted. An important aspect for future demand will be the development of CBE consumption, which depends mainly on consumer countries' legislation. Finally, different forecasts of cocoa market variables were discussed.

Chapter 5

Methodology to Analyse the Efficiency and Competitiveness of Cocoa Production

This chapter provides a methodological tool to calculate economic efficiency and international competitiveness in the context of technological change. The theoretical framework to make the analyst aware of the various assumptions and limitations of this approach, will be presented in the first Section 1. In this part, major welfare terms necessary to understand the economic meaning of efficiency and competitiveness are explained.

The second section describes a methodological tool to assess efficiency and competitiveness of agricultural systems taking into account the effects of distorting policies and market failures. This powerful instrument enables practitioners to analyse - among other things - the economic impact of technological change. The possibilities of it are shown as well as what kind of results can be expected and how to interpret them. In addition, the limitations and shortcomings of this methodological approach are revealed.

In the third section of this chapter guidelines for the empirical application are introduced. The guidelines are structured in five steps. The data required as well as the necessary transformation to fit them in the methodological framework are discussed. Beside the listing of the different results, this section deals with the incorporation of technological change. Furthermore, recommendations are made for sensitivity analyses and scenarios in order to establish forecasts.

5.1. Theoretical Background

Economic analysis deals with the optimal resource allocation. In that situation, society is at a Pareto optimum where nobody can be made better off without somebody else being made worse off under given resources and production technology. This situation can only be reached under a perfect competition model[17], in a so called first-best world. Unfortunately, we are living at the most in a second-best world (see below). But the model of perfect competition shows at least theoretically the efficient resource allocation of an economy. The feature of such an optimal allocation is that prices reflect the scarcity of commodities and thus lead to the highest level of welfare. In this case, the market prices correspond to the opportunity costs (Tsakok, 1990).

Using the concept of opportunity cost the value of a commodity traded in international markets is its border price, i.e. the world market price converted into domestic currency whereas the value of an internationally non-traded commodity (especially domestic factors of production) equals the value in its best alternative use. These are referred to as social prices and lead to the paradigm of comparative advantage[18].

According to Tsakok (1990, p.106) the term comparative advantage has two meanings: „In the first sense the efficiency of production is being compared among two or more trading nations. Nations with the lowest opportunity costs are relatively more efficient and have a comparative advantage. (...) The second meaning of comparative advantage refers to the efficiency of different kinds of production within the domestic economy, which are compared

---

[17] The concept of perfect competition is underlying the following assumptions:
i) suppliers and consumers are pricetakers
ii) there is freedom of market entry and exit
iii) perfect information for all market participants
iv) production factors are mobile.

[18] See for instance Chapter 13 in Stevens and Jabara (1988) for the theory of comparative advantage and the difference of comparative and absolute advantage.

in terms of earning and saving a unit of foreign exchange." Under the assumption of perfect competition the comparative advantage is a measure of international competitiveness for a national economy and a production system, respectively. But in the real world facing market failures and government interventions comparative advantage indicate merely a potential competitiveness. Nevertheless, this paradigm gives valuable indications regarding the efficient use of domestic resources. The measurement of comparative advantage will be discussed in the next section.

To estimate the effective or actual international competitiveness of a country or a production system, existing price distortions have to be taken into account. Consequently, the calculation of the competitive situation for a nation or commodity system will be executed under market (or private) costs and prices. Before presenting an instrument to analyse the competitiveness of cocoa production the factors to the above-mentioned price distortions will be briefly discussed. There are two events causing price distortions and therefore inefficiency: market failures and government interventions, where the latter can prevent as well as contribute to the former. The most common market failure concern externalities, public goods, and market power. In such cases appropriate policy interventions can be justified to improve market performance and thus welfare (Monke and Pearson, 1989):

- *Externalities:* The production of negative and positive externalities through economic activities is not always incorporated in costs and benefits. With policy instruments like taxes and subsidies the government tries to value these goods, although a quantification would often be very difficult if not impossible.
- *Public goods:* Some necessary investments (e.g. infrastructure, research and development of new technologies) to induce sustainable developments will not be made by market participants due to a lack of direct benefits. In this situation, governments ought to intervene for increased economic activity.
- *Market power:* Violated conditions underlying perfect competition model can result in uneven distributed market power like for instance monopolies, lack of information and other market imperfections. In such cases the prices do not reflect the scarcity of goods and therefore government interventions can improve market efficiency.

In his criticism of the dominance of the neo-classical efficiency criteria (Pareto optimality) for collective action, Bromley (1990, p.97) stated: „To analyse something is not to reduce all of its components to dollar estimates surplus, or to changes in net national income. While these measures may clearly be one part of a complete benefit-cost analysis, to analyse a proposed policy is to attempt to understand who the gainers and losers are, how they regard their new situation in their own terms, and what this means for the array of beneficial and harmful effects." Monke and Pearson (1989, p.6) also mention, that „the establishment of an efficient economy and the maximisation of aggregate income are not the only, or necessarily the most important, goals of economic policy."

The wide range of policy priorities which includes nonefficiency objectives have been listed in Chapter 2. Limited resources, however, make it difficult for all the stated objectives to be realised. Consequently, we have to set priorities concerning these objectives. Efficiency criteria may help to assess the different policy measures which has been seized. In this sense, the analysis can be seen as an instrument to evaluate the social costs of the achievement of any particular objectives. The methodology discussed in the following section provides results to analyse both, the efficiency and the competitiveness of a production system.

5.2. Methodological Tool[19]

5.2.1 The Policy Analysis Matrix

There are a number of approaches used in the analysis of efficiency and competitiveness of agricultural production systems[20]. In this study, the Policy Analysis Matrix (PAM) is

[19] This section draws heavily on Monke, E.A. and Pearson, S.R. (1989) The Policy Analysis Matrix for Agricultural Development, Cornell University Press, Ithaca and London.

presented as an appropriate tool to meet the objectives mentioned in the first chapter. (A detailed assessment of the PAM approach is discussed at the end of this section). The policy analysis matrix was developed in the early eighties by Monke and Pearson and is an expansion of the social benefit-cost analysis. A major goal of the PAM is to analyse the impact of government policy on efficiency and competitiveness of agricultural production systems. In addition, as the authors indicate (p.30): „The approach is particularly well suited to empirical analysis of (...) technological change." The theoretical framework of the PAM is a partial equilibrium model and therefore allows only a comparative static analysis. In contrast with traditional methods that rely on estimates of demand and supply functions, the PAM method is based on the construction of a double entry budget for costs and returns to represent a commodity system. Figure 5.1 shows the general structure of the matrix.

Figure 5.1: *Policy Analysis Matrix*

		Costs		
	Revenues	Tradable inputs	Domestic factors	Profits
Private values	A	B	C	D
Social values	E	F	G	H
Effects of divergences	I	J	K	L

Source: adapted from Monke and Pearson, 1989

The central element of the PAM is the profitability in the last column defined as revenues minus costs and the measuring of the effects of divergences in the last row. In the first row the profit is calculated at observed market prices[21] (private values): D=A-B-C. The observed prices include market failures as well as policy distortions. The second row refers to efficiency values i.e. prices that would prevail if the divergences were removed. The resulting social profit is: H=E-F-G. Because social values are by definition the correction of market values for the distorting effects, the last row refers to market failures and policy effects. The letters in this row, therefore, indicate the degree of inefficient use of the resources. For a more detailed interpretation of the effects of divergence it is possible to split them up in (a) effects of market failures, (b) effects of distorting policy, and (c) effects of efficient policy. As the precise identification and analysis of these effects are not the main issue of the present study, it is not necessary to go further into it.

The costs are divided into tradable inputs and domestic factors. Tradable inputs are goods and services (or parts of them) that have a world market price, i.e. that are exported or imported, whereas the domestic factors are nontradable items such as land, capital and labour[22]. Consequently, intermediate inputs like fertiliser, pesticides, water, transportation, electricity, etc. have to be disaggregated into their tradable and nontradable components. As it will be seen below, this distinction of the costs allows a more detailed interpretation of the results.

For the analysis of competitiveness under changing technologies the private and social profits in the last column of the PAM plays a key role. We, therefore, take a closer look at these terms in the following paragraphs.

---

[20] One of them is the Total Factor Productivity (TFP) described in Alston, J.M. *et al.* (1994); another is the so called effects method which is frequently used in french-speaking countries (see Hanak Freud and Freud (1993) for an application of this approach).

[21] Depending on the authors, 'market prices' are also called 'private prices' 'financial prices' or 'actual prices' and for 'social prices' expressions like 'economic prices', 'efficiency prices' or 'shadow prices' are used.

[22] This distinction between tradables and nontradables is a simplified but for the present purpose appropriate definition. For a economically more concise explication of these two terms see Tsakok, I. (1990), p.45.

5.2.2. Private Profitability

The private profits as difference between revenues (A) and all costs (B+C) show the competitiveness of the commodity system under discussion, given current technologies and actual market values for inputs and outputs. As mentioned above, the market distortions due to policies and market failures are included in these calculations. Negative private profits ($D<0$) indicate a loss for the producer. It will be expected under these conditions that he will change his production activities towards a more profitable crop in the middle or long term, indicating that this commodity system is not competitive (remember that the prices and costs are world market values). On the other hand, positive private profits ($D>0$) point to a profitable activity and thus competitiveness of the commodity. The farmer as a pricetaker will expand the production of the crop until the profits are zero ($D=0$), i.e. the product prices are equal to the marginal costs.

For the objective of the present study - the analysis of the impact of a new production technology on the competitiveness of the crop - the profits of the commodity system under the current technology (D_0) have to be compared with the profits of the production under the new technology (D_n). If $D_0<D_n$, the technology under consideration is superior to the current technology and therefore is more competitive.

5.2.3 Social Profitability

Analogous to the private profits, the social profits are the revenues (E) less the costs (F+G). The tradable inputs (F) and outputs (E) are valued at world market prices and the domestic factors (G) at opportunity costs, i.e. the values in their best alternatives[23]. Thus, according to the theoretical framework, the social profits are a measure for the efficiency or comparative advantage of the considered commodity system. They can also be seen as a valuation of the potential competitiveness of the activity, that is the situation without any distortions. This potential competitiveness is an interesting and useful result for policymakers because it indicates the degree of an efficient resource allocation (where the prices reflect scarcity values) for a production system.

Yet the parameter L as difference between private and social profits (D and H, respectively) is a measure for the influence of the politically and market based distortions on competitiveness. For the purpose of this study, the comparison of the social profits of two different production technologies (H_n-H_0) reveals the theoretically possible gain of competitiveness due to a technological change. Moreover, if the change in private profits is compared with the change in social profits (L_n-L_0) - both entailed by the use of a new technology - the susceptibility of the new technology on the distortions could be assessed.

A more detailed analysis of competitiveness and efficiency with respect to the use of inputs, particularly domestic factors, is provided by the calculation of ratios. These ratios are specially useful for comparisons of commodities produced with different production technologies. In such cases, the parameters D_0 and D_n could have the same magnitude although the level as well as the kind (tradable or domestic factors) of inputs is very different. The private cost ratio (PCR), defined as ratio of domestic factor costs (C) to value added (A-B): PCR=D/(A-B), shows the valuation of domestic factors through the value added generated by the activity, measured always in private prices. A PCR of 1 indicates an adequate pricing of domestic factors and corresponds to D=0. The smaller the PCR the better the compensation of the domestic resources. Accordingly, the measure for the social profitability is called domestic resource cost (DRC) and is calculated as G/(E-F). The interpretation is the same as for the PCR, but all parameters are valued at social prices. For the assessment of production systems using two different technologies, the ratios can

---

[23] A more detailed explanation of how to derive these values is given in Section 5.3.

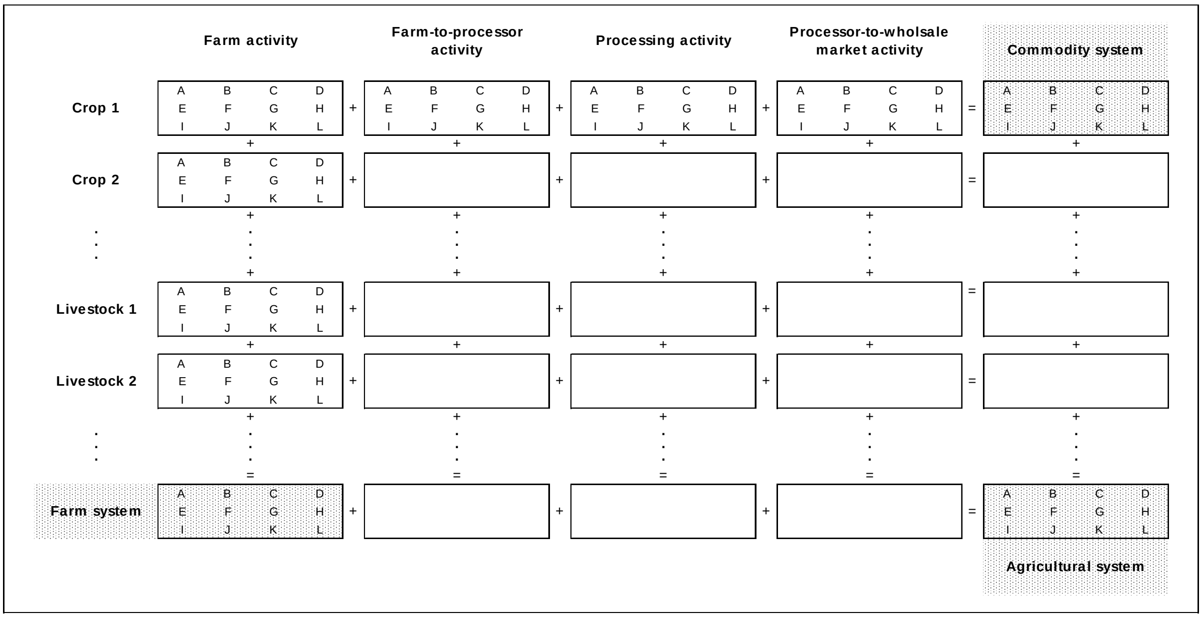
provide some indications regarding the valuation of domestic resources at private and social prices.[24]

A primary requirement to the PAM approach is forecasting the economic impact of future biotechnological developments. A first step in doing this is the estimation of the pure effects of technological change based on present values as it has been described above. This calculations take place under *ceteris paribus* conditions taking into account the results of Chapter 3. The next step is a sensitivity analysis to evaluate the crucial parameters. These parameters should be estimated as accurate as possible for the time frame in which the application of the new technology is foreseen. As estimation, either the values discussed in Section 4.3 or own sources can be used. The new calculations using the estimated values should result in forecasts of changing competitiveness on the basis of biotechnological developments.

5.2.4 Extended Analysis

The PAM is not only suitable for the analysis of the production activity of one commodity but also as a measure of the competitiveness and efficiency of an entire commodity system including processing, marketing and transportation. As shown in Figure 5.2, the commodity system generally consists of four activities, namely farm, farm-to-processor, processing, and processor-to-wholesale market, from the left to the right hand side. The PAM of the commodity system is the aggregation of the PAMs from the four activities mentioned above. In addition, Figure 5.2 indicates the analysis of a farm system by adding up the single PAMs of each crop and livestock activity from top to button. The PAM approach can even be used for the analysis of a complete agricultural system. The sum of the PAMs in the last row and column provides the final PAM in the lower left hand corner for the overall agricultural system under consideration.

Figure 5.2: *PAMs for commodity and farm systems*



Source: adapted from Monke and Pearson, 1992

Since the objective of the present analysis is to examine the competitiveness of a single crop (cocoa) under changing production technologies, the PAM of interest is only that on the

24 The DRC as measure for comparative advantage is disputed because it seems to overstate the social profitability of activities using large amounts of tradable inputs and consequently, discriminates those activities relying more on domestic resources. For a full discussion of this issue see Masters and Winter-Nelson, (1994).

upper left hand corner, that is the respective values for this PAM should be measured at the farm-gate level. It is, therefore, beyond the scope of this study to construct the PAM of the entire cocoa commodity system (production, processing, marketing, and transport) unless the new technology has not relevant influence on the downstream stages.

Finally, an assessment of the PAM approach with respect to the objectives of the present study is discussed. First of all it has to be mentioned that this tool is primarily developed to analyse agricultural policies. Therefore, the analysis of technological change is only part of the possible use of the PAM. On the other hand, the adoption of a new technology could pursue other objectives than increasing efficiency and a better competitiveness of the commodity (as discussed in Chapter 2). But these nonefficiency objectives are impossible to estimate with the PAM. The method presented above represents a clear and theoretically consistent framework for the measurement of competitiveness and efficiency as well as changes of them. In this context, an important point to mention is the easy communication between economists and non-economists (Monke and Pearson, 1992). A great deal of good experience in practical consultancy is reported from Hartmann *et al.* (1993) who analysed and evaluated the method. A further advantage is the possibility of a step by step action, that is, to start constructing a PAM with a relatively small amount of data. This initial PAM allows the finding of sensitive and therefore crucial values and as a result of that to continue the analysis in a more efficient manner. Concerning the required data, the real situation is often more difficult than the authors of the PAM suggest. Especially the calculation or better estimation of the social values is „far from trivial“ (Sarris, 1992). Hartmann and her colleagues also emphasise the difficulties in this respect and argue that the estimation depends partly on the judgement of the analyst. Another criticism concerns the ignoring of price-induced changes in quantities, i.e. due to the difference of private and social prices the quantities of output and input for the social and private valuation can change. A fundamental problem is raised by Alston and his colleagues in their forthcoming work. They argue that the social valuation is not a true measure of comparative advantage and thus potential competitiveness because of existing distortions in world market prices. Their objection is completely correct but what else could be the basis for efficiency measure? For a domestic economy the world prices represent the opportunity cost which are usually beyond the influence of the affected country.[25]

By and large, it can be said that, the PAM approach is a suitable tool for the issue considered in this study. The theoretical framework of is understandable for non-economist and the work for the calculation of the required values is reasonable. For the constraints set by the theoretical framework, one has to be aware of them for the examination of the PAM results.

5.3 Guidelines for Empirical Application

The presentation of guidelines for an application of the PAM approach to analyse the economic impact of technological change in cocoa production is structured as follows:

1) Prerequisites
2) Activity budget
3) Incorporating technological change
4) Interpretation of the PAM results
5) Sensitivity analysis and forecasts

5.3.1 Prerequisites

- Point of measurement: As the primary interest is the change in competitiveness due to an alteration in production technology, it is sensible to measure the relevant data at the farm

[25] But one has to bear in mind the 'large country'-case desribed in Section 5.3.

level. Usually, the following processes are included up to this point: cocoa establishment, maintenance, harvesting, breaking, fermentation, drying and bagging. The final product of cocoa production is, therefore, fermented, dried, and bagged beans.

- Representativity: Constructing a budget for every farm producing cocoa is simply impossible and superfluous too. The analyst chooses a few representative groups of farm according to differences in size, region, agro-ecological zone, production technology, and other characteristics. These average farms should cover the full range of variation in cocoa production and their budgets will be evaluated in order to raise PAMs.
- Base year: The intention of this study is a forecast of the consequences of biotechnological developments not yet incorporated in the cocoa production. As the time frame for the establishment of these technologies is not only three or four but twenty or even more years, the estimation of all relevant data is extremely difficult. Hence, the following action is suggested. First, the analysis of the impact is carried out by using actual data. Second, sensitivity analysis (see below) helps to identify the values with a large influence on competitiveness. Third, the estimated values from Chapter 3 and from other sources can be used to construct scenarios and to analyse the impact of future technologies. The base year for the calculation is defined by the forecast application of new biotechnological developments.
- Data source: As far as possible, secondary information should be used because surveys to collect farm budget data are very time consuming. The latter can be deployed for special requirements or to fill gaps in secondary data. Sources for data collection are governmental offices like the ministry of agriculture, the marketing board, and customs authorities but also institutions like export organisations, trade unions, producer associations or private ones like input suppliers, intermediaries, processors and other buyers. Additional sources of data are universities, research stations and extension services. Generally, the establishment of private values is quite easy compared with that of social values particularly if nontradables are concerned. Details will be discussed in the corresponding paragraphs.
- Units: The costs and revenues are listed in domestic currency. That raises the question of exchange rate for the conversion of world market prices. As we will see below, the official exchange rate is not appropriate to calculate social values, thus a real exchange rate has to be found. The use of factors as well as the production of output is calculated per surface and usually expressed in hectares.
- Production knowledge: An important prerequisite is detailed and comprehensive information concerning the production systems for cocoa. The first step in preparing a PAM is, therefore, the full listing of all relevant inputs and outputs as well as the necessary technical coefficients. This task encompasses the cocoa activity from establishment over production up to processing.

5.3.2 Activity budget

The activity budget is the crucial instrument for the preparation of a PAM. It provides a well designed framework for the data collection. Figure 5.3 shows schematically the construction of an activity budget. This kind of budget has to be established for each type of farm under consideration. Furthermore, as the analysis concerns a situation with and without the technology in question, respectively, two activity budgets for each type are needed.

Figure 5.3: *Basic structure of an activity budget*

			Private values								***Social values***							
				Non-tradables					Tradables			Non-tradables					Tradables	
	Quantity	Units	Price/ Unit	Labour		Land	Capital	**Total**		**Total**	Price/ Unit	Labour		Land	Capital	**Total**		**Total**
Costs				unskilled	skilled							unskilled	skilled					
Fixed input Direct labour Intermediate input																		
Total costs				C1	C2	C3	C4	C	B			G1	G2	G3	G4	G	F	
Revenues																		
Output										A								E
Profit									D = A - B - C →	D							H = E - F - G →	H

Source: adopted from Monke and Pearson, 1989

Basically, the costs are split into 'Fixed Input', 'Direct Labour', and 'Intermediate Input'. All the factors used in the cocoa production have to be assigned to these categories. The necessary quantity to produce one hectare of cocoa, the unit of measurement, and the price per unit - in private as well as social values - are determined. The same procedure will be used for the output. Afterwards, the costs must be divided in tradables and nontradables - a difficult task, especially for the intermediate input. In the subsequent paragraphs we are discussing the division of the factors according to the respective category, how to calculate their prices (private and social ones), and the features requiring special attention. Analogous discussion is taking place regarding the output.[26]

Fixed Input

The first part of this paragraph is dedicated to the private valuation of the various factors summarised under this category.

A major problem for the analysis of permanent crops like cocoa is the fact that, the culture needs an investment period lasting several years before getting a profit of it. Therefore, the year of analysing the crop is a crucial matter. Monke and Pearson (1989) suggest several methods to deal with this problem. For cocoa, the most appropriate solution is to choose the year of full production as base of calculation. Assuming a production cycle of 25 years, of which 5 years is the investment period (drawn from Hanak Freud and Freud, 1993), the sixth year is the base year for the construction of the budget.[27] The profitability of the activity has to be calculated for each of these 5 years. The sum is then compound to a present value and treated as investment cost which has to be amortised[28] over the remaining 20 years. The corresponding annual amount of capital is one element of the fixed costs.

The same method is used to calculate the costs of other fixed inputs (in contrast with intermediate inputs, fixed inputs are not consumed within a year). Buildings, machinery, equipment but also necessary infrastructure are examples of factors requiring a certain amount of capital. In addition, significant investments could emerge from drying according to the used processing technology (e.g. see Indranada *et al.*, (1993) for a comparison of costs for different drying systems). For the determination of the annual value of a fixed input only the percentage of investment employed for the cultivation of one hectare of cocoa might be taken into account.

The next step is to decompose these costs into tradables and nontradables. In practise, they are classified in the capital cost category because the portions of other categories is only a very small part of the total costs.

To determine the social value of the annual capital costs is far from being a simple task because capital markets are often lacking perfect competition. To calculate the social rate of return to investment, the real rate of interest is needed (for the private valuation the observed one is used). The real rate of interest is the observed rate corrected for inflation. In addition, the political distortions (subsidies, taxes, controls on interest rates and the like) as well as the market failure (e.g. institutional imperfections) should be estimated and removed for the sake of achieving the opportunity cost of capital. As a rule of thumb, Monke and Pearson give real rates of return of 10 to 15 and 6 to 10 percent for low and middle income countries, respectively.

The most important fixed factor in agricultural production is land. To calculate its private price the rental value is considered as a good approximation. As social price, it will also be the rental value if there is a competitive market. Otherwise, the net value of its use in the

---

[26] Detailed and thorough instructions for the calculation of all necessary valuations including the various tricky problems that emerge during the analysis would go beyond the scope of this study. Besides the work of Monke and Pearson, excellent explications and practical examples can be found in Gittinger, (1982); Tsakok, (1990); FAO,(1992a) and (1992b).

[27] The production cycle as well as the achievement of full production depend on the yield profile, i.e. the planted variety among other things (see also Fry, 1990).

[28] Generally, the amortisation of capial can be performed according to the capital recovery cost method using the initial capital cost, the useful live of the investment, and the rate of return which correspond to a mean interest rate that an invested capital could earn.

best alternative is a good estimation. It can be determined as residual by assessing the value added in the alternative crop and deduct the costs of other domestic resources like capital and labour (Tsakok, 1990). However, the costs for land could be omitted by constructing a partial budget if there is no change in quality of land (see the paragraph 'Incorporating technological change').

Direct Labour

The next category of costs concerns direct labour. This do not encompass the indirect labour used in the production system, for instance, to repair machinery. As discussed in the context of capital, the non-labour components of this input is only a small percentage of total cost and therefore direct labour is not further decomposed into tradables and nontradables. However, labour can - as indicated in Figure 5.3 - divided in subgroups. The distinction can be made according to the aim of the analysis with respect to the socio-economic effects on labour forces. Other possibilities than skilled and unskilled labour could be to distinguish between family and hired, male and female (for gender issues) or labour forces of different ages.

Pricing labour can be a complex task, in particular in the context of family labour, seasonal fluctuations or by paying parts of wages in kind. A further complication is brought by the existence of an informal economy. But principally, the private prices are determined by the labour market. However, particular features as described above have to be taken into account. More difficult is the estimation of the social values due to distortions like minimum wage rate, isolated regions, monopolies and the like. If the distortions are known and can be quantified, the social values could be obtained by deducting these amounts from the private prices. If not, wages for similar work in unregulated sectors might provide an indicator for the opportunity costs of labour. Another approximation of the social costs for labour is to multiply the market wage rate with the unemployment rate, as - in theory - distorted wage rates entail unemployment.

Intermediate Input

Intermediate or variable inputs are characterised by their consumption within one year. Examples for this category are seeds, fertiliser, pesticides, small tools, bags but also fuel and electricity or services like transportation, repair, and maintenance.

In this category the decomposition of the costs of each factor into tradables and nontradables is a major task. Additionally, the nontradables are further classified in labour (skilled and unskilled), land, and capital. For instance, fertiliser could virtually be seen as tradable because this product has a world market price (see definitions in Section 5.1). But in a more detailed analysis fertiliser can be decomposed in tradable and nontradable as the farmers price include transportation, marketing, and storage as well (FAO, 1992a). These factors of costs can again be classified in tradables and nontradables (e.g. transportation in fuel, spares, truck, drivers wages). The costs for the truck consist of different traded and non-traded components and so on. This kind of analysis is endless in principle. Therefore, only the decreasing influence of disaggregating on the results as well as the available resources in time and money set limits, and the analyst has to decide when the point to stop decomposing is reached.

The private values for intermediate inputs - tradables and nontradables - are the observed market prices. The determination of the social prices for the nontradables (labour and capital) does not pose any problems as prices per unit have already been calculated during the same procedure for the other cost categories. The social pricing of tradable items involves some difficulties. Basically, the value correspond to the border price, i.e. c.i.f. or f.o.b. price[29]. Usually, they are measured in U.S. dollar whereas the PAM calculations are carried out in domestic currency. As noted in Section 2.2, the official or nominal exchange

---

[29] c.i.f.: cost, insurance and freight
f.o.b.: free on board

rate (OER) is often distorted it is not an appropriate measure to convert the border price into domestic currency. A shadow or real exchange rate (SER) is needed for a correct estimation of the social prices of tradable commodities. In fact, the OER correspond to the private value of foreign currency whereas the SER is the social value.

There are several approaches to determine the SER (e.g. Gittinger, 1982). A commonly used one is the derivation of a premium on foreign exchange by taking the ratio of the value of all exports and imports at domestic prices to their value at border prices - converted into domestic values at the OER (Tsakok, 1990). The premium arises as a result of national trade policy that raise the price of traded over non-traded goods. The shadow exchange rate is then calculated as follows:

$$\text{SER} = \text{foreign exchange premium} \times \text{OER}$$

For a rough approximation the arithmetical mean from OER and parallel market exchange rate provides also an indication for the SER.

These may be another way of calculating the social price of tradable items if information about price distortions of tradables are available. From private prices the effects of policy distortions (e.g. taxes or subsidies) have to be removed in order to find social values. Remembering the PAM, that is to say F is estimated as residual from B and the observed divergences J.

Having listed all the costs as in Figure 5.3, the Figures in the individual column can then be added up to give the corresponding values in the row 'Total costs'.

Output

The next task to fill out the activity budget is the calculation of the private and social values of the outputs. The plural for 'output' refers to the fact that for some agricultural activities by-products are produced. In the case of cocoa the by-product could be earned from shade trees like bananas, cassava, or coconut palms. For pragmatic and theoretical reasons the assumption is made that these crops „are not relevant to the economics of cocoa cultivation“ (Fry, 1990 p.44).

The private prices equal the national producer prices at farmgate level. To estimate the social price , the cocoa price on the international market is used. However, to compare prices on a comparable level we need to allow for different costs associated with bringing the commodity from the farmgate to the world market. These costs include national and international transport and marketing calculated at social values to reflect the opportunity costs. For the same reason, the shadow exchange rate is used to convert the price from foreign in domestic currency (see above). A correction has to be made for considerable quality differences existing between producers (Bloomfield and Lass, 1992). Figure 5.4 shows the general steps necessary to get the export parity price at farmgate level. Depending on the production system, additional costs for storage, quality control or processing (if not executed on the farm) should be taken into account.

Figure 5.4: *Steps in the calculation of the farmgate export parity price*

World market price (c.i.f.) at point of entry
x factor for quality difference
+ unloading
+ freight
+ insurance
= World market price (f.o.b.) at point of export in foreign currency
x shadow exchange rate
= World market price (f.o.b.) at point of export in domestic currency
- local port charges
- local transport and marketing cost from farmgate to point of export
= **Export parity price at farmgate**

Unfortunately, the world market price is only for small producers (pricetakers) an exogenous factor, whereas large producers have the possibility to influence this price and can, therefore, treat it as an endogenous factor (see Figure 2.1). It has been shown in Chapter 3 that several producers could potentially alter the border price by means of their large export share on international cocoa market. In such a case, the analyst should adjust the observed border price for the likely impact of the country's market power. For this purpose, more information concerning estimations of supply and demand elasticities is needed. Because this kind of data may not be available, the determination of the relevant world price facing the large country can be quite difficult. In appendix B, Tsakok provides detailed instructions to deal with the 'large country' case. In the long run, however, most countries are unable to influence world market prices due to strong substitutional effects in production and consumption. Consequently, the use of the observed border price seems to be practicable for the long term perspective but nevertheless one has always to be aware of the potential influence of large countries' trade policy.

Finally, by calculating the profit D as A minus B minus C (as sum of C1, C2, C3, and C4) in Figure 5.3, the activity budget is completed. Now, the relevant letters can be transferred to the PAM (Figure 5.1) and the divergences in the third row determined. Although these are not the crucial results in the present study, they provide interesting indications for the economics of cocoa production and the marginal costs for their determination is very small. For a closer discussion of these results see above.

5.3.3 Incorporating technological change

An activity budget and the derived PAM do not provide enough information to analyse technological change. As mentioned at the presentation of the PAM approach, only the comparisons of two budgets (with and without the technology under consideration) give the necessary information about the impact on competitiveness and other economic effects like, for example, the change in input requirement or alteration in comparative advantage of cocoa production. Once the activity budget is constructed, the incorporation of technological change is not very time-consuming as merely a relatively small number of data change, i.e. a partial budget is used. Monke and Pearson (1989) explicitly recommend this analytical tool for (predicted) technological change by arguing: „Partial budgeting is most often used in the PAM methodology as a means of assessing the effects of new technologies on farm profitability. (...) Working with technical experts, agricultural economists can use partial budgeting technique to simulate the impact of hypothetical technological changes on profitability.“ (p.166/167)

Required information on the potential alterations of the cocoa production system due to technological change can be derived from Chapter 3. On the output side, the effects are either improved quality characteristics or increased yields. The former can be taken into account by changing the factor for quality difference in the calculation of the export parity price whereas the latter influences the quantity per output in the activity budget. On the input side, the requirement for labour and capital are mainly affected. The effect for the factor labour can be twofold. On the one hand, labour is going to be substituted for capital and, therefore less labour is needed, on the other hand, increased output entail more labour to harvest and handle it. Because the discussed calculations refer to one unit of land, the quantity and therefore the price of land remain unaffected. Hence, the determination of the land value can be omitted because the analysis is limited to differences. But for certain technologies, a change regarding the quality of land could take place and then the difference in quality expressed by a changing value has to be allowed for the analysis. A new variety, for instance, with very special requirements concerning soil quality will force the farmer to rent or purchase the appropriate land. That is, the variation of the price will influence the results. In the next paragraph the kind of potential results stemming from technological change will be discussed and guidelines for their interpretation made.

5.3.4 Interpretation of the PAM results

The results consist of different PAMs according to the principal types of cocoa production systems and each of these PAMs are constructed twice using the partial budgeting method in order to reflect the technological change. The relevant results for this study concern the change in competitiveness, i.e. the difference of the parameters D_0 and D_n or - if competitiveness is expressed in the more appropriate manner of ratios - the difference of PCR_0 and PCR_n. But for a more comprehensive examination of the present issue other results provided by the PAM should be included in the discussion. These other results are:

- The comparative advantage or potential competitiveness of the production system and its change, respectively;
- The effects of market failure and policy distortions expressed as difference between the effective and potential competitiveness;
- The consequences of the national cocoa price policy and market imperfections as the difference between the private and social output prices;
- The distortions of purchased and domestic (land, labour, capital) factor markets as difference between private and social prices of traded and non-traded inputs.

If the private cost ratio (PCR) is bigger than 1, the farmer earns a profit from the production of cocoa and the system is internationally competitive. As only the production system is analysed, the PCR is not a measure for the competitiveness for the cocoa beans on the world market. (If transport and/or marketing is not competitive, the cocoa system as a hole could lack competitiveness.) For a PCR less than 1, the farmer makes a loss and will - sooner or latter - abandon cocoa production or has to accept lower wages than he could earn elsewhere. For the introduction of a new technology, the relation between PCR_0 and PCR_n is relevant. $PCR_0 = PCR_n$ indicates no change in competitiveness, $PCR_0 > PCR_n$ indicates a deterioration of the competitive situation for the producer adopting the new technology. If $PCR_0 < PCR_n$, the newly introduced technology is more competitive than that one used before.

The alteration of the DRC for a defined production system shows the change in comparative advantage or competitiveness under free market condition on the basis of a new technology. The interpretation of the comparison between the DRC before and after the introduction of the technology is equal to those discussed for the PCR.

The difference in DRC_0 and DRC_n is exactly the net effect on competitiveness, i.e. without any distortion wherever they come from. Thus, the comparison of the differences between the PCRs and DRCs, respectively, shows the effect of market imperfections and the domestic policies. This result could provide decision makers valuable insights regarding the efficient allocation of available resources. For instance, the effects of removing some discriminating policy measures (that costs the government some money in form of lower revenues) could be far bigger than investments in expensive and risky technologies (that cost the above-mentioned amount of money).

The interpretation of the remaining results (divergences on input and output markets) provides more detailed explanations concerning the distortions on markets related to cocoa production. If the results are accepted by decision makers, they could help to remove obstacles preventing the full development of the positive effects from a newly introduced technology. Furthermore, the correct interpretation and the subsequently drawing of the obvious conclusions could improve the adoption of new innovations. A new variety, for instance, that produces a better cocoa quality will not be adopted unless the government removes fixed producer prices where no quality premium exists.

5.3.5 Sensitivity analysis and forecasts

Sensitivity analysis is a key element of the interpretation of the PAM results. As has been mentioned several times, the estimation of the social values is very difficult and contains, therefore, considerable uncertainty. To balance these shortcomings, sensitivity analysis is a useful tool. By varying each of the parameters, their influence on the results can be evaluated. This provides guidelines for the calculation of the parameters in the sense that, the degree of influence determines the accuracy of the estimation. In other words, it will be pointless to invest a lot of time for the precise calculation of a price if its influence on the result, is - in spite of large variations - only marginal. Sensitivity analysis helps, therefore, to save time in the way that, in a first round the parameters could be roughly estimated and, after a sensitivity analysis is executed the important parameters, with respect to their influence on the results, can be calculated more exactly.

As the potential biotechnological change takes place in a time frame far from now (see Chapter 3), projections have to be made to execute appropriate forecasts. For this purpose, assumptions concerning the future development on the world cocoa market have been made in Chapter 3. In addition, analysts need further assessment of national environments, especially the development of costs referring to cocoa production. As these assumptions are highly uncertain, a careful sensitivity analysis of the estimated parameters is needed. One possibility could be the calculation of a breakeven point of each parameter. At that value of the parameter the ratio indicating competitiveness is zero under *ceteris paribus* conditions (Monke and Pearson, 1989). These breakeven points show the sensitive scope of the parameters and are, therefore, important for the interpretation of the results. These breakeven points can also be used to construct scenarios where different developments are simulated by assuming changing costs and prices.

Chapter 6

Conclusions

(1) Decisionmakers need to be conscious of the wide range of implications which developments of biotechnology may have. these concern the potential direct impact on cocoa production on the one hand and the more indirect effects through intermediary tools in order to increase the efficiency of traditional agricultural research.

(2) Innovation in biotechnology may have a bias against individual cocoa production systems. This bias has to be analysed and brought into line with the prioritisation of the various national objectives. Depending on this national process and its outcomes of prioritisation of objectives the biotechnology research policies and programs should be finalised. These could focus the development of new biotechnologies on nonefficiency objectives too as decisionmakers may be concerned about, for instance, the promotion of small-scale farmers or the protection of the environment.

(3) Biotechnology, along with conventional technology, can create the opportunity to boost the performance of the cocoa sector by productivity enhancement and/or quality improvement resulting in an increase in comparative advantage. As this advantage indicates just the potential for competitive production, policymakers should attach importance to the real competitiveness on the world market which is further influenced by national policy interventions and market failures. Therefore, the political, institutional, and economic structures must be assessed in order to identify the real scope for enhancing the productivity through biotechnology. Moreover, research planning should be a continuous process which fully adjusts programs to changes in the economic and policy environments with regular dates for reviews.

(4) The methodological tool presented ought to be a valuable instrument in order to assess the comparative advantage as well as the competitiveness of a technological change. In addition, this kind of analysis allows the quantification of the distortion effects and the economic costs of nonefficiency goals. The analysis also can shed light on the factor requirement of the new biotechnology. Therefore, employing such an approach may lead decisionmakers to enquire compulsory towards a socio-economic analysis in the context of future innovation of biotechnology.

(5) An important step in the proposed approach is the sensitivity analysis of basic parameters in order to assess the impact of changed assumptions and errors in estimating efficiency and competitiveness. This would facilitate dealing with uncertainties based on determinants of biotechnology and competitiveness which are outside national influence. The examination will bring more reliable results by taking into account developments of world cocoa prices, international regulations, terms of trade or the future behaviour of consumer countries and competitors.

(6) Structural adjustment programmes have highlighted that national macroeconomic and sectoral policies merit absolutely a closer examination. In particularly because they can easily reverse the potential impact of new biotechnology. The policy framework should be consistent in order to increase the efficiency of technological innovation. Fostering infrastructure, for instance, will enhance the price response of producers and therefore promote adoption and diffusion of new biotechnologies.

(7) Due to the close interrelationship between the different subsectors of agriculture, the related policies must be fine-tuned. The methodological approach presented would also enable decisionmakers to analyse the entire agricultural sector and to catch at diversification opportunities. This would guarantee an optimal outcome of technological possibilities by tracing an appropriate research strategy.

(8) Finally, biotechnology issues, as a considerable part of research policy, cannot be analysed in an isolated manner. It is essential that an interdisciplinary approach is adopted for the formulation of research policies.

Bibliography

Affou, S.Y. (1993) Impact on State Intervention on Cocoa Production in Côte d'Ivoire. Paper presented at the International Conference on Cocoa Economy, October 19-22, 1993, Bali, Indonesia.

Alston, J.M., J.R. Anderson and P.G. Pardey (1994) Perceived Productivity, Foregone Future Farm Fruitfullness, and Rural Research Resource Rationalization. Paper presented at the XXII International Conference of Agricultural Economists, 22-29 August, Harare, Zimbabwe.

Alston, J.M., G.W. Norton, and P.G. Pardey (forthcoming) Science under Scarcity - Principles and Practice for Agricultural Research Evaluation and Priority Setting. Cornell University Press, Ithaca and London.

Amin, M.M. (1993) The Influence of the Speculative Activity in the Determination of the International Cocoa Prices in the New York Futures Market. Paper presented at the International Conference on Cocoa Economy, October 19-22, 1993, Bali, Indonesia.

Bautista, R.M. and A. Valdés (eds) (1993) The Bias against Agriculture: Trade and Macroeconomic Policies in Developing Countries. ICS Press San Francisco, California.

Bhat, M.G. (1994) Trade-Related Intellectual Property Rights for Genetic Resources: Implications for Developing Countries. Paper presented at the XXII International Conference of Agricultural Economists, 22-29 August, Harare, Zimbabwe.

Binswanger, H.P. (1992) Determinants of Agricultural Supply and Adjustment Policies. Paper presented at the Conference of the European Association of Agricultural Economists, September, 1992, Stuttgart.

Bloomfield, E.M. and R.A. Lass (1992) Impact of Structural Adjustment and Adoption of Technology on Competitiveness of Major Cocoa Producing Countries. Technical Papers No 69, OECD, Paris.

Brenner, C. and I. Goldin (1993) Economic and Technical Change - Moving to Market-Led Development and Its Implications for Agriculture. In: Barghouti, S., E. Cromwell, and A.J. Pritchard (eds) Agricultural Technologies for Market-Led Development Opportunities in the 1990s. World Bank Technical Paper, No.204, Washington.

Brenner, C. and J. Komen (1994) International Initiatives in Biotechnology for Developing Country Agriculture: Promise and Problems. Technical Papers No. 100, OECD, Paris.

Brewer, A.C. (1993) The Relevance of Tree-stock Evaluation to Production-Management Programmes. Paper presented at the International Conference on Cocoa Economy, October 19-22, 1993, Bali, Indonesia.

Bromley, D.W. (1990) The Ideology of Efficiency: Searching for a Theory of Policy Analysis. Journal of Environmental Economics and Managment 19, 86-107.

Bull, A.T., G. Holt and M.D. Lilly (1982) Biotechnology: International Trends and Perspectives. OECD, Paris.

CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Developpement) (1990) Compétitivité du Cocoa Africain: Analyse du marché mondial et des principaux producteurs. Rapport d'étude, France.

Coleman, J.R., T. Akiyama and P.N. Varangis (1993) How Policy Changes Affected Cocoa Sectors in Sub-Saharan African Countries. Working Papers No.1129, World Bank, Washington.

Cottier, T. (1994) The Protection of Intellectual Property Rights: A Requirement for Technology Cooperation, Foreign Investment and Equitable Returns in Biotechnology Prospecting. Paper presented at the Meeting: 'Biotechnologie für Entwicklungsländer? - Chancen und Risiken der Biotechnologie bei landwirtschaftlichen Nutzpflanzen' July 8/9, ETH, Zürich.

Diakosavvas, D. and C. Kirkpatrick (1990) The Effects of Trade and Exchange Rate Policies on Production Incentives in Agriculture. FAO Economic and Social Development Paper No. 96, Rome.

FAO (Food and Agriculture Organisation of the United Nations) (1992a) Policy Analysis Matrix: The Case of Pakistan. Training Module on Agriculture Price Policy. Economic and Social Commission for Western Asia.

FAO (Food and Agriculture Organisation of the United Nations) (1992b) Agricultural Price Policy: Government and the Market. Training Materials for Agricultural Planning No 31, Rome.

FAO (Food and Agriculture Organisation of the United Nations) (1993a) Commodity Review and Outlook, 1993-94. Economic and Social Development Series No 52, Rome.

FAO (Food and Agriculture Organisation of the United Nations) (1993b) La Situation Mondiale de l'Alimentation et de l'Agriculture 1993. No 26, Rome.

FAO (Food and Agriculture Organisation of the United Nations) (1994) Medium-term Prospects for Agricultural Commodities. Projections to the Year 2000. Economic and Social Development Paper 120, Rome.

FAO (Food and Agriculture Organisation of the United Nations) Production Yearbook. various issues, Rome.

Fry, J. (1990) A Methodology for the Estimation of Comparative Cocoa Production Costs. Cocoa Growers' Bulletin No.43, 34-44.

Gardner, B.L. (1990) The Economics of Agricultural Policy. Mc.Graw-Hill Publishing Company, USA.

Gittinger, J.P. (1982) Economic Analysis of Agricultural Projects. Second Edition. Economic Development Institute of the World Bank, Series in Economic Development. The Johns Hopkins University Press, Baltimore and London.

Gnaegy, S. and J.R. Anderson (eds) (1991) Agricultural Technology in Sub-Saharan Africa. A Workshop on Research Issues. World Bank Discussion Papers No.126, Washington.

Hanak Freud, E. and C. Freud (1993) Methodological Issues in the Analysis of the Competitivity of Cocoa Sub-Sectors. Paper presented at the International Conference on Cocoa Economy, October 19-22, 1993, Bali, Indonesia.

Hanisch, R. and C. Jakobeit (eds) (1991) Der Kakaoweltmarkt. Band I, Schriften des Deutschen Übersee-Instituts, Hamburg, Germany.

Hartmann, M., C. Nöth, und P.M. Schmitz (1993) Instrumente und Modelle zur Analyse und Formulierung von Agrarpolitiken in Entwicklungsländern. Arbeitspapier Nr.49, Frankfurt am Main, Germany.

Herrmann, R., K. Burger, and H.P. Smit (1993) International Commodity Policy: A Quantitative Analysis. Routledge, London and New York.

IBS (Intermediary Biotechnology Service) (1994) International Initiatives in Agricultural Biotechnology: A Directory of Expertise. The Hague.

ICCO (International Cocoa Organisation) (1993a) The Medium- and Long-term Prospects of the World Cocoa Market. Paper presented at the International Conference on Cocoa Economy, October 19-22, 1993, Bali, Indonesia.

ICCO (International Cocoa Organisation) (1993b) The World Cocoa Market: An Analysis of Recent Trends and of Prospects to the Year 2000. London.

ICCO (International Cocoa Organisation) (1994a) ICCO Cocoa Newsletter, No 7, June 1994, London.

ICCO (International Cocoa Organisation) (1994b) Quarterly Bulletin of Cocoa Statistics. Volume XXI, No 1, December 1994, London.

Indranada, T.K., M.P. Prayudi, and D.K. Chok, (1993) Sun-Drying, a Viable Alternative for Cocoa Plantations. Paper presented at the International Conference on Cocoa Economy, October 19-22, 1993, Bali, Indonesia.

Jarrige, F. (1993) Côte d'Ivoire and Malyasia Cocoa Supply: A comparative Study of Structures and Performances. Paper presented at the International Conference on Cocoa Economy, October 19-22, 1993, Bali, Indonesia.

Kamann, D.-J.F. and P. Nijkamp (1991) Technogenesis. Technological Forecasting and Social Change 39(1/2): p.45-66.

Keunecke, K. (1995) The Cocoa-Prducing Coutries Must Realise That Cocoa Is No Longer Sold Only As Chocolate Bars. ICCO Cocoa Newsletter, No 8, January 1995, pp. 8-10.

Komen, J. and G.J. Persley (1993) Agricultural Biotechnology in Developing Countries: A Cross-Country Review. ISNAR Research Report No.2, International Service for National Agricultural Research, The Hague.

Krueger, A.O., M. Schiff and A. Valdés (eds) (1991) The Political Economy of Agricultural Pricing Policy. Volume 3, Africa and the Mediterranean, The Johns Hopkins University Press, Baltimore and London.

Larson, R.E. (1986) Cocoa Raw Product - Production and Problems. In: Dimick, P.S. (ed) Proceedings of the Cocoa Biotechnology Symposium. The Pennsylvania State University, University Park; pp.3-17.

MacBean, A.I. and D.T. Nguyen (1987) Commodity Policies: Problems and Prospects. Croom Helm, London.

Masters, W.A. and A. Winter-Nelson, (1994) Measuring the Comparative Advantage of Agricultural Activities: Domestic Resource Cost and the Social Cost-Benefit Ratio. Paper presented at the XXII International Conference of Agricultural Economists, 22-29 August, Harare, Zimbabwe.

Monke, E.A. and S.R. Pearson (1989) The Policy Analysis Matrix for Agricultural Development, Cornell University Press, Ithaca und London.

Monke, E.A. and S.R. Pearson (1992) Evaluating Policy Choices in Developing Countries: The Policy Analysis Matrix. In: Peters, G.H. and Stanton, B.F. (editors) Sustainable Agriculturual Development: The Role of International Cooperation. Proccedings of the XXI International Conference of Agricultural Economists, Dartmouth Publishing Company, Aldershot, England.

Orsenigo, L. (1989) The Emergence of Biotechnology. Pinter, London.

Persley, G.J. (1990) Beyond Mendel's Garden: Biotechnology in the Service of World Agriculture. Biotechnology in Agriculture No. 1, CAB International, Oxon UK.

Persley, G.J., L.V. Giddings and C. Juma (1993) Biosafety: The Safe Application of Biotechnology in Agriculture and Environment. Research Report No. 5, International Service for National Agricultural Research, The Hague.

Sarris, A. (1992) Discussion Opening on ‘Evaluating Policy Choices in Developing Countries: The Policy Analysis Matrix’ by Monke and Pearson. In: Peters, G.H. and Stanton, B.F. (editors) Sustainable Agriculturual Development: The Role of International Cooperation. Proccedings of the XXI International Conference of Agricultural Economists, Dartmouth Publishing Company, Aldershot, England.

Söndahl, M.R. (1994) Biotechnology Prospects to Coffee and Cacao. Document prepared for the ISNAR/IBS report bevcrops/mrs/05/18/94: Analysis of economic impact of biotechnology on tropical beverage crops, ISNAR, The Hague.

Stevens, R.D. and C.L. Jabara (1988) Agricultural Development Principles - Economic Theory and Empirical Evidence. The Johns Hopkins University Press, Baltimore and London.

Stryker, J.D. (1991) Ghana. In: Krueger, A.O., M. Schiff and A. Valdés. The Political Economy of Agricultural Pricing Policy. Volume 3, Africa and the Mediterranean, The Johns Hopkins University Press, Baltimore and London.

Tsakok, I. (1990) Agricultural Price Policy, Cornell University Press, Ithaca and London.

UNCTAD (United Nations Conference on Trade and Development) (1991) Prospects for the World Cocoa Market until the Year 2005. New York.

UNCTAD (United Nations Conference on Trade and Development) (1994) Improving Market Opportunities for Commodities in the Medium Term, with Emphasis on Achieving Diversification. Geneva.

UNCTAD (United Nations Conference on Trade and Development) Monthly Commodity Price Bulletin, various issues, Geneva.

van Roozendaal, G. (1992) Biotechnology and the current shift in the world's cocoa production. Biotechnology and Development Monitor, No.10: p.12-13.

van Wijk, J., J.I. Cohen and J. Komen (1993) Intellectual Property Rights for Agricultural Biotechnology: Options and Implications for Developing Countries. A Biotechnology Research Management Study. ISNAR Research Report No.3, International Service for National Agricultural Research, The Hague.

Wood, G.A.R. and R.A. Lass, (1985,) Cocoa. Fourth Edition, Longman, London, New York.

World Bank (1990) Making Adjustment Working for the Poor: A Framwork for Policy Reform in Africa. A World Bank Study, Washington.

World Bank (1994) Commodity Markets and the Developing Countries. A World Bank Quarterly, November 1994, Washington.

Appendix

Experts Participating in the Survey

In December 1994, 92 experts from 23 countries were addressed. 50 replied. This corresponds to a rate of return of 58% which is considerable. In addition, three experts participated who had not been addressed personally but received the questionnaire from invited experts. Nine experts answered but did not fill a questionnaire. Thus, 44 experts from 15 countries returned filled questionnaires or expressed their opinion in personal letters.

The experts were asked to declare their level of professional expertise for eight given research fields into one of the four classes ‘high’, ‘medium’, ‘low’, ‘none’ or for an individually determined research field. An overview of the participants professional profile is given in Table A1. In addition, those fields for which the experts assessed their level of professional expertise as ‘high’ or ‘medium’ are included for each expert separately in the list below. Only the fields 1-8 and 12 in Table A1 were given in the questionnaire. The fields 9-11 have been identified as important after the questionnaires were returned. Field 1 includes *in vitro*-regeneration, -multiplication, and -screening as well as cryopreservation and other forms of *in vitro* conservation. Field 4 comprises resistance breeding to diseases, pests, viruses, bacteria and field 6 covers resistance/tolerance to drought, flooding, cold, heavy metals. Field 9 includes the use of methods of molecular biology such as molecular markers for the quantitative characterisation of the genome of cocoa or pathogens. Field 10 comprises the phenotypic characterisation of cocoa germplasm using e.g. botanical descriptors but also aspects of the analysis and management of the collected information. In field 12, all knowledge or skill is embodied which was mentioned by only one or two experts and which is not included in previous categories.

Table A1: *Fields and level of expertise of the participants*

Field of expertise		Level of expertise High	Medium	Low	None
1	*In vitro* techniques	13	7	8	10
2	Genetic engineering	4	10	6	17
3	Traditional crop breeding	13	13	9	5
4	Resistance breeding	12	12	10	5
5	Biological and microbial pest and disease control	9	8	13	8
6	Resistance/tolerance to environmental stress	4	9	13	12
7	Nutrient assimilation capacity and availability	2	4	14	18
8	Photosynthesis	2	1	15	16
9	Genetic characterisation (molecular markers)	5	0	0	0
10	Evaluation and management of germplasm	3	2	0	0
11	Agronomy	4	0	0	0
12	Others	9	0	0	0

The following list includes the addresses and level of professional expertise of the experts participating in the survey except the address of one expert who did not wish his address to be published. The abbreviation ‘N.A.’ means that there is no information available to the respective topic. The second line of each expert's data field contains the experts academic title before the semicolon and the position in his organisation after the semicolon. The last item of each data set is the self-declared professional expertise of the respective expert. The figures 1-8 refer to the eight research branches listed in the table above. If the figures are bold, the expert considers his expertise as high for the respective domain. Normally written figures mean medium knowledge in the respective domain. Knowledge declared for other areas than those listed in the table are recorded explicitly.

List of Participating Experts

Adomako Daniel
Dr.; Executive Director
Cocoa Research Institute,
International Airport, Private Mail Bag
Accra
Ghana
Telephone: 233-81-2221 or 233-81-3097
Telefax: 233-81-3257
E-mail: N.A.
Professional expertise: **Raw bean processing and utilisation, by-products development**

Adu-Ampomah Y.
Dr.; Head Plant Breeding Division
Cocoa Research Institute,
International Airport, Private Mail Bag
Accra
Ghana
Telephone: 233-81-3097 or 233-81-2221
Telefax: 233-81-3257
E-mail: N.A.
Professional expertise: **1; 3; 4; 6**

Andebrhan Teklu
Dr.; Research scientist
American Cocoa Research Institute Molecular Biology Laboratory,
The Pennsylvania State University,
214 Borland Laboratory
University Park PA 16802-2505
USA
Telephone: 1-814-8637785
Telefax: 1-814-8636132
E-mail: DBF1@PSU.EDU
Professional expertise: **1; 2;** 3; 4**; plant lipid biochemistry**

Bekele Frances Louise
N.A.; Research scientist
The Cocoa Research Unit,
The University of the West Indies
Sainte-Augustine
Trinidad and Tobago
Telephone: 1-809-6628788
Telefax: 1-809-6628788
E-mail: N.A.
Professional expertise: Characterisation using botanical descriptors

Bezerra José Luiz
Dr.; Researcher
CEPLAC/CEPEC, Seção de fitopatologia,
Caixa Postal 7
CEP 45.600-000 Itabuna-BA
Brazil
Telephone: 55-73-2143244 or 55-73-2143279
Telefax: 55-73-2143204
E-mail: N.A.
Professional expertise: **1; 5; Mycology**

Clapperton John
Dr.; Retired
19 Parkside,
Maidenhead SL6 6JP
United Kingdom
Telephone: 44-628-76511
Telefax: N.A.
E-mail: N.A.
Professional expertise: **Flavour research**

Ducamp Michel
Dr.; Research scientist
CIRAD-CP,
The University of the West Indies
Sainte-Augustine
Trinidad and Tobago
Telephone: 1-809-6628788
Telefax: 1-809-6628788
E-mail: N.A.
Professional expertise: **4**

Eskes Albertus
Dr.; Head cocoa and coffee breeding
CIRAD-CP,
BP 5035,
F-34032 Montpellier Cedex 1
France
Telephone: 33-67-615610
Telefax: 33-67-615793
E-mail: eskes@mont.cirad.fr
Professional expertise: 1; 2; **3; 4**; 5

Figueira Antonio V.O.
Dr.; Research Manager
Centro de estudos de cacau,
Almirante Cacau, Comercio e Exprotaçao ltda.,
Cx. Postal 55
Itajuípe, Bahia
Brazil
Telephone: 55-73-2111001
Telefax: 55-73-2111673
E-mail: N.A.
Professional expertise: **1; 2**; 3

Flood Julie
Dr.; Research officer (team leader)
Tropical Plant Pathology Laboratory,
School of Biology and Biochemistry,
University of Bath, Claverton Down
Bath BA2 7AY
United Kingdom
Telephone: 44-1225-826826 ext. 5437
Telefax: 44-1225-826779
E-mail: bssjf@bath.ac.uk
Professional expertise: **1; 4; 5**

Fritz Paul
Dr.; Asociado Profesor
CATIE, P.O. Box 47
Turrialba
Costa Rica
Telephone: 506-556-7050
Telefax: 506-556-1533
E-mail: pfritz@computo.catie.ac.cr
Professional expertise: 1; 2; 3; 4; 5; 6

Furtek Douglas
Dr.; Director
American Cocoa Research Institute
Molecular Biology Laboratory,
The Pennsylvania State University,
214 Borland Laboratory
University Park PA 16802-2505
USA
Telephone: 1-814-8637785
Telefax: 1-814-8636132
E-mail: DBF1@PSU.EDU
Professional expertise: **1; 2**; 3; 4; **plant lipid biochemistry**

Gilmour Martin
Dr.; Commodity Research Analyst
Mars Confectionery,
Division of Mars (UK),
Dundee Road
Slough, Berks SL1 4JX
United Kingdom
Telephone: 44-753-514495 or
44-753-514369
Telefax: 44-753-529221
E-mail: N.A.
Professional expertise: **1; 2; molecular biology**

Guest David
Dr.; Senior Lecturer
The University of Melbourne,
Parkville, Victoria, 3052
Australia
Telephone: 61-3-3445042
Telefax: 61-3-3475460
E-mail:
david_guest.botany@muwaye.unimelb.edu.au
Professional expertise: 4**; 5; integrated disease management**

Hadley Paul
Dr.; Reader in Crop Physiology
University of Reading,
School of Plant Sciences, Dept. of Horticulture,
Whiteknights, P.O. Box 221
Reading RG6 2AS
United Kingdom
Telephone: 44-734-38074 or
44-734-875123
Telefax: 44-734-750630
E-mail: ahscocoa@rdg.ac.uk
Professional expertise: **6; 7; 8; crop modelling**

Hall David Robert
Dr.; Resource Centre Mananger
Natural Resources Institute,
Central Avenue, Chatham Maritime
Kent ME4 4TB
United Kingdom
Telephone: 44-634-880088 or
44-634-883207
Telefax: 44-634-880066 or
44-634-880067
E-mail: david.hall@nri.org
Professional expertise: **5**

Hardwick Keith
Dr.; N.A.
Dept. of Botany,
University of Liverpool, P.O. Box 147
Liverpool L69 3BX
United Kingdom
Telephone: 44-51-7942000 or
44-51-7945131
Telefax: N.A.
E-mail: N.A.
Professional expertise: 1; 6;**8**

Janick Jules
Prof. Dr.; N.A.
Dept. of Horticulture, Purdue University
West Lafayette IN 47907-1165
USA
Telephone: 1-317-4941329
Telefax: 1-317-4940391
E-mail: N.A.
Professional expertise: **1; 3; 4**

Kennedy A.J.
Dr.; Geneticist
West Indies Central Sugar Cane Breeding
Station, Groves
St. George
Barbados
Telephone: 1-809-4331308
Telefax: 1-809-4335568
E-mail: N.A.
Professional expertise: 1; 2; **3; 4**; 6; **data base mangement; computer programming; biometrics; germplasm management**

Lachenaud Philippe
Dr.; Research scientist
CIRAD-CP,
Amélioration des plantes, BP 701
97387 Kourou Cedex
French Guyana
Telephone: 594-32-0430
Telefax: 594-32-4227
E-mail: lachen_p@kourou.cirad.fr
Professional expertise: 3; 4; 5; 6; genetic resources

Lamin Kelvin
N.A.; Research Officer
Malaysian Cocoa Board,
Biology Research Unit Quoin Hill,
P.O. Box 60079
91010 Tawau, Sabah
Malaysia
Telephone: 60-89-761722 or 60-89-761840
Telefax: 60-89-761050
E-mail: N.A.
Professional expertise: **3**

Lass R. A.
N.A.; Head, Agricultural and Environmental Affairs
Technical Development Department, V52,
Cadburry Limited,
P.O. Box 12, Bournville Lane
Birmingham B30 2LU
United Kingdom
Telephone: 44-21-4582000
Telefax: 44-21-4514333
E-mail: N.A.
Professional expertise: **All scientific disciplines relevant to agronomy and marketing**

Lee Ming Tong
Dr.; Director (Biology)
Malaysian Cocoa Board,
Tingkat 5, Blok A, Wisma MUIS, Jalan Tunku
Abdul Rahman, Beg Berkunci 211
88999 Kota Kinabalu, Sabah
Malaysia
Telephone: 60-88-212572 or 60-88-211573
Telefax: 60-88-239575 or 60-88-213037
E-mail: leemt@koko.gov.my
Professional expertise: **3**; 4; 5; 7; **agronomy**

Lim David H. K.
N.A.; Scientific Research Officer
Bal Plantations Sendirian Berhad,
Scientific Department, P.O. Box 135
91007 Tawau, Sabah
Malaysia
Telephone: 60-89-913533
Telefax: 60-89-913222
E-mail: N.A.
Professional expertise: 3

Lockwood Rob
Dr.; Senior Agriculturalist
Commonwealth Development Corporation,
One Bessborough Gardens
London SW1V 2JQ
United Kingdom
Telephone: 44-171-8284488
Telefax: 44-171-8286505
E-mail: N.A.
Professional expertise: **3; 4; 5**

Maddison Alan
Dr.; Consultant
20A Moor Lane,
Chessington, Surrey KT9 1BW
United Kingdom
Telephone: 44-81-3971942
Telefax: 44-81-3971942
E-mail: N.A.
Professional expertise: 4**; 5; epidemiology**

Martins Newman Luz Edna Dora
Dr.; Head of the Cocao Research Center
CEPLAC/CEPEC, Seção de fitopatologia,
Caixa Postal 7
CEP 45.600 Itabuna-BA
Brazil
Telephone: 55-73-2143244 or 55-73-2143279
Telefax: 55-73-2143204
E-mail: N.A.
Professional expertise: 1, 3, **4, 5**, 6

Mawardi Surip
Ir, M.Sc; Associate Director for Research and Development
Indonesian Research Institute for Coffee and Cocoa, Jl. PB. Sudirman 90
Jember 68118
Indonesia
Telephone: 62-331-57130 or 62-331-87278 or 62-331-85864
Telefax: 62-331-87735 or 62-331-57131
E-mail: N.A.
Professional expertise: **3; 4**; 5; **agronomy**

Meunier Jacques
Dr.; Scientific director
CIRAD-CP,
BP 5035,
F-34032 Montpellier Cedex 1
France
Telephone: 33-67-615800
Telefax: 33-67-615659
E-mail: N.A.
Professional expertise: 1; 2; **3; 4**; 5; 6; 7;8

Morera Jorge A.
Dr.; Genetic Resources Co-ordinator
CATIE, P.O. Box 25
Turrialba
Costa Rica
Telephone: 506-556-6440
Telefax: 506-556-1533
E-mail: jmorera@catie.ac.cr
Professional expertise: **3**; 4; **6**; 7; **genetic resources**

Morgan Jeffrey N.
N.A.; Director Chocolate/Cocoa and Raw Materials Research and Development
m&m Mars, Incorporated, 295 Brown Street
Elizabethtown, Pennsylvania 17022-2192
USA
Telephone: 1-717-3671500 or 1-717-3670991
Telefax: 1-717-3670311 or 1-717-3614608
E-mail: N.A.
Professional expertise: N.A.

Mumford J.
Dr.; Deputy Director, Centre for Environ-mental Technology
Imperial College, Silwood Park,
Ascot, Berks SL5 7PY
United Kingdom
Telephone: 44-1344-294206
Telefax: 44-1344-294339
E-mail: j.mumford@IC.AC.UK
Professional expertise: **5; integrated pestmanagement**

Patterson Gordon R.
N.A.; Staff Scientist
Technical Center,
Hershey Foods Corporation, P.O. Box 805,
1025 Reese Avenue
Hershey PA 17033-0805
USA
Telephone: 1-717-5347658
Telefax: 1-717-5345076
E-mail: N.A.
Professional expertise: 3; 4; 6; 7; cocoa curing; generalist experience in a number of cocoa production areas

Perea Dallos Margarita
Dr. Scs. Natur.; Head Plant Cell Tissue Culture Laboratory
Biology Department, Sciences Faculty,
National University Bogota
Colombia
Telephone: 57-1-2141352 or
57-1-2442388 or
57-1-2686540
Telefax: 57-1-2225192 or
57-1-2692951
E-mail: N.A.
Professional expertise: **1**; 2; 3; 4; **5; 6; 7**

Pétiard Vincent
Dr. ; Head manager
France Reco S.A.,
Plant Biotechnology Research,
101, avenue Gustave-Eiffel
F-37390 Notre-Dame-d'Oé
France
Telephone: 33-47-628383
Telefax: 33-47-491414
E-mail: N.A.
Professional expertise: **1**; 2; 3; **freeze preservation; DNA fingerprinting**

Purdy Laurence H.
Dr. ; Professor Emeritus
IFAS,
Plant Pathology Dept., University of Florida
Gainsville FL 32611-0680
USA
Telephone: 1-904-392-7235
Telefax: 1-904-392-6532
E-mail: LHP@gnv.ifas.ufl.edu
Professional expertise: 3; **4**; 5; 6; **evaluating germplasm for disease responses**

Rodríguez Helga
M. Sc. Plant Breeding; Research Assistant
CATIE,
Laboratorio de Biología, Apdo. 28, P.O. Box 7170
Turrialba
Costa Rica
Telephone: 506-556-6431
Telefax: 506-531-1345
E-mail: hvonplat@catie.ac.cr
Professional expertise: **1**; 2; 6; **mapping genes**

Schnell Raymond J.
Dr.; Research Geneticist
USDA-ARS National Germplasm Repository,
13601 Old Cutler Road
Miami FL 33158
USA
Telephone: 1-305-2543632
Telefax: N.A.
E-mail: miars@ars-grin.gov
Professional expertise: 1; 2; **3; 4; molecular biology and quantitative genetics**

Sounigo Olivier
Msc.; Research scientist
Cocoa Research Unit,
The University of the West Indies
Sainte-Augustine
Trinidad and Tobago
Telephone: 1-809-6628788
Telefax: 1-809-6628788
E-mail: N.A.
Professional expertise: 3**; molecular markers**

Suarez Carmen
Dr.; N.A.
INIAP Pichilingue, Apartado no. 24
Quevedo
Ecuador South America
Telephone: 593-2-750966 or
593-2-750967
Telefax: 593-2-751018
E-mail: N.A.
Professional expertise: **3; 4; 5**

Subali Sapiyah
N.A.; Research Officer
Cocoa & Coconut Division,
Malaysian Agricultural Research and Development Institute, MARDI Hilir Perak, P.O. Box 25
36307 Sungai Sumun, Perak D.R.
Malaysia
Telephone: 60-5-669242 or 60-5-69249
Telefax: N.A.
E-mail: N.A.
Professional expertise: **3**; 6

Taniwiryono Darmono
Dr.; Research scientist
Research Center of Estate Crops Biotechnology,
Jl. Taman Kencana No. 1
Bogor, West Java 16151
Indonesia
Telephone: 62-251-324048
Telefax: 62-251-328516
E-mail: N.A.
Professional expertise: **1**; 2; **5**

Tay Eong Beok
Dr.; Deputy Director-General (Research)
Malaysian Cocoa Board,
Tingkat 5, Blok A, Wisma MUIS, Jalan Tunku Abdul Rahman, Beg Berkunci 211
88999 Kota Kinabalu, Sabah
Malaysia
Telephone: 60-88-211573 or 60-88-212572 or 60-88-222970
Telefax: 60-88-239575 or 60-88-213037
E-mail: N.A.
Professional expertise: 1; 3; 4; 5; 6; 7

Villalobos Victor
Dr.; N.A.
FAO, Via delle Terme di Caracella
I-00100 Rom
Italy
Telephone: 39-6-52251 or 39-6-573705 or 39-6-573152 or 39-6-575155
Telefax: 39-6-52256347 or 39-6 -5789610
E-mail: victor.villalobos@fao.org
Professional expertise: **1**; 3; 4; **cryopreservation, *in vitro* conservation**

Wheeler Bryan
Dr.; Consultant
40 Simons Walk, Englefield Green
Egham, Surrey TW20 9SQ
United Kingdom
Telephone: 44-784-432835
Telefax: 44-784-432835
E-mail: N.A.
Professional expertise: **Diseases**