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Agricultural Research, Technological Change and Small Farmer Participation: A Case Study of North-East Brazil

by

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Abstract

This thesis discusses technological change among a group of small and resource-poor farmers in North-East Brazil. The core of the dissertation analyses the processes involved in the generation of a new technology and attempts to identify and assess the socio-economic impact of such a technology upon those farmers. They live in the Caruaru region, a semi-arid area of the Agreste of Pernambuco, and practice rain-fed agriculture.

The nature of the technological change was carefully considered and is very important because it was part of a new initiative involving local agricultural researchers. After a long history of failing to provide small farmers with a relevant type of new technology, IPA (Institute of Agricultural and Livestock Research of Pernambuco) researchers tried to move away from what is often called the transfer-of-technology (TOT) approach to agricultural development or a top-down, linear and researcher centred research methodology. After adopting a Farming Systems Research (FSR) methodology in the late 1970s, scientists together with farmers realized, among other things, that without a higher degree of farmer participation, it would be very difficult, if at all possible, to promote technological changes which would meet farmer's needs and improve their livelihoods.

The case study selected illustrates that agricultural research and the processes of generation of new technologies are anything but well defined, carefully planned and a systematic set of actions. Agricultural research is part of a dynamic process which involves overcoming competing world views, changing alliances and conflicting interests. Improvisation and adaptation on the part of agricultural researchers, as well as farmer participation, proved very important when developing a new research methodology which appears capable of generating technologies which meet farmers' needs.

Farmers, not in isolation but organized in their own association which they managed without the interference of outsiders, played a crucial role in promoting the technological change discussed in the following chapters. Contrary to what many have believed, the small farmers of Caruaru, like so many small farmers around the world, possess a vast degree of knowledge or ITK (Indigenous Technological Knowledge) and are constantly experimenting and looking for solutions for their agricultural problems.

The thesis concludes that there is scope and a large potential for participatory and systemic/holistic forms of technological change to promote the betterment of small farmers livelihoods in a sustainable manner.

Agricultural Research, Technological Change and Small Farmer Participation: A Case Study of North-East Brazil

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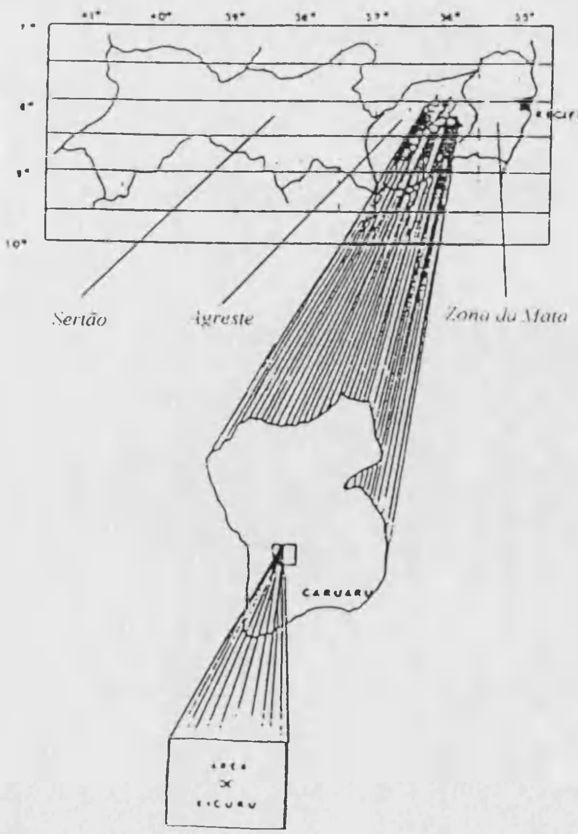
(a) Map of the North-East Brazil highlighting the state of Pernambuco and its capital Recife;

(b) Map of the state of Pernambuco divided into three distinct phisiographic zones (*Sertão, Agreste, Zona da Mata*) displaying the municipality of Caruaru, Caruaru (pop. 250,000; 130km west of Recife) and the Xicuru area. Xicuru, where fieldwork for this thesis was carried out, comprises 13 villages and is located 15km away from Caruaru.

(a)

(b)



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Abbreviations

APROBACA	**Associação dos Produtores de Batata de Caruaru** (Association of Potato Growers of Caruaru)
ATRAM	**Associação dos Trabalhadores Rurais de Maniçoba** (Association of Rural Workers of Maniçoba)
CAR	**Conventional Agricultural Research**
CAT	**Centro Agroambiental do Tocantins** (Agricultural and Environmental Centre of Tocantins)
CECAPAS	**Centro de Capacitação e Acompanhamento de Projetos Alternativos** (Centre for Capacitation and Follow-Up of Alternative Projects)
CPATSA	**Centro de Pesquisa Agropecuária do Trópico Semi-Árido** (Centre for Agricultural and Livestock Research for the Semi-Arid Tropics)
ECLA	**United Nations Commission for Latin America**
EIU	**Economist Intelligence Unit**
EMATER	**Empresa de Assistência Técnica e Extensão Rural** (Technical Assistance and Rural Extension Company)
EMBRAPA	**Empresa Brasileira de Pesquisa Agropecuária** (Brazilian Agricultural and Livestock Research Company)
ESG	**Escola Superior de Guerra** (Higher War College)
FSR	**Farming Systems Research**
FPR	**Farmer Participatory Research**
GNP	**Gross National Product**
HYVs	**High Yielding Varieties**
IBGE	**Instituto Brasileiro de Geografia e Estatística** (Brazilian Institute of Geography and Statistics)

IPA	**Instituto de Pesquisa Agropecuária de Pernambuco** (Agricultural and Livestock Research Institute of Pernambuco)
ITK	**Indigenous Technological Knowledge**
ISI	**Import Substitution Industrialization**
MNC	**Multinational Companies**
NDP	**Net Domestic Product**
NGOs	**Non-Governamental Organizations**
PAPP	**Programa de Apoio ao Pequeno Produtor** (Small Producers Support Programme)
PROÁLCOOL	**Programa Nacional de Álcool** (National Alcohol Programme)
PRORURAL	**Programa de Desenvolvimento Rural** (Rural Development Programme)
PTC	**Participatory Technological Change**
SIP	**Sistema Integrado de Produção** (Integrated Production System)

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I wish all a better and fulfilling future.

CHAPTER 1

Three Recent Approaches to Agricultural Research and Small Farmers in Developing Countries

1.1 Introduction

Agricultural research models which have evolved over the past century and into the 1960s - Conventional Agricultural Research or CAR - have largely failed to provide small farmers in developing countries with the means to increase food crops output and productivity. The problems associated with rural poverty have remained unsolved and living standards continue very low by any measure (Scarborough, 1997; Stewart, 1987). As the population of these countries continues to grow at a fairly rapid pace, per capita staple food production has declined in many countries, for example, Brazil (Chapter 2; Homem de Melo, 1983). A FAO study (Agriculture: Toward 2000) has examined 90 developing countries and concluded that, if growth trends continued unchanged, agricultural production and food production levels would reach worrying levels by the year 2000: 'half of the 90-country population would still have per capita caloric supplies under 100% of national average requirements, and a substantial margin above 100% is needed to ensure adequate supplies to everyone. It is in this sense that a continuation of trends leads to alarming results' (cited in Jahnke, 1985, p.27). Thus, there is a fundamental need for the enhancement of domestic food production (Homem de Melo, 1985).

By the mid-1960s, it had become clear that the emphasis on transferring existing, often capital-intensive, modern technologies from the industrialized nations to developing countries was not producing the anticipated results in terms of promoting significant increases in agricultural production and land productivity. Besides, as indicated by Ruttan (1985), it also became increasingly apparent by then that the rural development programmes and technical assistance which were largely based on a presumption of inefficient resource allocation among 'irrational tradition-bound' peasants had failed to generate the expected modernization of traditional farms and did not deliver rapid growth in agricultural output.

The response from the research establishment was the development of high-yielding varieties (HYVs), first of maize in the late 1950s, and then of rice and wheat in the mid-1960s (Lipton and Longhurst, 1989). The Green Revolution, as it became known, was geared to production goals and practically disregarded the social, political and even the broader economic consequences of its implementation. The vast majority of small farmers in developing countries who depend on rain-fed agriculture for their livelihood could not adopt the technological innovations on offer. Frankel (1971) and others (Griffin, 1974; Pearse, 1980) argue that the HYVs largely benefited big farmers in irrigated areas, while often making small farmers worse off, particularly those in rain-fed areas such as Caruaru, North-East of Brazil, which will be the focus of this study. The results and impact of the Green Revolution are complex and have been extensively discussed elsewhere and, therefore, will not be dealt with here (Farmer, 1977; Pearse, 1980; Byres, 1983; George, 1986; Lipton and Longhurst, 1989).

With the realization that small farmers were not adopting the new technologies mainly because they were unsuitable for their socio-economic circumstances came the proposal that technology development should be determined by farmers' needs rather than the preconceptions of researchers (Simmonds, 1985). Based on this principle and placing greater emphasis on small farmer food crops and farming systems, new agricultural research approaches have emerged: Farming Systems Research (FSR) in the 1970s and Farmer Participatory Research (FPR) in the 1980s. As Redclift (1984, p.110) indicated, the development of FSR was: 'partly stimulated by the social, economic and environmental effects of the Green Revolution'. Both methodologies are based, among other things, on farmer participation in the research process and support for indigenous farming practices that attempt to correct the bias toward the high-technologically-intensive approach to agricultural research characteristic of the Green Revolution.

With that in mind, this chapter proceeds with a brief description of the Conventional Agricultural Research approach to technology development and then examines in more detail the contribution of Farming Systems Research and Farmer Participatory Research. However, due to the nature of the important methodological change promoted by IPA (Agricultural and Livestock Research Institute of Pernambuco, Brazil) in the early 1980s, which will be explained in detail in chapter 4, the core of the present chapter discusses FSR.

The terms 'technology', 'technological innovation' and 'technological change' will be used interchangeably and are broadly defined here as new crop varieties, the use of new inputs and/or equipment and new husbandry practices.

1.2 Conventional Agricultural Research (CAR) and Agricultural Development

In the 1950s and early 1960s there was a wave of optimism about development prospects for the so-called 'developing world'. Modernisation theory (Webster, 1984) dominated the debate about how developing countries would grow, develop or change. At that time, these three different concepts were treated as having the same meaning (Meier and Seers, 1985).

On the whole, development was nearly always seen as an economic phenomenon in which rapid gains in overall per capita Gross National Product (GNP) growth would either trickle down to the masses in the form of jobs and other economic opportunities both in the urban and rural sector, or create the necessary conditions for the wider distribution of the economic and social benefits of growth (Rostow, 1971). Problems of poverty, income distribution and unemployment were of secondary importance to achieving growth. Moreover, throughout the 1950s and 1960s, as Hall has observed, it was largely accepted that 'industrilization held the key to rapid economic progress and that agriculture was relatively unimportant in promoting growth'(Hall, 1986a, p.90).

The concept of diffusion is one of the tenets of modernisation theory which, due to its neo-evolutionist roots, suggested as a matter of fact that the path of development to be followed by developing countries was quite a straightforward one. According to that view, all societies would be following the same evolutional path and therefore, developing countries would inescapably develop as well (Hoogvelt, 1984a; Webster, 1984). To put it simply, development and rural development, for modernisation theory, meant westernisation or economic growth. That is very much how CAR views the process of agricultural development.

CAR aims to promote agricultural development, or in other words, increase agricultural output and productivity rapidly, and thus solve the basic food problem in many developing countries through technology innovation which is considered the 'heart of the development process' (Rogers, 1972, p.87). One of the basic ideas of this research approach is that agricultural production and productivity in developing countries could be significantly expanded as a result of the transfer of known agricultural technology from the so-called industrialized nations to developing countries. Rogers and Shoemaker (1971) are probably the main representatives of this research model which was consolidated in the 1960s.

CAR is organized along disciplinary or commodity lines. It has typically been conducted in research stations by agronomists and biological scientists under conditions which are not representative of farmers' fields (Gomes, 1986). Social scientists and farmers are not normally involved in the research process. Research is carried out on-station and then, when the new technology is ready, it is sent 'down' to farmers. Within this context, the process of technology diffusion is based on a linear communication model: messages are transferred from the source to the receiver in an unilinear fashion. In other words, from the scientist or technician to the farmer (Souza, 1991).

CAR assumes as a fundamental requirement for transforming traditional agriculture that farmers would need to be persuaded to modify not only their farming practices but their ways of thinking in general. 'In order for a nation [less developed country] to move toward modernization, the majority of its population [peasants] must change its life style' (Rogers, 1969, p.21). Or, 'Modernizing the peasant millions became a major goal. Emphasis was placed upon communicating such ideas as the use of fertilizer and other food-producing innovations, as well as family-planning ideas, and on securing their adoption' (Rogers, 1969, p.11). Only then could farmers in the developing countries be able to solve their problems and succeed in improving their socio-economic conditions. A rural extensionist, who is an expert in persuasive techniques, is the agent responsible for transforming the views and behaviour of the small farmers (Souza, 1991). Thus, persuasion is a key element of the CAR approach.

Despite the fact that technology is developed away from the farmers' fields and without taking into consideration their socio-economic circumstances, the assumption is that researchers know best and that the technology on offer is the most appropriate solution to a farmer's problems. Thus, CAR neglects what authors such as Richards (1990) calls 'indigenous knowledge' or indigenous technological knowledge (ITK) - farmer's accumulated knowledge (see 1.3.1).

Moreover, CAR gives no consideration to the biological and location-specific nature of agricultural production processes. CAR lacks a balanced appreciation of the merits and demerits of intercropping, shifting cultivation and other important components of the complex mixed farming system of small farmers all over the world. Other important factors leading to this complexity and also not taken into consideration by this research approach are: unreliable input and output markets, uncertain climate, low farm incomes, low labour productivity and heterogeneity of resources employed by the farm household (Byerlee et al., 1980).

In spite of the efforts of agricultural researchers, in general, CAR was largely unable to generate the technological innovations necessary to satisfy the needs and preferences of small farmers' complex farming systems. Some authors have blamed the farmers themselves for not adopting the new technologies; their backwardness and ignorance being the main obstacles to change (Boserup, 1983, cited in Abramovay, 1992).

Rogers, for example, said that 'available evidence seems to indicate that peasant behavior is far from fully oriented toward rational and economic considerations' (Rogers, 1969, p.31). Others defended the point of view that rural extensionists are at fault or that inputs are not available at the right time (Chagas, 1986). However, it was only more recently that a less frequently heard explanation began to be considered and seriously acted upon. The explanation is a simple one: 'The recommended technologies are simply not appropriate to farmers' (Byerlee et al., 1980; Mellor, 1986).

There are several interrelated factors upon which the adoption of new technology depends. Broadly speaking, farmers adopt technologies that are likely to increase their income and satisfy their needs and preferences within the farmer's circumstances. Farmer circumstances being the resources available to the farmer, the type of soil and topographic characteristics of the land being cultivated, the climate, pests and diseases and the economic environment in which she or he operates, such as product markets (Byerlee et al., 1980). Many of the farmer's circumstances mentioned above do not appear to be taken into consideration by researchers working within the CAR approach and, therefore, CAR's inability to generate technologies that would meet farmer's needs should not come as a surprise.

In addition, and probably contrary to what CAR researchers might expect, small farmers do not necessarily try to adopt technologies that would maximize their profit or agricultural output (Lipton and Longhurst, 1989; Clayton, 1983). Within this context, small farmers' objective is to minimize risks which may endanger their subsistence supplies or cash income (CIMMYT, 1985; Brandão, 1988). Thus, small farmers aim for reliability and stability of yield rather than profit maximization, especially if they are practising rain-fed agriculture in a semi-arid region such as Caruaru, North-East Brazil

(Chapter 5). As Lipton (1986) explains, even if a farmer acts as if he or she were a maximizer, it does not mean that he or she is actually a profit maximizer. Moreover, 'if we consistently assume that *acting like* a maximizer, under crippling constraints, is as good as *being* a maximizer - then we shall conclude, quite wrongly, that here is little scope for helping peasants to improve their traditional tools and practices. We shall be forced to conclude that only big, expensive new investments can help. But if a man is maximizing his efficiency in washing his face with one hand tied behind his back, it is cheaper to untie his hand than to buy him a sponge' (Lipton, 1986, p.260).

Small farmers in Caruaru agree with Lipton's view when he suggested that small farmers would soon be out of business if they tried to behaved as profit maximizers (as assumed by Schultz, 1964) under the conditions in which they often have to farm. Given all the uncertainties and risks involved in small farmers activities, Lipton (1968) seems to be right in saying that small farmers are 'optimizers' and are constantly trying to balance the goal of increasing output and profit with minimizing risks and guaranteeing the survival of their families. On many occasions, therefore, small farmers do not adopt a certain technology that might increase their farming income, in the short-term, simply because they consider it too risky. It is a rational decision given their circumstances and the type of technology involved.

1.2.1 The Risk Factor and the Small Farmer

Having referred to the issue of risk in the previous section, it is appropriate to briefly consider its role in the small farmer decision-making process. Fieldwork data collected for this thesis (see chapter 6) confirms the idea that small farmers in general, and of the Agreste region of Brazil in particular, are exposed to considerable risk both in production (yield fluctuations) and in the market (price fluctuations).

Roumasset's (1979) simple definition of risk is sufficient within the context of this thesis: 'In insurance parlance and in common language, risk is the probability that returns will fall below a specific level, or below zero or some subsistence requirement'. It is largely accepted that the small farmers of the Agreste region practising rain-fed agriculture face serious risks due to the semi-arid conditions prevalent in the region - low annual rainfall, sporadic intensive rainfall interspersed with unpredictable droughts, high variability of annual rainfall, a short rainy season and poor soils with low infiltration capacity (Queiroz, 1979). Within this environment, the risk of practising rain-fed agriculture is further exacerbated by the cost of adopting innovations such as improved seeds, fertilizers and agro-chemicals to control pests and diseases (see Chapter 5).

Nevertheless, it is important not to overestimate the importance of risk here because, as could be observed during fieldwork for this study, small farmers in the Caruaru region do not seem to be too concerned with that question. Or, as Roumasset (1979) pointed out, researchers should avoid using the hypothesis of risk aversion to provide an easy and often convenient way of resolving the apparent paradox that small farmers are rational but inefficient, especially now when it has become outdated to assume that small farmers are either irrational or lazy.

Roumasset also encourages researchers to go deeper in their analyses and try to explain farmers' behaviour with reference to more fundamental causes. His conclusion is that the a priori assumption that risk aversion of low-income farmers causes serious resource misallocation has no theoretical or empirical basis: 'One should remain sceptical of results that assert the importance of risk and ask whether they are explainable on other grounds' (Roumasset, 1979, p.63). Roumasset's conclusion applies to the small farmers of the North-East of Brazil as well. That is to say, risk is a factor that influences the decision-making process of small farmers, but is not necessarily a very important one in explaining why farmers may reject a new technology. In the words of a farmer of the Brazilian North-East: "We all know that agriculture is a gamble here but we will not stop" (fieldwork, 1990). Thus, farmers are not often intimidated by the risks they have to face. On the contrary, they are willing to gamble (risk) and know well the rules of the game. As Roumasset also suggested in his article, the widespread speculation that risk helps to explain a farmers' apparent reluctance to adopt a new technology is not fully justified. There are many other reasons that provide a better explanation for that phenomenon. A common one, for example, is that the technology does not meet the needs and circumstances of farmers.

To illustrate the point, farmers from the Caruaru region, North-East Brazil, surprised local researchers by not adopting a new technology for sowing manioc (cassava). Although farmers have agreed with researchers that the new technology could increase manioc productivity and thus output, Caruaru farmers concluded after testing the innovation that it would not meet their needs - mainly because it was too time consuming and the price of the final produce, manioc flour, was too low in the local market. Fieldwork data (Chapter 6) revealed the fact that cultivators in that Brazilian region were interested in increasing output of crops which were more profitable than manioc and, therefore, many decided to reduce their manioc fields and use their extra time and resources to grow more potato; to the surprise and consternation of local researchers who expected farmers to adopt the new manioc technological change which they were trying to introduce in the region. As it will be explained in chapters 4 and 5, cultivators in Caruaru were keen in adopting potato cropping - the technological change which is the focus of this thesis - and not the new and apparently adequate manioc technology. Caruaru farmers believe that potato is their most profitable crop.

1.3 Farming Systems Research, 1970s to Present

1.3.1 Introductory Remarks

As it will be argued in the next chapter, the economic policies of the late 1960s and 1970s, in particular, which relied on massive technological inputs and commercialization of agricultural produce - and that are still largely prevalent today - could not meet the needs and preferences of small farmers. The Green Revolution, despite some notable successes, proved to be not very advantageous for the small farmer and highlighted the problems inherent in top-down strategies of generation and diffusion of new agricultural technology (Dasgupta, 1977). This was also the case in Brazil as will be explained in chapter 2.

In an attempt to overcome the limitations of the Conventional Agricultural Research (CAR) approaches, advocates of an extended role for indigenous technical knowledge (ITK) in agricultural research have argued against the assumptions of the CAR model and in favour of participatory research approaches such as FSR and FPR which are discussed below. There is a vast body of literature on ITK showing that it often holds a comparative advantage in terms of being better adapted to eco-systems and favouring the development of more appropriate technologies (Richards, 1990; Conklin, 1957 cited in Howes, 1979).

It is very important for the main idea behind this argument not to be misunderstood. It is not being suggested that scientific knowledge has no role to play in the development of appropriate technology nor that it should be substituted by indigenous technical knowledge. As a matter of fact, one of the main hypotheses being put forward in this thesis is that a research process involving the collaboration of scientists of different areas and farmers is essential for the development of technologies that are in accordance with farmers' circumstances and that contribute to the welfare of the farmer.

Taking into consideration the overwhelming dominance of the knowledge of organised science, linked to the relative power of the State in developing countries, it becomes part of the task to achieve a partnership between researchers and farmers 'to transfer the power of action back to rural people, and to equip them with an adequate understanding of what modern knowledge and technology have to offer in this respect, without merely replacing all that is useful in their traditional knowledge by our modern knowledge' (Swift, 1979, p.43).

Howes (1979) suggests three areas where indigenous participation could prove feasible and desirable. First, farmers could provide scientists with fairly precise information on soils, vegetation, pests and so forth, saving them a lot of time and other scarce resources (money, skilled manpower, etc.) when trying to determine the effective resource base of a region. Secondly, ITK can be very relevant for the formation of an effective environmental and early warning system. Indigenous observers, or farmers, are capable of quickly alerting scientists about a number of problems that have a greater chance of being successfully dealt with if detected soon enough. This is particularly important in regions of developing countries such as the North-East of Brazil where extension services are deficient and leave a great deal to be desired. Thirdly, local rural people could act as the 'eyes and ears' of science. In other words, farmers could inform researchers about the performance of different crops, husbandry practices, and livestock, for example, under different local conditions. These are just three of the major areas where ITK may prove very helpful in assisting or complementing formal scientific knowledge.

These three examples are particularly important within the context of this thesis, due to the fact that in the Caruaru region of the North-East of Brazil, where fieldwork for this study was carried out, the local research station (IPA) is already benefiting from taking ITK into consideration and allowing a certain degree of farmer participation in its research work, as explained in Chapter 4. In this specific case, ITK has shown that it can coexist and even contribute to the development of scientific knowledge which is better prepared to generate and diffuse appropriate technologies and, therefore, to help rural people to bring about rural development, as defined in chapter 3 (3.2).

1.3.2 An Overview

The development of this agricultural research methodology (FSR) emerged largely from the work carried out in the 1970s by the Guatemalan Institute of Agricultural Science and Technology (ICTA) and a few of the International Agricultural Research Centres (IARCs) such as the International Maize and Wheat Improvement Centre (CIMMYT) in Mexico and the International Rice Research Institute (IRRI) in the Philippines (Clayton, 1983). Other agricultural research centres, for example, the International Centre for Tropical Agriculture in Colombia (CIAT) and the Tropical Agricultural and Training Centre (CATIE) in Costa Rica, were working along similar lines and therefore, contributed to the several distinct approaches to FSR that were developed almost simultaneously (Jones and Wallace, 1986a, in Jones and Wallace (eds)).

Farming Systems Research (FSR) was developed mainly as a response to the poor results of the CAR approach and to the limitations of 'top-down' research produced in research stations, especially with regard to providing small farmers with the technical means to increase and diversify their output and raise productivity. It is largely admitted that the low levels of adoption of technological innovations generated by that traditional methodology stem from the fact that those innovations were inappropriate to farmers' circumstances, objectives and preferences (Simmonds, 1985; Clayton, 1983). The rejection of improved technologies by these farmers is often based on the perception that their own 'traditional' technologies are superior for their purposes (Jones and Wallace,1986a, in Jones and Wallace (eds)).

The general aim of FSR is to 'help improve the relevancy of agricultural research and extension services' (Clayton, 1983). By that, Clayton means making agricultural research and extension respond more effectively to farmers' preferences and priorities. These often include higher incomes, a more reliable farming system for a preferred food crop and reduced risk. Although FSR was first developed for use with annual crops, it has grown into a research methodology that tries to deal with several of the important aspects of small farm management requirements and, therefore, encompasses many different activities such as animal and forestry production, as well as, access to credit, household consumption preferences and off-farm employment (Gilbert, Norman and Winch, 1980).

1.3.3 The Concept

FSR is based on two main propositions. Firstly, that effective research on agricultural technology starts and finishes at the level of the small farmer; FSR carries out farmer-level research through what Norman (1980) defined as a farmer/researcher partnership in problem identification and farm-level testing of improved technologies. Secondly, that the methodology is multidisciplinary and attempts to bring together natural and social scientists.

In the traditional agricultural research approach (CAR) described above, research would be conducted almost exclusively by agronomists and biologists. In contrast, FSR teams - acknowledging the complexity not only of the agricultural reality faced by small farmers but also the difficult social and economic (not to mention political) conditions that surround them and which have a direct effect on the management of their agricultural activities - propose to work in collaboration with economists and other social scientists such as anthropologists and sociologists. According to Jones and Wallace (1986), social scientists have already become engaged in multiple roles including research, implementation and management of FSR projects.

In addition to farmer participation and an interdisciplinary approach to agricultural research, several other characteristics of FSR are important in the context of this thesis:

- FSR is concerned mainly with small farmers; their circumstances and problems. Relatively homogeneous groups of farmers are identified as the clients of research in specific agro-climatic zones. Farmers' circumstances being the resources available to the farmer, the type of soil and topographic characteristics of the land being cultivated, the climate, pests and diseases and the economic environment in which she or he operates, such as product markets (Byerlee et al., 1980).

- FSR works within a 'holistic' farming systems framework. The farming system is the complex arrangement of soils, water resources, crops, livestock, labour, and other resources and characteristics within an environmental setting that the farm family manages in accordance with its preferences, capabilities and available technologies (Shaner, Phillip and Schmehl, 1982).

- FSR is strongly focused on applied ('downstream') research. It is an empirical, problem-solving approach to research that is also concerned with finding ways of ensuring that there are effective linkages to influence basic ('upstream') research.

- FSR involves on-farm research, surveys (technical and socio-economic), specifically designed field workshops and other communication methods (Biggs, 1985).

The term FSR is often misunderstood and means different things to people with dissimilar backgrounds and training. However, the most significant characteristic of the different FSR approaches is - according to Jones and Wallace (1986) - their intention to carry on their research work outside the experimental station.

One of the main reasons that motivated researchers to leave the research station is the assumption that, by working with farmers under 'real'/local conditions (of soil, rainfall, pest, etc.), they would be able to identify constraints specific to their target population defined in terms not only of their agronomic conditions but also in terms of their socio-economic and cultural conditions as well. Once they had identified the constraints, with the participation of farmers, research efforts would have a higher probability of developing technologies that would meet farmer's needs.

1.3.4 Farmer Participation

The issue of farmers' participation in the process of generation and diffusion of agricultural technology is not new. It gradually gained in importance as FSR began to consolidate itself as a research approach in the 1970s, and as an increasing number of case studies from different parts of the developing world showed that agricultural research approaches involving farmers which took their indigenous technical knowledge (ITK) into consideration were more likely to be successful in providing farmers with the necessary technology than research based on the top-down transfer-of-technology paradigm (Horton, 1986). However, the issue of farmer participation in the agricultural research process remains an area of debate, especially as far as FSR literature is concerned. There is no consensus among advocates over the administration of participatory research (Oasa and Swanson, 1986).

The extent and form of farmer participation, as well as determining the moment during the research process (e.g. at diagnosis, design, technology development, testing, verification and diffusion) when farmers should be called upon to co-operate with scientists, has been largely neglected. The kind of idealized notion of participation that Midgley et al. (1986) referred to as being present in the social development literature is also a common feature in FSR. While lacking in specificity about the nature of the farmer/researcher partnership and how it would work in practice, many writers appear to treat participation as a panacea (Chambers and Jiggins, 1986).

Despite the widespread use of the concept of participation in most FSR literature, it is probably a fair comment to say that participation is often used as a means to legitimate what in practice are top-down research approaches. In this context, participation means that farmers provide their physical labour and land while researchers design the whole experiment, give detailed instructions about the way it should be implemented and are responsible for the evaluation as well. Nelson and Wright (1997), among others, refer to these types of practices as 'participation as a means', or a way used by researchers or policy-makers to 'accomplish the aims of a project more efficiently, effectively or cheaply' (Nelson and Wright, 1997a, p.1). This concept, participation as a means, is opposed to 'participation as an end' where farmers are in control of the process of technology generation. There are many ways of defining participation as Fernándes et al. (1991) remind us, however, the actions or practices which may be classified under the label 'participation as a means' do not fit any of them. 'Different levels and types of participation exist, from local contributions to development programmes to active participation in decision-making by the local population' (Fernándes et al., 1991, p.61).

Even in cases where farmers are involved in the diagnostic phase of the research process and in testing technologies, it is possible to observe that the form of consultation carried out by researchers does not necessarily result in farmers effectively participating in the design of trials nor in the evaluation of their results. Consultation is aimed largely at helping researchers to reach their own interpretation of farmers' needs and problems. As Ashby has observed, researchers are constantly delaying the moment in the sequence of research activities when farmer participation is considered important. Methodologies for involving farmers in on-farm testing of agricultural technologies conventionally defined farmer participation 'as the implementation of management operations for farm trials which compare a few alternative technologies quite late in the process of identifying recommendations' (Ashby, 1987, p.235).

To end this section, it is a very important to be aware and alert to the fact that it is not enough to give farmers a certain space for them to participate in the research process if their views are not respected, if their ITK is not taken into consideration and if they are not treated like partners in a very difficult undertaking: the promotion of rural development. It may also be necessary as was suggested by Swift (1979), among others, to create new institutional channels for releasing the creative abilities of rural people in a financially feasible way so that the few successful cases might be replicated on a larger scale and in the foreseeable future (Tendler, 1993).

1.3.5 Implementation

In practice, FSR methodology may be difficult to implement. This is not only because of the complexity of the processes involved, but also because it requires the identification of farmers capable and willing to communicate to the researcher their perceptions about the new technology being tested and its potential usefulness and applicability.

In addition, and perhaps even more importantly, is the fact that researchers are not trained nor used to working in partnership with small farmers. They very often put their own priorities first and the farmer's welfare a poor second. It has also proved difficult for them to accept and to overcome the limitations of the conventional research methodology in which they are steeped and with which they are used to working. In practice, it is still probably only a minority of researchers/biological scientists who have recognised the value of farmers' participation in the research process and the value of indigenous technical knowledge, or farmers' own accumulated knowledge. Very often, researchers and rural extensionists are prepared and equipped to carry on their work in a way that is incompatible with many of the ideas which form the backbone of FSR, such as farmer participation, or the idea of a mutual learning process where both sides would learn from each other and together towards the solution of farmers' problems. Natural science researchers also have difficulties in working together with their colleagues from the social sciences, as observed in detail by Rhoades, Horton and Booth (1986).

Despite FSR rhetoric, researchers have shown a limited disposition to learn from the farmers themselves. Little dialogue has been taking place and it would perhaps not be incorrect to say that researchers have a long way to go to become genuinely committed to practising FSR. As Chambers (1979, p.1) suggests, it is still commonly assumed that 'science-based knowledge is sophisticated, advanced and valid and, conversely, that whatever rural people may know will be unsystematic, imprecise, superficial and often plain wrong'.

The practical difficulties of successfully implementing FSR become more evident when the fact is taken into consideration that small farmers themselves have been having difficulties in embracing this research approach. Even when farmers are not suspicious of researchers' intentions and are honestly trying to work with them, farmers still face the obvious problems of communicating and trying to work with someone who, as Paulo Freire (1979) has observed, is trained not to communicate with them but to persuade them about how they should change their farming activities in order to be commercially successful.

The educational process that needs to take place in order for the FSR approach to be fully implemented and have a chance of working is far from being achieved. In many respects, FSR still resembles the process of 'domestication' (*domestificação*) of the farmers which was very well described by Freire (1979). Chambers (1986) also addresses this issue when describing the behaviour of the 'outsiders' (researchers) in determining not only the farmer's priorities but the solution to their problems. In sum, carrying out research with farmer participation, as will be shown in chapters 4 and 5 with regard to the small farmers of North-East Brazil, 'requires high levels of creativity and flexibility, especially at the field level. Researchers must not only be willing to look at new problems, but also be able to adapt research methods to the farmers' production system and take ecological, economic and social organisational factors into account' (Fernandez, 1991, p.91).

1.3.6 Further Differences between FSR and CAR

With respect to FSR, the intention of natural scientists and agronomists was not only to 'jump the fence of the research station' and take their trials to farmers' fields, but also to work together with farmers under their own local conditions. CAR, on the other hand, tends to focus on optimal production conditions, whereas farmers - and small farmers in particular - do not work under those optimal or near optimal conditions. FSR, therefore, aims to develop a technology that may display less yield potential than would be recommended by the conventional approach, but one that is implementable and still profitable at the farm level (Oasa and Swanson, 1986).

An important difference between FSR and CAR that also deserves to be underlined is that the former treats concepts and procedures for planning technologies for a single crop within the farmers' total cropping system, and not in isolation. Even when looking more closely at technologies for a specific crop, FSR examines the farming system as a whole, or as mentioned above, in a 'holistic' manner, in order to detect important interactions which may influence the particular crop under consideration; interactions among crops, interactions between crops and other enterprises and possible interactions between the household and environmental factors beyond the household's control. Therefore, FSR contrasts sharply with the single commodity or single resource orientation, which is a main feature of CAR. Conventional research separates tasks into progressively narrower subject areas to be studied more or less independently, and then evaluates results by standards within the discipline, and not by their contribution to farmers' goals (Shaner, Phillip and Schmehl, 1982).

Another significant difference between the two research methodologies being discussed here is that FSR focuses on farming systems which are predominantly subsistence-oriented and of relatively low productivity. Therefore, food crop production technology has been the main focus of FSR, whereas CAR has concentrated on export crops, which are rarely cultivated by small farmers.

1.4 Farmer Participatory Research

1.4.1 Introduction

As a development of FSR, and as part of the continuing process carried out by farmers to achieve sustainable agricultural development, new research approaches have emerged in the 1980s. A small minority of agricultural research scientists, social scientists and fieldworkers in non-government organizations (NGOs) have been finding new ways of collaborating with small farmers, and demonstrating that there are other methods of identifying priorities and developing and testing technologies. Many labels have been used to describe these research approaches: 'Farmer-back-to-farmer' (Rhoades and Booth, 1982); 'Farmer-first-and-last' (Chambers and Ghildyal, 1985); 'Farmer Participatory Research' (Farrington and Martin, 1988a). These will be grouped here under the heading of Farmer Participatory Research (FPR).

According to Farrington and Martin (1988a) and many others, Farmer Participatory Research (FPR) is a research method complementary to those currently available in problem-oriented agricultural research. It is an iterative process which defies adherence to a strict sequence of activities and in which farmers and researchers from different areas (such as biology, sociology, economics and anthropology) work in partnership. As in the case of FSR, there is no one method of doing FPR that can be held up as a single model and, therefore, different approaches should be tolerated. The IDS (Institute of Development Studies, University of Sussex) Workshop in 1987 on "Farmers and Agricultural Research: Complementary Methods" concluded that different methods should be encouraged, and pointed out the complementarity that exists between several participatory methods such as, innovator workshops, systems diagrams, and on-farm experiments (IDS Workshop, 1989). As a result of this complementarity and depending on the resources available to researchers and farmers, as well as local social and environmental conditions, a varying mix and sequence of methods can be used.

The main difference between FPR and FSR resides perhaps in the degree of farmer participation in the research process. FPR is highly participatory in character; farmers and researchers are supposed to really act as equal partners. Furthermore, in comparison with FSR, FPR adds more flexibility to the research process: researchers consult with farmers throughout the research process and change the design wherever necessary (Okali, Sumberg and Farrington, 1994).

In addition, FPR should not be seen as a substitute for basic research developed inside research stations. Despite possible misunderstandings, basic research designed to generate new understanding of biological processes (on-station and in-laboratory research) is still considered indispensable. On-farm and on-station research are not in competition, and efforts should be made for them to be complementary (Rhoades and Booth, 1982). Norman and his colleagues also emphasised the necessity of improving the connections between research involving farmers' groups and experimental stations, in order to ensure that experiments done in each context produce results of mutual value (Norman et al.,1989). The complementary roles of different types of research were well presented by Galt at the 1987 IDS Workshop on "Farmers and Agricultural Research: Complementary Methods" (cited in Chambers et. al., 1989, p.158).

To sum up, supporting farmers' own innovations, increasing and fostering their participation in agricultural research, giving their agendas priority and promoting what Chambers (1986) called 'reversals' (as opposed to the conventional approach) - all these are central elements of this new approach to agricultural technology development. In principle, FPR, instead of starting with the problems, priorities, knowledge and analysis of scientists, starts with the problems, priorities, knowledge and analysis of farmers. Instead of the scientists as the main or only experimenter, the farmer is now considered an important experimenter and persuasion is not a means of technological diffusion.

FPR was an important improvement to the conventional research approach (CAR) and appears to have resulted in a more relevant process of agricultural technology development for small scale producers. However, researchers and agencies established to promote agricultural development tend to disregard the fact that experimenting is an important and intrinsic part of farming and, therefore, of the small farmer's life. As a consequence, small farmers continue to be treated, basically, as adopters of technologies developed by outsiders. Their knowledge, experience and potential to participate and collaborate in formal agricultural research and extension remain largely unexplored. Experiences in FPR try to readdress this issue, as the many case studies reported in Haverkort et al.(1991) and Chambers et al. (1989) suggest.

Before exploring in more detail the role farmers play in FPR, it is necessary to make it very clear that, despite their farmer focus, proponents of FPR are not suggesting that scientists have no positive contribution to give to farmers and to the research process. Neither is FPR advocating the rejection of modern technology as a means of solving small farmers' problems. 'Complex, capital-using technology has had, and will continue to have, important applications in attacking rural deprivation' (Chambers, 1986, p.175). Even very sophisticated technology, such as satellite-sensing have proved useful for small farmers. In one particular case, this modern technology allowed scientists to discover underground water resources in semi-arid areas of rain-fed agriculture in North-East Brazil (CPATSA, fieldwork interviews, 1989).

Nevertheless, the FPR emphasis is clear: 'to posit that farmers' knowledge, inventiveness and experimentation have long been undervalued and that farmers and scientists can and should be partners in the real and full sense of that word in the research and extension process' (Rhoades, 1989, p.4, in Chambers et al.(eds)).

1.4.2 The Researcher's Role and Farmer Participation

There is no common agreement with regard to the exact role that farmers and scientists should play in FPR. One of the most radical views advocates that researchers should be no more than consultants to farmers (Chambers, 1997). Thus, according to Chambers and Jiggins (1986), farmers would play the major role and would be responsible for all decisions in the research process. Contrary to what happens in FSR, farmers would not only be in charge of testing innovations, but perhaps more importantly, farmers would be in command of the design, the full conduct of research and evaluation as well.

Farrington and Martin (1988b) appear to present a more balanced view of the researcher's role in FPR. They do not accept the view that researchers should play only a secondary role in the research process, and find it unrealistic to assume that farmers' knowledge would be broad enough to allow them to take into consideration all the available technological alternatives. They suggest no fixed roles for farmers and researchers, adding that in practice their contribution will depend on three factors. First, the purpose and character of the investigation. Second, the extent to which researchers' knowledge can be applied to the problem in question; and third, the relevance of ITK to the problem.

Farrington and Martin also argue that Chambers and Jiggins' views neglect an important contribution of researchers, that is: 'researchers' ability to analyse and quantify interactions observed in the field so as to incorporate them into the wider body of scientific knowledge, and to draw from this knowledge those elements bearing on the problem in hand' (Farrington and Martin, 1988b, p.250).

Despite differences in opinion with regard to the researcher's role in FPR, there seems to be little disagreement that a critical component is the partnership between researchers and farmers. A partnership, nevertheless, that may assume many different forms depending on the degree of farmer participation in the research process.

Biggs (cited in Farrington and Martin, 1988a, p.30) suggests four categories, based on the degree of interaction, in an attempt to classify field experience with farmer participation. They are as follows: (a) contract, (b) consultative, (c) collaborative, (d) collegiate. The contract type of relationship between farmer and researcher is typical of what is being called here CAR. FSR may be associated with the consultative and collaborative types of interaction, while FPR is characterized by a collegiate type of relationship.

In the contract (a) type of research, farmers participate only in an indirect or minor way. In order to test the technologies that were developed on-station under farmers' conditions, researchers may borrow or hire the farmers' land, and in some cases their family services, and set up their own experiments. All decisions are taken by researchers.

In consultative cases (b), farmers' views begin to be taken into consideration. In order to find out more about farmers' farming practices, objectives and perhaps economic situation, researchers do consult with farmers. However, researchers maintain a superior attitude and, in spite of exchanging ideas with farmers about the design, conduct and evaluation of trials, researchers still take the bulk of decisions.

Collaborative (c) experiments involve a deeper and more intense contact between researchers and farmers through most phases of the research process. Farmers' views and feedback help shape the development of technologies and the way trials are planned and conducted.

Farmers' participation in the research process is even greater in the collegiate category (d). Farmers are respected and treated as equal partners throughout the research process, from diagnosis to dissemination. ITK is incorporated into the research process. Moreover, farmers are encouraged to carry out experimentation and evaluation of trials, together with scientists.

1.4.3 Destructive and Constructive Participation

There is one aspect of the concept of participation that is largely neglected and needs be taken into consideration due to its importance for the implementation of both FSR and FPR. Very often the concept of farmer participation in the process of agricultural research is treated as innately good. FSR and FPR implicitly or explicitly appear to assume that participation is always constructive and automatically leads to the solving of farmer's problems.

However, as Bunch (1991, p.31) appropriately reminds us: 'participation can divide and tear down as well as unite and build up'. Thus, two types of participation can be distinguished: destructive participation and constructive participation. They may occur not only between farmer and researcher but also among farmers and among researchers themselves.

Destructive participation may assume many forms and is likely to pose many obstacles to the formation of a researcher/farmer partnership capable of producing the necessary technological changes to satisfy small farmers' needs. For example, when researchers choose a number of farmers to be their partners without allowing the local community or farmer's organisation to participate in the selection of candidates, participatory research may have disastrous effects. On-farm experiments may be maliciously interfered with; factions can easily develop and research processes may be disrupted. In similar circumstances, farmers collaborating with researchers may become isolated from the rest of the community because of jealousy or rivalries, among other things, and dissemination of technology will be impaired.

Types of participation that involve payments of salaries to certain farmers or give-aways (such as selected seeds, fertilizers, farming equipment, etc.) also tend to produce undesirable results that lead to non-adoption of new technologies. The same result can easily occur when farmers are invited to participate in the research process as partners and are given nothing but orders to follow or when their opinions and suggestions are merely ignored by researchers. Farmers' organizations attempting to work in a participatory way may fall apart due to favouritism or even lack of experience at taking group decisions. In all these instances and many others, destructive participation is likely to breed distrust and mutual recrimination and lead to failures.

Constructive participation, on the other hand, is carried out in an atmosphere of mutual respect and companionship. It is non-paternalistic in character and implies that researchers support farmers in order to increase their capacity to manage change in their farming system. It often starts with farmers actively participating in the identification of problems and research priorities and advances through the different phases of the process of generation of new technologies up to dissemination. It ultimately results in the development and adoption of technologies that satisfy small farmers' needs. However, no absolute guarantees can be given that the research process will succeed because even well-made decisions may lead to failure.

In addition, constructive participation is part of a learning process that develops gradually over time and needs to be nourished by both researchers and farmers, especially because the distance between the reality of the researcher and the farmer in developing countries tends to be very large indeed. A great deal of effort, understanding, creativity, honesty and communication skills (how to speak in public, how to make constructive criticisms, etc.) is necessary to bridge this gap. This learning process is often taken for granted by FSR and FPR. Thus, there is very little discussion about the skills and strategies needed to build the partnership between farmers and researchers. Ways of developing it further are absent from the main body of the agricultural participatory research literature.

In practice, a constructive interaction between farmers and researchers does not happen automatically, as is often suggested in the literature. It is particularly difficult to achieve because it involves two different groups of people working together. In the case of Caruaru in North-East Brazil, which will be explained in detail later (Chapter 4 and 5), researchers are mainly middle class, urban citizens with university degrees while small farmers are very poor, rural people with very little formal education, 33% being illiterate (fieldwork, 1990). Both groups have very different interests and life expectations and even their common language or, the language they speak (portuguese), is not necessarily the 'same'. It is not the same in the sense that researchers' 'agronomic' language proved very difficult for farmers to fully comprehend and vice versa. In chapters 4 and 5 there are a few examples which illustrate well this point and, therefore, they will not be repeated here. Furthermore, researchers from different areas like biology, anthropology, sociology and economics do not normally work together as a team as proposed by FPR and also FSR. Rhoades, Horton and Booth (1986) provide a detailed and very interesting account of the problems faced by an interdisciplinary team of researchers at the International Potato

Centre (CIP) in Peru when trying to work as a team. The authors admit the fact, although their interaction eventually leads to synthesis and synergism: 'we spend an enormous amount of time in what we euphemistically call "constructive conflict" which at the moment it occurs can be deeply personal and difficult interaction' (1986, p.22).

Farmers may also find it difficult to organize themselves in a group and openly discuss their problems and needs before meeting with the research team. In many cultures small farmers work in a fairly individualistic manner and, therefore, it cannot be easy for them to start co-operating and working with each other. In the case of the small farmers of Caruaru, who are the focus of this study, farmers did manage to overcome their personal differences and created a farmer's association (Chapter 5) which played a very important and positive role in the search and development of technological innovations which would meet their needs and improve their livelihoods (Chapter 6).

1.4.4 Farmer Experimentation

Supporting farmers' experiments and development of innovations is very important especially when we take into consideration what Bunch (1989) views as a nearly universal assumption which, until recently, drastically limited the effectiveness of agricultural development efforts throughout the developing world. The basic assumption behind most technological solutions presented to farmers is that increases in productivity achieved through the successful adoption of technological innovation will be maintained indefinitely. However, in the forever changing world of agriculture a solution for a problem today will not last indefinitely. New diseases and pests may arrive in an area where they did not previously exist, pests develop resistance, soil fertility tends to decrease with environmental degradation, important inputs may become unavailable to farmers, new ones appear in the market and seeds degenerate with time. These changes, and many others that may be triggered by agro-climatic changes for instance, will force farmers to seek new answers for problems that could be considered finally solved by researchers. A productive agriculture does require a constantly changing mix of technologies and inputs and, therefore, experimentation and development.

Three major different types of farmer experiments can be distinguished: (a) curiosity experiments; (b) problem-solving experiments and (c) adaptation experiments (Rhoades and Bebbington, 1991). Fieldwork carried out in North-East Brazil for this thesis revealed that these three kinds of experiments are common practice among small farmers:

(a) Curiosity experiments

Small farmers, like most human beings, are curious and keen to try out new ideas. As an example, small farmers in North-East Brazil, without taking any risks, would separate a small area of their backyard to experiment with new varieties of potato seed that they could find in the market or to fertilise a few rows of their potato crop in a different way to that which they used to, or which was being officially recommended by the scientists. Although these experiments could have a very practical application, they were largely fuelled by the farmers' own curiosity.

(b) Problem-solving experiments

Contrary to what many scientists believe, farmers do not tend to look at their problems in a fatalistic way, nor do they passively take them for granted. Through constant experimentation and by observing what their fellow farmers are doing, they often try to find solutions to their problems. Tests are always carried out on a small scale and, if successful, they will gradually be expanded. Several individuals of the same group of Brazilian farmers in this research project were, for example, carefully trying intercropping sorghum with their potato crop in order to overcome their fodder shortage and make the most of the fertilized potato fields. Some would introduce the sorghum after 30 days, others after 45 or 60 days. Different spacing was also being tried in order not to sacrifice potato output and to facilitate the potato harvest. Researches had not thought about this option.

(c) Adaptation experiments

After having received a new technology from researchers or extension workers, farmers are likely to attempt two types of experiments: testing an unknown component technology within a known environment; and testing a known technology within an unknown environment, such as a different type of land.

It is the process of small-scale experimentation carried out by farmers and their capacity to innovate, experiment and adapt that Bunch (1989) argues must be supported and further developed by FPR approaches. In his view, this is probably the only practical alternative open to small farmers to respond to the constant changes that are natural to agriculture and, thus, carry their production on to steadily higher levels. The resulting self-sustainability of development is probably the most important but not the only reason behind the idea of strengthening the small-scale experimentation capacity of farmers proposed by Bunch. There are other advantages that can be gained from small-scale experimentation:

First, by avoiding large scale experiments farmers can minimize their risks and avoid substantial losses that may very easily pose a serious threat to their families' livelihoods. Technologies that are inappropriate to farmers' conditions or an incorrect understanding of the new technology are two common causes of failed experiments that farmers are well aware of and like to avoid, particularly on a large scale.

Secondly, small-scale experiments allow farmers to test several different technologies in a single agricultural year and still keep the level of risk low. Instead, if farmers decided to change their entire crop, for example, they would only be able to try out one new technology.

Thirdly, the introduction of small-scale experiments facilitates assessment of the impact of the new technology. Comparing the results of the new technology with the traditional in the same field enables farmers to better understand the possible changes in performance that may arise.

Fourthly, researchers and extensionists trying to diffuse new technologies tend to face less resistance from farmers when small-scale experiments are suggested. Farmers, especially those involved in participatory research, are quite keen to try out different technologies in a controlled and gradual way that will not risk the well-being of their families. The loss of a small fraction of a farmer's field is unlikely to cause resentment and lead to the loss of the scientist's credibility and prestige. As farmers increase experimentation, researchers will have a much better opportunity to learn about the technologies being tested and about the necessary adaptations to local conditions. And 'the more researchers encourage farmer participation and present scientific knowledge in a form which they can absorb, the more powerful will become the capacity of farmers to adapt technology to their circumstances' (Farrington, 1988, p.272).

Thus, the result of the process of small-scale experimentation is an increased quality and range of technologies available to small farmers (Chapter 5).

1.5 Final Remarks

The three agricultural research approaches discussed here reveal a clear movement towards on-farm research (research on farmers' fields) and increased farmer participation in all phases of the research process: from problem identification to dissemination of technology. They also show that research has become increasingly systemic and location-specific.

This trend appears to be the result of a concerted effort aimed at generating agricultural technologies that would satisfy the needs and preferences of small farmers' complex farming system. An effort prompted by the realization that CAR methods are largely unable to offer answers to the technological problems faced by small farmers.

Evidence from around the world seems to confirm the hypothesis that participatory research approaches such as FSR and FPR would be more able to satisfy small farmers and contribute to the promotion of rural development. The present study of small cultivators in North-East Brazil aims to examine the hypothesis that participatory research can generate technologies that would have positive socio-economic impacts as far as small farmers are concerned.

Chapter 2
The Brazilian Agricultural Sector After the Second World War: An Overview

2.1 Introductory Remarks

It is generally accepted that the performance of the agricultural sector in Brazil throughout the postwar period was fairly good or at least satisfactory in terms of overall output growth. Despite the sector's low levels of productivity and technological development, the lack of infrastructure, the very pronounced regional disparities and discriminatory Government policies, many studies have shown that the aggregate record of output growth of the agricultural sector improved continuously (Nicholls, 1971 and 1972; Graham, Gauthier and Barros, 1987). Some of these studies also point out that in relation to the five classic functions of agriculture, the sector has not done badly. The five functions are: (a) providing increased supply of food and raw materials to meet the needs of the secondary sector; (b) generating foreign exchange via export production; (c) providing a net flow of capital to finance a considerable part of the requirements for infrastructure and industrial growth; (d) freeing labour resources from the rural areas in order to promote industrialization at low costs; (e) creating a market for goods from the secondary sector (Albuquerque, 1984 and 1985; Paiva, 1979; Castro, 1977; Johnston and Mellor, 1961).

However, what is often not sufficiently emphasized is the very specific context in which Brazil's agricultural performance could be described by the World Bank as one of the best in the world (World Bank, 1982). This judgement ignores the social consequences of the modernization process and its broader impact upon the agricultural sector itself. The promotion of the economic and social well-being of all those involved in the rural sector, particularly the low income groups have not been considered (Abramovay, 1984). Small farmers, the focus of this work, were largely disregarded despite the fact that they are responsible for the production of a significant percentage of the main staple food crops in Brazil (Chapters 3 and 7).

A recent study carried out by the International Fund for Agricultural Development (IFAD, 1992, cited in Graziano da Silva, 1996, p.184) involving 144 developing countries shows that Brazil is one of the worse countries in a rural poverty ranking. Brazil came in sixth place, with 73% of its rural population living under the poverty line. Only Bolivia (97%), Malawi (90%), Bangladesh (86%), Zambia (80%) and Peru (75%) presented figures that were no better than Brazil's. Moreover, in most developing countries in this study rural poverty is decreasing, while in Brazil the percentage of rural poor increased from 65% in 1965 to 73% in 1988 (Graziano da Silva, 1995).

One of the main aims of this chapter is both to describe the performance of Brazilian agriculture in the postwar period and show the limitations of the optimistic point of view mentioned above about the agricultural sector's achievements. A few alternative ways of looking at the performance of the agricultural sector will also be presented. It is, nevertheless, beyond the scope of this study to provide a detailed or complete analysis of such a vast, complex and controversial issue. This approach, however, may help us comprehend the reasons why small farmers received little support from both the Brazilian Government and also from agricultural research (Chapter 1).

Besides, in order to better understand the changes experienced by the agricultural sector, it is necessary to consider the broader context of Brazilian political economy of this period and how agriculture fits into it. It then gradually becomes clearer that several of the difficulties that the sector had to face during the period in question were directly related to the overall development strategy adopted by the Brazilian State. A brief discussion of the main characteristics of Brazilian political economy and its effects on agriculture forms the first section of this chapter. In the second section, the agricultural modernization process is examined in some detail. Then, the influence of the National Security Ideology upon the sector is discussed. The last section, before the closing remarks, concerns the performance of the agricultural sector itself. Together these sections provide the reader a general context in which small farmers of the North-East and local researchers from IPA are inserted and, thus, put into perspective the changes promoted by them (Chapter 4 and 5).

2.2 Brazilian Political Economy After the Second World War and the Role of Agriculture

The Brazilian Government, like many other Latin American and Third World countries after World War II, engaged in a programme of modernization based almost exclusively on a strategy of industrialization. Import Substitution Industrialization (ISI) was chosen as the principal source of stimulus for industrial growth until approximately the mid-1960s (Collier, 1979; Hirschman, 1967; Tavares, 1982). Within this new developmental context, the agricultural sector, once the engine of growth of the Brazilian economy (Frederico, 1985; Villela and Suzigan, 1977) was now mainly considered a mere source of financing and input to the industrial sector (Paiva, Schattan and Freitas, 1973).

ISI assumed, to a large extent, that industrialization alone would bring about progress and economic development. Explicit or implicit in the development model adopted was the belief that ISI, stimulated by a moderate and selective protection policy, was an economically sound policy for achieving economic growth which would remove Brazil from the group of underdeveloped countries. ISI was also expected to help correct an existing tendency to foreign constraint on development resulting from the low elasticity of demand for imports of primary product by the developed countries, compared with the high elasticity of demand of developing countries for manufactured products from the developed world (Meier and Seers, 1985).

The assumption that economic growth in itself would eventually correct great income disparities through the play of market forces was an integral part of the developmental model adopted in Brazil. Optimism was widespread particularly in the 1950s and early 1960s. Optimism in the sense that the complex task of developing the underdeveloped countries, removing poverty and improving the living standards of the masses was considered a relatively easy task (Bhagwati, 1985). Remarkable as it may now seem, this is what most development economists believed in during the early postwar years.

The new bureaucratic-authoritarian political regime that emerged in Brazil after the 1964 military coup led to a new model of economic development which would move away from the ISI policy orientation with its emphasis on the expansion of heavy industry and on the formation of infrastructure for the production of durable goods. One of the key features of this model that Cardoso (1973) called 'associate-dependent development' is a new and more complex international division of labour based on income concentration and the relative increase in poverty. The Brazilian Government, through various means such as credit, fiscal and income policies fostered the process of income concentration with the aim of producing a demand profile that would satisfy the plans of multinational corporations (MNCs) and attract them to the country (Furtado, 1973).

Third World countries were no longer seen only as importers of manufactured goods and exporters of primary products. Some of them, Brazil for example, were experiencing a high degree of industrialization - part of a process of internationalization of the internal market in which multinational corporations play an important role (Cardoso and Faletto, 1984). Despite being responsible for less than ten per cent of the Brazilian Gross National Product (GNP) in the mid-1970s, Bacha has shown that MNCs have in fact been the growth pole for the whole economy and the agent responsible for the diffusion of innovation (Bacha, 1978). MNCs control activities which rely mainly on technical progress such as the production of durable goods and equipment in general. They have also increasingly penetrated the food industry for supplying upper income groups. Domestic capital is concentrated in the production of non-durable goods whereas the State has an important participation in the production of intermediate products (Furtado, 1973).

Foreign capital, previously an external force whose interests were believed to be represented internally by compradores and agrarian exporters, now operated locally sharing with domestic capital the intention of continuing to develop local industry (Evans, 1979). After the mid-1960s the older ruling sectors, including the latifundiários, lost their relative power position in the total structure of political forces because the entire economic system became closely linked to the international capitalist system of production. The incorporation of Brazil into the international capitalist system, after the mid-1960s, resulted in the 'triple alliance' - a complex alliance between elite local capital, international capital and State capital (Evans, 1979).

A primary objective of this new process of accumulation was to increase the economy's productivity, including that of agriculture. In practice, it did not represent a break with the past, in the sense that many of the contradictions produced by the previous growth model remained basically unchanged; especially those created by the exclusion of the vast majority of the Brazilian population from participation in the development process (Oliveira, 1986; Abramovay et al., 1984; Bieri, de Janvry and Schmitz, 1972). According to official statistics (IBGE, 1984), approximately two-thirds of the Brazilian labour force had an income that placed them below the poverty line in 1983. In the North-East region this figure is far higher, 78,6 per cent (Jaguaribe et. al, 1986). Thus, it is argued, the internal dynamics of the triple alliance constrained the State in such a way that it became virtually impossible to adopt a development strategy which could more equitably distribute the benefits of industrialization (Evans, 1979; Cardoso and Faletto, 1984).

Distributive ideas were put aside and the policies intended to raise agricultural productivity and output have not involved any significant change in the very unequal land ownership and income distribution structure. Land ownership data for Brazil as a whole reveals a high degree of land concentration. Data from the Agricultural Census show that in 1960, for example, 50% of the total number of rural establishments (the smaller units) occupied only 3.1% of the total agricultural land, whereas, one per cent of the total number of those properties (the larger ones) occupied no less than 44,5% of the total area. In 1970, these figures were 2.9% and 43.1%, respectively (Graziano da Silva, 1982, p.51). In 1985 those statistics continued to display the huge inequalities which characterize the Brazilian society. Fifty per cent of the total number of establishments occupied only 2.3% of the productive land, while 1% of the larger rural properties detained 43.7% of the total agricultural area (IBGE,1987) (1).

Income distribution figures for Brazil also indicate a high degree of concentration. In the 1970s, Brazil experienced a dramatic increase in income concentration in the rural sector (Bacha, 1978a; Hoffmann, 1988). The richer ten per cent of the labour force employed in the agricultural sector detained 34.7% of the total income in 1970. This figure jumped to 47.7% in 1980. During the same period, the income share of the poorest 50% dropped from 24,2% to 17.9 per cent (Graziano da Silva, 1996). Thus, income inequalities increased despite claims that absolute poverty levels in the rural sector decreased in the 1970s. The rich became richer, but the poor became less poor it is argued (Hoffmann, 1988).

However, the countryside became relatively less poor in the 1970s largely because it expelled the poorest of the poor to the cities. It was believed that more welfare-oriented policies would have threatened the whole of the elite consensus on which industrialization was based. It would also have created conflict with the growth strategies of multinational corporations which depended on income concentration (Evans, 1979). In the 1980s, the perversity of the Brazilian development model became even more apparent: income inequalities continued to increase while the rural poor got poorer (Graziano da Silva, 1996).

As far as agriculture itself is concerned, no particular strategy was designed or implemented to develop the sector in the long-term. It is widely accepted that Brazil did not have a long-term strategy of agricultural development and lacked a consistent set of policies that would promote the modernization of that sector during the period under consideration (Accarini, 1987; Manoel, 1986; Dossa, 1983). Agriculture was largely reacting and adapting to changes in the secondary sector of the economy. Agricultural policies were short-term in character and showed little continuity. These policies were often implemented only when necessary to overcome a major conjunctural problem caused by variable weather conditions (flood, drought or frost, for example), inflationary pressures, changes in supply conditions and/or domestic political interests (Dias and Lopes, 1982; Manoel, 1986).

The modernization model adopted in Brazil after World War II penalized the agricultural sector, impairing the incentive to produce, damaging the growth of productivity and the generation and adoption of technology (Blumenschein, 1984; Alves and Pastore, 1978). CAR (Conventional Agricultural Research) fitted well into this model which promoted industrialization, especially due to its emphasis on export crops capable of generating foreign exchange that could easily be transferred from the primary sector and the use of modern industrial inputs that might be produced domestically (Chapter 1). In order to accomplish rapid industrial development and promote the transfer of resources from agriculture to industry, a number of policies were brought into action: an overvalued exchange rate, price controls, export taxes and quotas on unprocessed goods and tariff protection for domestic industries (Schuh, 1970).

The State policy of an overvalued exchange rate and export quotas, particularly before 1963, discouraged agricultural exports and was not fully compensated by certain selected agricultural imports such as tractors and machinery (Veiga, 1975). Nevertheless, Brazilian exports continued to be highly dependent on agricultural commodities such as sugar, cocoa, cotton and particularly coffee. Only after 1965 did coffee export earnings decrease to less than 50% of Brazil's total foreign exchange income (Homem de Melo, 1979).

The agricultural export sector opposed the draining of income towards industry and forced many concessions out of the Government on different occasions. Special policies for coffee, sugar and cocoa and subsidies for imports of modern inputs were examples of these concessions which are said to have softened the export sector's dissatisfaction towards the economic model being pursued by the authorities (Bergsman and Candau, 1969). It is very likely that ECLA's (United Nations Commission for Latin America) or Prebisch's ideas about the limited developmental scope for agricultural exports may have influenced Brazilian policy-makers and contributed to this bias against agricultural exports (Prebisch, 1985). At the same time, ill administered price controls, mainly aimed at benefiting urban consumers and facilitating ISI, inhibited the expansion of staple food production for the domestic market (World Bank, 1983; Graham, Gauthier and Barros, 1987).

Contrary to what is generally admitted, the industrial policies of the 1960s appear to have penalised the agricultural sector more than in the 1950s (Veiga, 1975). In the 1970s, subsidized credit proved not to be an appropriate form of compensation to farmers and, therefore, did not offset the discriminatory trade and exchange-rate policies that turned the terms of trade against agriculture. The minimum price policy and the provision of subsidized credit (negative real interest rates in many cases) that the Government allegedly used to repair the damage to the agricultural sector had little impact. In the 1980s, orthodox macro-economic policy geared to tackle the debt crisis (Arida, 1983) resulted in a reform of the rural credit system which was then drastically reduced. Following what was probably a World Bank recommendation, the Brazilian Government adopted a strategy to support domestic food production which favoured the use of guaranteed minimum prices (Rezende, 1989). This strategy was not very successful and as Homem de Melo (1985) also explained, these new measures were not sufficient to reverse the historical trends of declining availability of staple food crops.

It is worthwhile stressing the point that the most important policy instrument used by the Government to promote agricultural development from 1965 to 1980 - rural credit - only benefited a minority of agricultural producers (Sayad, 1980). Rural credit was concentrated by size of landholding, by crop and by geographical region (Goodman, 1986). Thus, it contributed instead to the rise in inflation and acted as a regressive instrument for the distribution of income in rural Brazil. According to the Agricultural

Census of 1970, only 11% of all agricultural producers were reached by institutional loans. That figure may have gone up to 20% after a decade in which the total credit available to agriculture increased considerably. Nevertheless, it is estimated that the bulk of the credit was concentrated in not more than four per cent of the total number of agricultural producers (Graham, Gauthier and Barros, 1987). Given the number of options open to these large farmers and considering both the higher risk involved in many agricultural activities and its lower rates of return, it is likely that a good share of production credit was diverted away from the agricultural sector, particularly after the development of the financial market (Sayad, 1980).

The heavy emphasis on industrialization promoted by State policies resulted in the re-allocation of resources in favour of the secondary sector (Mello, 1982). This is clearly shown in Table 2.1 on the composition by sectors of Brazil's Net Domestic Product (NDP).

Table 2.1. Composition of Brazilian Net Domestic Product (%) by Sectors, Brazil.

Year	Agriculture	Industry	Commerce	Others
1947	27.6	19.9	19.4	33.1
1950	26.6	23.5	18.0	31.9
1955	25.1	24.4	16.3	34.2
1960	22.5	25.2	15.1	37.2
1965	15.9	32.5	15.1	36.5
1970	10.1	35.9	15.6	38.4
1975	11.0	37.1	17.1	34.8
1980	13.0	34.0	16.1	36.9

Source: IBRE/FGV. Adapted from Albuquerque, 1985, p.3.

The share of agriculture in the NDP fell sharply during the postwar period. From 27.6% in 1947, to 22.5% in 1960 and to 10.1% in 1970. It then increased slightly to 13.0% in 1980 - only half of the 1947 level. At the same time, industry's share of the NDP increased steadily until the mid-1970s from 19.9% in 1947 to 35.9% in 1970 and then dropped to 34.0% in 1980. The share of the tertiary sector remained fairly stable throughout the period at around 50.0% of the NDP. A similar indicator, GNP (Gross National Product, at factor cost), reveals that the share of agriculture and industry remained virtually the same in the 1980s and 1990s. It was 13.3% and 34.4% in 1995, respectively (EIU, 1997).

In Brazil, excessive income concentration, especially since the early 1960s as shown by Langoni (1973), meant lower than average income-elasticities of demand for agricultural products. That contributed to the sharp decline of agricultural participation in the national product shown in Table 2.1. The poorest 50% of the total population share only 13,6% of the total income (in 1983), whereas ten per cent of Brazilians who belong to the richest group command 46,2% of total income (Jaguaribe et al., 1986).

Nevertheless, despite the negative impact of income concentration on the overall development of Brazilian agriculture, Albuquerque (1985) concluded that factors other than the worsening of income distribution were more important in explaining the decline of the agricultural share in the national product. Factors such as the growth rate of income itself, the low elasticity of demand for agricultural products and changes in the export markets are considered to have a greater bearing on the declining share of agriculture shown in Table 2.1.

The special emphasis that the Brazilian Government placed on industrialization after World War II is also reflected in the annual growth rate of agriculture and industry as indicated in Table 2.2. During most of this period industrial growth rates were more than double those of agriculture.

Table 2.2. Annual Growth Rates (%) of the Real Product by Sectors, Brazil.

Year	Agriculture	Industry	Real National Product
1947-50	4.3	12.0	6.8
1951-54	4.5	7.2	6.8
1955-58	4.2	9.9	6.5
1959-62	5.8	10.0	7.7
1963-66	3.2	3.1	3.1
1967-70	4.7	10.1	8.2

Source: Adapted from Sorj, 1980, p.15.

The conclusion must be that the development of the rural sector was clearly thought secondary throughout the postwar years given the assumptions of the developmental model being followed by the Brazilian Government and discussed earlier on. Historical evidence reveals that the relevance of the agricultural sector diminishes as a country develops. However, it does not suggest that the sector should be treated with disregard or penalized as was the case in Brazil. The decrease in importance of agriculture is relative, since in absolute terms it is still a necessary and crucial part of Brazilian development. As regards the labour force, for example, the agricultural sector still employed 30% of those in work in Brazil in the early 1980s whereas, in most developed countries, its share is less than six per cent (Alves and Contini, 1988). This percentage continued approximately the same in the 1990s. The agricultural sector is still the biggest employer in Brazil (EIU, 1997).

2.3 Modernization of the Agricultural Sector

The mid-1960s is considered by many an important watershed in the process of modernization of Brazil's agriculture. Before discussing in more detail the relatively profound and significant changes that occurred in the agricultural sector from the mid-1960s onwards, I shall briefly describe the situation prior to that and attempt to identify some of the main factors and/or policies that affected the pace of the agricultural modernization process. Despite the selective nature and broad focus of this approach, it is hoped that it might contribute to the understanding of the complex transformations that took place in Brazilian agriculture in the more recent past.

2.3.1 From the Postwar Years to the Mid-1960s

The pace of modernization of the agricultural sector during this period was fairly slow (Schuh, 1975). By modernization of the agricultural sector is meant the intensification of capital accumulation in agriculture, or to quote Graziano da Silva and Kohl (1984, p.123): 'The diminishing influence of natural factors (climate, soil fertility, biological variations) in the productive process which enhances control of capital; and the more effective subordination of labour to capital through the latter's increasing control of the intensity and rhythm of work and through corresponding modifications in employment relations'.

The only significant exception occurred in the state of São Paulo which developed a relatively modern, economically efficient and more productive agriculture. It alone produced approximately 30% of the total Brazilian agricultural output in the mid-1960s.

In Brazil as a whole productivity levels were very low and the use of tractors, agricultural machinery and other modern inputs such as fertilizers, pesticides and herbicides were not only negligible but also to a large extent applied incorrectly (Martine and Garcia, 1987). Moreover, modernization of agricultural production was actually limited to selected areas and a few crops in the South/Southeast of the country that could benefit, among other things, from agricultural research, credit, imported tractors, fertilizers and some technical assistance (Graham, Gauthier and Barros, 1987; Goodman and Redclift, 1981).

Regional disparities were immense. In the South, output and technical levels were rapidly increasing, particularly in Paraná and Rio Grande do Sul. The process of modernization in this region was being largely stimulated by the growth of export crops - first coffee and then soybean - and the replacing of extensive cattle-ranching by commercial crops such as rice, wheat and soybean. In the Southeast, higher levels of capitalization and technological development had been achieved, especially in São Paulo. In sharp contrast, the North-East region is characterized by very low levels of both capitalization and technical innovation. The latifúndio-minifúndio complex is still dominant with its disappointingly low productivity. The Centre-West is an agricultural frontier that expanded gradually in the early part of the period and then more quickly through large scale production of soybean, maize, rice and cattle, all subsidized by the State. As regards the North, this area showed few signs of agricultural modernization until the mid-1960s. It is an area of recent settlement (Graziano da Silva and Kohl, 1984; Martins, 1984).

It was estimated that not more than five per cent of Brazilian farmers used commercial fertilizers in the early 1960s and that only about 12 per cent of the nutrients being removed from the soil were being replaced. The consumption of fertilizers was heavily concentrated in the state of São Paulo and in export and cash crops such as coffee and sugar-cane (Graziano da Silva, 1982). Domestic production of fertilizers was still low and increasing consumption was probably made more difficult given the high prices of imported fertilizers. High prices that were mainly a result of policy-makers' attempt to protect new local industries.

The figures indicating a rapid increase in the use of tractors in the 1950s are misleading due to the small base and, therefore, do not represent a relevant modernization of the sector. The numbers of tractors being used in Brazil increased dramatically in the 1960s but even in this case, the ratio of tractors per area cultivated is said to have been quite low (Schuh, 1973).

Very little technological progress was actually achieved during the period under consideration. Agricultural output expansion was almost exclusively achieved by the increase of the cultivated area. Approximately 90% of total output increase, during the period from 1948-50 to 1967-69, could be attributed to a mere horizontal expansion of production. Continuing a process that started in the 1940s and intensified in the 1950s, the expansion of the agricultural frontier was a vital force promoting the growth of the sector, particularly in the state of Paraná. Paraná contributed with 20% of the new land under cultivation and absorbed 23% of the new rural population. Despite the fact that the main migration movement was from the North-East and Minas Gerais to São Paulo and Paraná (1,350,000), Sorj (1980, p.17-18) points out that a relatively high number of people was gradually moving to Goiás (542,000) and Mato Grosso (257,000) in the 1950s and then, probably more speedily in the 1960s after the construction of Brasília, the new Brazilian capital.

In sum, Government policies aimed at expanding the agricultural frontier and total output horizontally and not through higher productivity itself. Productivity levels - both of labour and land - were fairly low by any standard and virtually have not improved in any relevant manner up to the mid-1960s but for a few particular crops in areas within the more advanced agricultural states of Brazil.

The poor educational level coupled with widespread lack of capitalization of the vast majority of the Brazilian rural population were important contributors to the small qualitative change verified in the agricultural sector. Investments in human resources were not seriously considered by policy-makers as a means of achieving a more efficient and prosperous agriculture not even after Schultz's claims about the allocative efficiency of traditional agriculture and the need to develop human resources through education (Schultz, 1964).

Income levels and real wages in rural Brazil remained poor despite the economic growth experienced during the period under review and also acted as a brake on the process of agricultural modernization. High land concentration is also said to be largely responsible for the low technological content of Brazilian agriculture and its overall backward character. (Furtado, 1982). A very clear and simple indication of this backwardness lies in the fact that even the use of animal power was still very limited at that time.

Agricultural research and rural extension are both important variables affecting the modernization of the agricultural sector that need to be included in the discussion in order to enable a better understanding of the fairly slow pace and restricted nature of that modernization up to the mid-1960s. Not surprisingly, the lack of modernization mentioned before coincided, in a large extent, with very low levels of investment in agricultural research and rural extension services and also with the paucity of policies in this area (Alves and Contini, 1988).

Agricultural development efforts throughout the world, particularly in the 1950s and 1960s, strongly emphasized the direct transfer of technology from high income countries to the Third World (Staatz and Eicher, 1985). The assumption that rural development could be achieved through the direct transfer of Western technology to developing countries was also dominant in Brazil and, in many respects, did not help the creation and development of domestic research centres.

The promotion and effectiveness of the American model of agricultural extension was also taken for granted. Despite the gradual expansion of the extension services during most of the 1960s, very little positive results could be found (Nicholls, 1975). The lack of capital available for research and the severe shortage of qualified personnel were further serious constraints on the promotion of agricultural research and extension services and perhaps another good illustration of the Government's neglect of agriculture.

In spite of experiencing a relative revival after 1960, public investment in research that was negligible in the 1950s, continued to be a serious obstacle to the modernization of the agricultural sector at least until the mid-1970s. Real expenditures on agricultural research declined during the 1950s and early 1960s (World Bank, 1983). Once again the exception is São Paulo, which was far more advanced in terms of agricultural research than the rest of Brazil and, therefore, could not serve as a parameter for what was happening in Brazil as a whole (Nicholls, 1975; Alves and Contini, 1988). The number of research workers itself illustrates this disparity. The Instituto Agronômico de Campinas (IAC), not the only research institute in São Paulo, had 547 researchers vis-à-vis 424 in all federal research institutes in 1965 (Homem de Melo, 1979).

Moreover, only a small number of crops was benefiting from research being carried out throughout the country, as already indicated in chapter 1. The bias in favour of export crops such as coffee, sugar-cane and cotton was very evident (Monteiro, 1985; Homem de Melo, 1980). Surveying the distribution of research results published in the research journal of the IAC during 1941/56, one finds that coffee, sugar-cane and cotton accounted for 47% of the publications while important food crops such as rice, beans and manioc accounted for only seven per cent (Homem de Melo, 1979). Although not representative of the whole of Brazil, such a survey clearly shows where the research effort was concentrated. Undoubtedly, staple food crops, largely in the hands of small producers, were largely ignored. No research strategy was designed or implemented to deal with problems facing small farming systems.

As far as the extension service is concerned, the picture is not very different from the one described above for agricultural research. The bulk of the extension service was concentrated in cash crops and export crops cultivated mainly by large and better-off farmers, while food producers received very little attention on the part of rural extensionists. The reality and goals, particularly of the small farmer, were not taken into account. The approach was top-down and coercive with no room for dialogue. As explained by Hall: 'Agricultural extension has traditionally been dominated by the notion that the easiest way of improving agricultural productivity is to unilaterally inject knowledge on an individual, face-to-face basis using external agents trained in distant colleges'(Hall, 1986b, p.77). The presence of what Chambers called 'outsider's bias' could easily be observed (Chambers, 1986). Extensionists often came from the urban centres with pre-conceived ideas about the nature of the problems in the rural areas that did not correspond well to the local reality. They were ready to implement solutions to those problems without questioning the quality of their own propositions and ignoring most of their consequences.

In addition to what was said above and in chapter 1 regarding the limitations of the research model (CAR) adopted in Brazil, it is worth mentioning a couple of other factors which had a negative impact on Brazil's agricultural research effort. The abundance of land and labour seems to have retarded the generation and adoption of new technologies and, thus, hindered the process of development of the agricultural sector (Pastore, Alves and Rizzieri 1974; Graziano da Silva, 1982).

In conclusion, the lack of an efficient system of agricultural research and rural extension together with poor rural education, widespread lack of capitalization and technification, income and land concentration, low rural wages and the Government's attitude towards the agricultural sector explain, to a large extent, the backward nature of Brazil's agriculture until the mid-1960s; and also the dramatic situation of small producers and the vast majority of the rural population whose level of living were appalling by any standard.

2.3.2 The Modernization of the Agricultural Sector After the Mid-1960s

A number of significant changes affecting the agricultural sector followed the 1964 military coup. In essence it represented, for the Brazilian agricultural sector, a move away from the extensive output growth model to a new model of rural production that was much more capital-intensive, highly internationalized and geared towards increasing the productivity of Brazilian agriculture. In other words, the new Government adopted a strategy that 'moved gradually but decisively from frontier occupation to the capitalization of the rural production process via state-subsidized investment policies, principally rural credit programmes' (Goodman, Sorj and Wilkinson, 1984).

There is a consensus that rural credit was chosen by the State as the main policy instrument to stimulate productivity gains and technical innovation in agriculture. The greater availability of credit in the early 1960s was significantly expanded after 1968 as was well documented by Sayad (1980). In comparison with rural credit, other Government initiatives such as the minimum price programme, agricultural research and rural extension services continued to play a minor role in promoting the modernization of the sector up to 1980. The National System of Rural Credit created in 1964-65 fostered a multitude of institutional credit programmes covering production, marketing and investment activities - at negative interest rates in many cases - that boosted mechanization and the use of many other modern inputs. Below, Table 2.3 displays both the rapid growth of the credit-product ratio, especially after 1968 and the increase in the share of rural credit itself.

Table 2.3. Rural Credit Indicators, Brazil 1951-74.

Year	Rural Credit / Rural Product	Rural Credit / Total Credit
1951	8.67	6.12
1955	12.47	9.85
1960	15.20	10.21
1964	19.55	10.96
1965	22.06	10.51
1968	22.39	20.78
1969	28.87	25.98
1970	36.62	26.54
1971	36.61	26.97
1972	38.78	27.44
1973	40.15	27.72
1974	41.75	29.40

Source: IBGE. Adapted from Homem de Melo, 1979, p.32.

The participation of the small farmers (less than 100 hectares) in total credit was fairly limited: less than one-third of the total value of loans in 1975. The example of the tractor industry below illustrates the claim that rural credit was concentrated in the hands of larger farmers due to their capacity to offer more collateral and because of their easy access to the banking system, which naturally selected less risky borrowers (Shiki, 1991).

The tractor industry, dominated by the big MNCs, was one of the agro-industries that largely benefited from the new policies adopted by the Brazilian Government and helped in promoting the relative modernization of agriculture after the mid-1960s. Production started in 1960 with only 37 units. In 1967 the number of tractors produced in Brazil increased to 6,223 units and then to 10,048 in 1970. In 1975, 56,928 units were produced locally. The share of imported tractors that represented 99.7% of total supply in 1960 was continuously reduced (Martine and Garcia, 1987, p.28).

A large proportion of the stock of tractors is concentrated in the South and Southeast. In 1970, São Paulo and Rio Grande do Sul together had 65% of all tractors in Brazil. This figure was reduced to 50% in 1977 while at the same time the combined share of Paraná and Minas Gerais increased from 18 to 29 per cent (World Bank, 1983, p.63).

Below, Table 2.4 shows the regional distribution of the use of tractors in Brazil from 1970 to 1980. The very unequal distribution is evident from the figures. In 1970, approximately 50% of all tractors could be found in the Southeast. Nearly 90% of the tractors were in the Southeast and South. The three other regions of Brazil accounted for just over ten per cent. During the 1970s it is possible to observe a relatively rapid increase in the number of tractors being used throughout Brazil. In a decade when the purchase of tractors and other agricultural machinery was heavily subsidized the total number of tractors increased by 364,821 units or 220 per cent.

Table 2.4. The Use of Tractors (units) in Brazilian Agriculture by Region, 1970-1980.

Region	1970	%	1975	%	1980	%
North	1,127	0.7	1,733	0.5	5,825	1.1
North-East	7,281	4.4	15,074	4.7	33,590	6.3
Southeast	82,517	49.7	131,881	40.8	198,809	37.5
South	64,605	38.9	145,393	45.0	230,334	43.4

Source: Adapted from Martine and Garcia,1987, p.29.

The immense regional disparities referred to in the previous section were maintained if not intensified. And so was the bias in favour of export crops and large farmers, particularly in the South and Southeast. Quantitative export controls were eliminated and a much more liberal trade policy was followed after 1967. A crawling-peg foreign exchange system was introduced and helped to reduce the taxation on exports caused by the overvaluation of the Brazilian currency (World Bank, 1982). The favourable international prices and increasing world trade of the early 1970s, combined with other export incentives, resulted in a rapid growth of Brazil's agricultural exports.

The highly concentrated nature of the process of agricultural modernization may also be observed through the use of chemical and biological inputs both by crops and regions. As in the case of tractors, consumption of fertilizers grew very rapidly from 1970 onwards; rural credit played an important role in stimulating this demand. However, only six crops absorbed almost 75% of the total fertilizer consumption during 1975-77. There is no doubt that export and cash crops and not food crops were among those that used fertilizers the most. Soybean was the main user with 21% of the total followed by sugar-cane (15%), wheat (11%), coffee (10%) and then rice and corn with approximately eight per cent each. Regionally, by the late 1970s, more than 60% of total fertilizer consumption was concentrated in the Southeast and Centre-West. A quarter of the total amount was used in the South while the remaining ten per cent or so was consumed in the North and North-East of Brazil (World Bank, 1983).

Two more Government initiatives aimed at accelerating and deepening the modernization of agriculture after 1964 will be briefly discussed below. Firstly, the minimum price programme and secondly, research and rural extension. The minimum price programme, created in 1943, was intended to promote the development of agricultural activities through the reduction of uncertainties facing farmers at the start of every new planting season and, therefore, stimulate investment and production levels. The programme expanded and in the early 1980s included some 42 commodities (coffee, sugar-cane, cocoa and wheat are not included) (Shiki, 1991). According to a World Bank report (1983), little is known - empirically - about the effects of the programme. The typical lack of consistency and short-term character of Government policies together with the frequent late announcements of the minimum price and lack of storage capacity seriously reduced the usefulness of such a programme.

By the early 1970s, the Government finally admitted that the existing agricultural research system was both inefficient and insufficient to attend the needs of the sector. Brazil, as many other countries that enjoyed the possibility of expanding agricultural output by simply bringing more land into production (at low cost), had until then postponed the development of a strong research system. The creation of EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária or Brazilian Agricultural and Livestock Research Company), which was explained in detail elsewhere (Macedo, 1997; Aguiar, 1986) and EMATER (Empresa Brasileira de Assistência Técnica e Extensão Rural or Technical Assistance and Rural Extension Company) in 1973 was intended to drastically reorganize investment in agricultural technology in a number of different crops and environments (Pastore, Alves and Rizzieri, 1974; Alves and Contini, 1988). Some partial breakthroughs were achieved in several soybean and black bean varieties and in mixed farming systems in the Cerrado region. However, as was pointed out, the long gestation period of agricultural research meant that the results of these investments were only beginning to materialize in the late 1970s and early 1980s (Barros and Graham, 1978). With regard to rural extension services its achievements after the mid-1960s do not seem to have been significantly different from those already discussed for the previous period.

In spite of what many have said about the dramatic changes that occurred within the Brazilian agricultural sector, it is still possible to qualify them as partial and fairly limited. Only a small percentage of Brazilian farmers are among those who could be called modern and capitalized. Or in other words, only a minority have achieved high productivity levels and became economically efficient. Of a total of 5.8 million rural establishments in existence in Brazil in 1985, approximately 90% or 5.3 million of these rural properties occupied areas smaller than 100 hectares (ha) in size (IBGE, 1987). The vast majority of these rural establishments belong to resource-poor small farmers whose technological level is very low. However, it was in these properties smaller than 100 hectares in size that 54% of the total area cultivated with permanent crops in 1985 was grown. The main crops in this case are coffee, cotton, cocoa, oranges and banana. In relation to temporary crops - maize, rice, beans, sugar-cane and soybean - this statistics is approximately 50% (IBGE, 1987).

The technological level of Brazilian agriculture is very low and leaves much to be desired. Not even cheaper biological technologies have been utilized in Brazil as a whole. The same is also true with regard to the use of animal power. The majority of farmers still depend almost entirely on their own physical strength, a simple hoe and their traditional knowledge. Only seven per cent of all farming establishments had tractors in 1980; less than five per cent had sowing machines and not more than two per cent had any type of mechanical harvester (Martine and Garcia, 1987, p.32). According to data from the 1985 Agricultural Census (IBGE, 1991), the last to be published so far, the situation does not appear to have improved. Less than 10% of the total number of rural establishments in Brazil owned a tractor in 1985 when the total number of this important farming equipment reached the figure of 665,280 units. The large historical regional disparity still persist: only six per cent or 41,727 of those tractors were found in the North-East (4,821 units in the state of Pernambuco). Nearly 80% of all tractors could be found in the rural establishments in the South (43%) and Southeast (36%). Moreover, only a third of all establishments utilized fertilizer (31% used organic and 26% chemical) and 55% used agro-chemicals in 1985. The figures for the North-East region of Brazil are six per cent and 19.5%, respectively. Among a total of 5,8 million rural establishments, a mere 13% carried out soil conservation practices and only 10% used contour cultivation in 1985 - a clear illustration of the very low technological level of the Brazilian agricultural sector.

The level of productivity of land, labour and capital continues to be low despite some localized improvements (Pastore, Rizziere and Barros, 1975). The highly concentrated landownership structure has shown little signs of changing and constitutes a major obstacle to the development of many regions (Leal, 1986; Martins, 1984). The very low per capita income of the vast majority of agricultural producers was also not affected by the transformations that occurred within the sector during the postwar years. More than 70 per cent of families in the rural areas were receiving less than half the minimum wage per capita and, therefore, living below the absolute poverty of line in the mid-1980s (Hoffmann, 1988). The small producer and a significant proportion of medium sized ones and particularly those producing staple food crops were hardly touched by the policies that are said to have modernized the Brazilian agricultural scene (Graziano da Silva, 1982; Ferreira Irmão, 1984).

It is true that in the 1980s the sector as a whole was very different from what it was in the early postwar years. By the end of the 1970s, agriculture had become more diversified and capitalized with mechanization and tractorization being more widespread and productivity levels higher. However, this new agricultural sector does not represent well the Brazilian agriculture as a whole but mainly certain areas of the South and Southeast of the country. It is in these areas that productivity has increased most and where fertilizer and other modern inputs are being used more commonly in a wider number of crops as it was shown.

In conclusion, the modernization experienced by Brazilian agriculture after the mid-1960s was a localized and complex phenomenon that needs to be treated carefully. It is worthwhile emphasizing here that, contrary to one of the main declared objectives of the Government's rural credit policy, i.e. the promotion of the small farmers, the bulk of the credit available certainly have not reached the smallholder or other groups of rural poor such as tenants, share-croppers, moradores and volantes (Nóbrega, 1985; Sayad, 1980). As rural credit was the principal instrument chosen by policy-makers to rapidly modernize the Brazilian agricultural sector after the mid-1960s, it is only natural that the degree of modernization actually achieved should be limited in scope. Moreover, income and land distribution patterns deteriorated during the period. Very appropriately, Graziano da Silva (1982) refers to the process of modernization of the Brazilian agriculture as 'painful modernization' (modernização dolorosa); painful due to its negative impact upon the poorer groups of society and its slow speed.

2.4 The Origins of the Transition and the National Security Ideology

The origins of the transition from agricultural development based on frontier occupation to the capitalization of the rural production process described in the previous section may be found largely in the food supply crisis and rural social unrest of the late 1950s and early 1960s.

Real domestic price increases for staple food crops - rice, beans, manioc, maize, sugar-cane and many animal food products - prompted the Government to seek new instruments to stimulate food supply and control inflation. It also alerted the authorities and ruling classes to the dangers of continuing with the same growth model. In the countryside, a social movement called Ligas Camponesas (Peasant Leagues)(2) mobilized a large number of small farmers and rural workers in the late 1950s and early 1960s. The movement, which had very close links with the Communist Party (PCB), was in favour of a radical land reform and, thus, raised many concerns, especially among the landed elite of the North-East (Azevêdo, 1982; Bastos, 1984).

Instead of promoting the land reform considered by many as the first step towards the development of agriculture, the Government's strategy led to a process that became known as 'conservative modernization' (Graziano da Silva, 1982). It was a strategy that would solve the agrarian question via the consolidation of a large domestic agro-industry without having to change the basis of the latifúndio-dominated agrarian structure so characteristic of rural Brazil. The latifúndio (large estate) would be modernized but otherwise left untouched (Goodman, 1986).

In order to better understand the reasons which led to this process of 'painful modernization' of the Brazilian agricultural sector and its relative neglect vis-à-vis the industrial sector, it is important to place it into a broader context. Thus, it is necessary to take into consideration an aspect of Brazil's history that is often missing from the literature which describes the economic changes that took place after the Second World War.

It seems that, amongst other things, the Green Revolution and the new miracle seeds, which were an important component of the process of agricultural modernization taking shape in Brazil, would be a good substitute for the 'red revolution' that appeared to be forming in the background (Dreifuss, 1981; Alves, 1984) and a solution for the food crisis of the early 1960s. It was, perhaps, an ingenious strategy to avoid a major shift in the balance of power of the different social groups; but one that had a high social cost for the majority of the Brazilian population, particularly the rural poor.

From 1948 onwards, with the creation of the Escola Superior de Guerra (ESG) or the Higher War College, reformist FEB officers (3) were able to develop an ideological cohesiveness that they did not have before. Moreover, they gained a platform from which the military could expand their goals to other sectors of society. General Cordeiro de Farias, founder of the ESG, declared in 1949 that ESG was a means to achieve development and national security for the country. The Higher War College rejected laisser-faire and criticized the Marxist theory for not having considered the potential of the State to regulate the economy. The military in Brazil identified with Keynesian economic theory.

Furthermore, the Brazilian military embraced, enthusiastically, the American Doctrine of National Security during the Second World War. They wanted to see a fully developed Brazil; a world power (potência mundial). General Golbery do Couto e Silva, ESG's chief ideologue, elaborated the basic ideas received from the USA and implicit in the Cold War (Silva, 1967). He used to argue that an indirect attack (communist) from within was a much more real threat in Latin America than a direct attack from the Soviet Union. General Golbery, as he was known, explained that, above all, indirect communist aggression which capitalizes on local discontent and on the frustrations of misery and hunger were threats which could result in insurrection or attempts to implant, though not openly, a Government favourable to the communist ideology and, thus, constitute a grave and urgent danger to the unity and security of the Americas and the Western World. Golbery's conclusions were reached before the Cuban Revolution of 1959. Its developments only intensified ESG's fears of the 'communist threat'.

General Golbery has presented the Brazilian Doctrine of National Security as being an extension of geopolitics. This Doctrine borrowed the concept of bipolarity from geopolitics. In other words, the nations of the world are divided into two groups: communists and non-communists. Therefore, the world according to this view, is in a situation of permanent total war against communist expansion (Silva, 1967).

Very significant, in the context of the present chapter, is the proposition explicit in the Doctrine of National Security that it is not possible to have national security without development. Furthermore, in the Brazilian National Security Doctrine, military defense, more than anything else, is the principal objective of its economic development strategy. Within the context of the National Security Ideology, economic development does not aim to provide the basic material needs for the population. The development policy in-built in the Doctrine does not consider the improvement of the standard of living of the bulk of the Brazilian population as a priority. In the ESG's view, economic growth and industrialization and not questions related to agriculture, public health, low-cost housing and primary education, for example, were the priorities (Alves, 1984).

In the 1950s, the participation of civilians became a key aspect of the programmes of the Higher War College (Stepan, 1973a). Because ESG was concerned with all phases of development and national security, it was felt that the Brazilian military should 'socialize' civilians from such fields as education, industry, communications and banking into correct national security perspective. The Brazilian civilian elite actively participated in the ESG: attending courses, giving lectures and participating in discussions. Well known individuals such as Gudin, Mario Henrique Simonsen, Roberto Campos and Delfim Netto are amongst the names of a large number of important civilians with ESG links (Stepan, 1973a).

Both groups, military and civilian, shared the same basic ideas: promote industrialization, reduce dependency on foreign trade and technology while focussing on material achievement and economic modernization rather than on raising per capita income (Leff, 1982). According to Dreifuss (1981), the Brazilian industrial class was national but not nationalistic. They wanted the capital and technology which would enable them to prosper without worrying whether the country as a whole would benefit or suffer as a result of their actions. ESG's economic development model, which the industrialists supported, aimed at transforming Brazil into a world power and it was understood that the sacrifice of a few generations could be necessary (Comblin, 1978).

Brazil, thanks to its sophisticated National Security Doctrine, had taken the lead in Latin America in preparing to fight the 'internal enemy'. Thus, in the mid-1950s, General Golbery was already suggesting that Brazil had to fill the 'vias de penetração' (penetration paths or open spaces). Then, he developed the concept of 'living boarders'. The first suggestion (fill the open spaces) may explain, among other things, why the new capital Brasília was built in the early 1960s in the middle of a 'desertic' and remote part of the country at that time. Open spaces needed to be occupied otherwise they could become basis from where a communist insurgency could develop. The military could also not admit having a capital near the coastline such as Rio de Janeiro showing concern both with the external and internal enemy. The second suggestion, regarding the concept of Brazil's 'living borders', refers to a possible communist revolution coming from Central America that could penetrate Brazil through its extensive and unpoliced, if not inaccessible, borders in the Amazon region.

This concept may help us understand the many uneconomic roads that were built in the Amazon region and some of the colonization projects which were implemented in that part of the country. DNER (National Department of Roads) admitted that many roads built in Amazonia in the 1960s and 70s were inspired by strategic reasons and without taking technical and economic questions into consideration. These roads were following the guidelines contained in the Plano de Integração Nacional (National Integration Plan).

Roads such as Transamazônica, Manaus-Porto-Velho, and Perimetral Norte are all part of the strategy of National Security. Within this broader context, agricultural and rural development were not considered priorities as it has already been explained above.

2.5 The Performance of the Agricultural Sector After the Second World War

After the end of World War II agricultural added value has expanded at an average annual rate of approximately 4.5 per cent. The average annual physical growth rate of output of the 21 major crops was about 7.6% for the period between 1955-1965 and 12.5% during 1966-1979. Or only 2.6% if soybean is not included (World Bank, 1983). During the same period agriculture's share of GNP declined from around 27% to only 11% in the early 1980s. Nevertheless, in the early 1980s agriculture still employed 30% of the labour force and directly supported almost 40% of Brazil's population. Agriculture's share of GNP increased slightly in the 1990s and reached 13.3% in 1995. The sector is still responsible for the employment of nearly 30% of the total number of people working in the Brazilian formal economy (EIU,1997).

Generalizations are difficult to make in the case of Brazilian agriculture due to the very large variations in the relative performances of the major agricultural commodities and regions. However, output growth of virtually all products derived mainly from the expansion of the area under cultivation and not from changes in productivity levels. It is estimated that even in the 1970s, when yield increases were more significant, over two-thirds of the growth in output came from area expansion. It was only in the 1980s that the nature of agricultural growth changed in a more substantial way. Land productivity became almost the only source of expansion of cereals and oil seed output and played a very important role with regard to increases in output of soybean, cotton, rice, corn, and wheat (Dias, 1988).

In summary, three main factors are behind the expansion of the agricultural sector after the Second World War: (a) the expansion of the agricultural frontier; (b) the large availability of rural credit; (c) the good situation of the international market for primary commodities in the 1960s and 1970s (Albuquerque, 1985; Pastore and Barros, 1975). As it could be appreciated from the discussion above, there are many different ways of looking at agricultural performance. After considering its performance in relation to the expansion of the area under cultivation, I shall briefly discuss the changes in physical output (volume harvested) that took place during the postwar years. That will be followed by an analysis of the role played by productivity in increasing output.

2.5.1 Expansion of the Area under Cultivation and Physical Output

In historical terms, the expansion of the area under cultivation has been the main source of growth of Brazilian agricultural output. For the country as whole, area expansion represented 83% of the growth of output in the 1940s, 72% in the 1950s and approximately 65% in the 1960s (Homem de Melo, 1985, p.131). That situation did not change significantly in the following decade despite the transformations experienced by the sector after the mid-1960s. Two-thirds of the output increase in the 1970s can be attributed to the expansion of the agricultural frontier (Dias, 1988). As was already mentioned, two other factors - the great availability of subsidized rural credit and favourable international markets - also had an important, although relatively secondary role in explaining the relative success of agriculture after the mid-1960s (Albuquerque, 1985).

The agricultural frontier can be divided into two groups: (1) the 'new agricultural areas', including the state of Santa Catarina, Paraná and what is now Mato Grosso do Sul; (2) the 'very recent agricultural areas', consisting of the state of Goiás, Mato Grosso, the North region of Brazil and the states of Maranhão and Bahia.

The 'new agricultural areas' were incorporated into the production system between the 1920s and the 1950s. They were a significant force behind the expansion of agricultural production from the 1940s onwards and particularly during the 1950s. The 'very recent areas' were growing at a fairly good pace in the 1940s (24%) but it was in the 1960s and especially in the 1970s that it expanded very quickly: 26% and 47% respectively. In the 1960s the creation of Brasília and then the construction of the Belém-Brasília highway helped the process of frontier expansion as new land, especially in the state of Paraná, was rapidly disappearing.

Overall, more than 170 million hectares of agricultural land were incorporated into the productive system during 1940 and 1980 (Albuquerque, 1985, p.93). Broadly speaking, the expansion of the frontier was following the dynamics of the development process of the Brazilian economy. In this respect, the rapid increase of the transport network coupled with the establishment and growth of the motor industry in Brazil were very important for the successful incorporation of this vast amount of land into the production system (Nicholls, 1975). Between 1952 and 1960 the road network grew considerably and enabled, for the first time, many rural areas to be integrated into the domestic economy. Although the South and Southeast benefited the most from these changes, it is fair to say that even the North-East - so often bypassed by the growth model being implemented by the authorities - was positively affected by the changes mentioned above. The beginning of a more integrated and dynamic regional economy could already be seen in the North-East by the late 1950s (Galvão, 1988).

By looking only at a few aggregate growth rates one may understand within which context many studies say that Brazil's agricultural performance after the Second World War was a good one. During the period of 1955-1965, for instance, the total growth rate of physical output was about 7.6% per annum for the 21 major crops. It increased to 12.5% per annum during 1966-1979. With regard to the expansion of the area under cultivation of these same 21 crops, the annual growth rate for 1955-1965 reached 4.1%. In 1966-1977 the area harvested grew at the annual rate of 3.7 per cent (World Bank, 1983).

However, a more careful interpretation of the data on growth of physical output and area under cultivation reveals a very different situation. Annual output growth rates (in volume terms) of domestic food crops for the two periods was only 5.7% and 3.3% respectively. The individual performance of the most important food crops - rice, beans, maize and manioc - leaves much to be desired, as shown in Table 2.5.

Table 2.5. Brazilian Growth Rate of Agricultural Output, 1955-79.

	Average Annual Growth Rate of Physical Output (%)	
	Year	
Crop	1955-1965	1966-1979
Rice	7.5	2.3
Beans	4.3	-0.8
Corn	5.3	2.8
Manioc	5.8	-0.9

Source: Adapted from World Bank, 1983.

All annual growth rates dropped significantly in the second period (1966-79). While rice and maize output grew at a relatively modest rate, beans and manioc - two very important staple food crops particularly for the poorer social groups - presented negative rates of growth. Actually, bean production decreased from 2,290 (thousand metric tons) in 1965 to 2,186 in 1979. Manioc output dropped from 24,993 (thousand metric tons) to 24,962 in the same period. Assuming an income-elasticity of demand for food of about 0.5, it appears that output of the major food crops, with the exception of beans did keep pace with the growth of demand during 1955-1965. However, as for the period of 1965-1979, output growth for the most important food crops fell well below demand (World Bank, 1983).

The apparently impressive performance of export crops also does not stand up to closer examination. After growing at an annual rate of 9.4% during 1955-1965, export crop output (in volume) increased by 19.2% annually in the period between 1966-1979. Nevertheless, that extraordinary figure is very misleading. The very high annual output growth rate of 19.2% was a mere one per cent when soybean is excluded. In other words, the output of oranges, sugar-cane, tobacco, cocoa, coffee, cotton and sisal added together hardly increased in more than a decade (World Bank, 1983).

Table 2.6 and 2.7 below show in more detail the annual growth of physical output and area of all major 12 crops for the period 1950-1980. Together these 12 crops represent 98% of all crop output in Brazilian agriculture. They are divided somehow arbitrarily into two groups: seven export and five domestic food crops.

The extraordinary performance of soybean from the late 1960s onwards, both in terms of area and output, is evident from Tables 2.6 and 2.7. As a matter of fact, soybean is the success story of Brazilian agriculture during the 1970s. The average growth rate of area and output was just over 20% per annum. Developed as an export crop, soybean is gradually becoming an important factor in the domestic food supply of edible oils as well as in the poultry industry (Word Bank, 1983).

Table 2.6. Rate of Growth of Area (ha) for Crops for Decades in Brazil, 1950-1980.

	Rate of Growth (annual average, %)			
Crops	1950-60	1961-70	1971-80	1950-80
Export crops				
Soybean	11.9	17.1	17.5	20.3
Oranges	3.9	5.5	8.8	7.1
Sugar-cane	4.7	2.3	4.5	3.4
Tobacco	3.0	1.2	4.1	2.3
Cotton	0.6	2.6	-2.2	1.8
Cocoa	5.8	-1.0	0.4	1.1
Coffee	5.5	-7.7	-0.1	-2.0
Food crops				
Wheat	6.1	6.9	5.6	5.0
Rice	4.2	4.3	3.1	4.1
Beans	3.3	3.8	1.9	3.3
Maize	3.4	3.9	1.3	3.3
Manioc	3.2	4.3	0.2	2.9

Source: Adapted from Graham, Gauthier and Barros, 1987.

The orange crop performance is the second best in both categories. Although a good performance - annual growth rates of more than seven per cent - it cannot be compared with that of soybean. The growth rates for sugar-cane are more modest but clearly show a sharp increase in the 1970s. This was largely due to the rapid rise in world sugar prices in the first half of the 1970s and the Pro-Álcool or Brazil's National Alcohol Programme. Pro-Álcool was created in 1973 as a response to the oil-price shock of that same year. It is the largest biomass liquid fuel programme in the world which aims at substituting alcohol for petrol (4). In only ten years an impressive 50 billion litres of alcohol were produced. The Government target of 10.7bn litres for the agricultural year of 1985/86 alone was easily reached . With the fall in international sugar prices, Brazil's sugar industry would probably be ruined if it were not for the Pro-Álcool (Sachs, Maimom and Tolmasquim, 1987). Traditional export crops such as coffee, cotton and cocoa performed poorly largely due to less attractive international prices. Their average output annual growth rate for the three decades was 1.9, 1.7 and 2.5 per cent respectively.

Table 2.7. Rate of Annual Growth of Physical Output (metric tons) in Brazil, 1950-80.

Crops	Annual Rate of Physical Output (metric tons)			
	1950-60	1961-70	1971-80	1950-80
Export crops				
Soybean	19.8	17.9	18.6	20.8
Oranges	3.3	6.1	11.8	7.3
Sugar	5.6	3.2	7.0	4.6
Tobacco	3.5	4.2	6.8	4.2
Cotton	2.0	0.8	-4.8	1.7
Cocoa	3.0	3.6	5.6	2.5
Coffee	12.8	9.1	-3.1	1.9
Food crops				
Wheat	2.2	11.8	6.9	5.6
Rice	4.0	2.8	2.7	3.8
Beans	3.1	3.5	-2.7	2.2
Maize	3.6	4.8	2.6	4.1
Manioc	3.5	5.5	-2.2	2.9

Source: Adapted from Graham, Gauthier and Barros, 1987.

As for domestic food crops, the figures seem to confirm the view that export crops compete with food crops for capital, land and other resources often scarce in developing countries. It is argued that expansion of export crops often has a negative impact on domestic food production and, therefore, on the rural poor (Matthews, 1988; Longhurst, 1988). Tables 2.6 and 2.7 above indicate that wheat is the food crop that performed better according to both criteria. That should not come as a surprise since its production has been heavily subsidized due to the import-substitution goals of the Brazilian State. Furthermore, wheat is a winter crop (off-season) that can be combined with soybean to produce a relatively successful pattern of year round production that cannot be easily replicated in other regions or by other crops; production is concentrated in the South in the state of Rio Grande do Sul. The growth rate of output (annual average) for the period 1950-1980 was 5.5 per cent while the area under cultivation expanded at an annual rate of five per cent.

Maize is largely produced on smallholdings and total production, although fairly dispersed throughout Brazil, is concentrated in Rio Grande do Sul, Paraná, São Paulo and Minas Gerais. Together these states accounted for 65% of total production in 1977. Despite the increasing importance of maize for animal consumption, it is still an important staple food crop, especially in the rural areas (World Bank, 1983). After increasing in the 1960s, the annual rate of output growth and area cultivated declined in the 1970s. The rate of growth of area under cultivation dropped from four per cent in the 1960s to only 1.5 per cent per annum in the 1970s. The production of maize is said to have suffered from the effects of the special wheat policy carried out by the Brazilian authorities.

Rice is a very important component of the Brazilian daily diet together with beans and manioc. Production is widely distributed among small producers in different parts of Brazil. Irrigated rice production is largely located in the South, particularly in Rio Grande do Sul. Non-irrigated rice areas (arroz de sequeiro) are less productive and account for approximately 80% of the total area and 60% of production (Monteiro, 1985). The irrigated area corresponds to just over ten per cent of the total area planted with rice and production reaches close to 30% of the total rice output. High risk areas such as the Centre-West and the North-East contributed with 37% and 17% of total output in 1975/77.

Despite the changes in demand, rice output in 1979 was approximately the same as in 1965 or 7,595 thousands of metric tons. The average annual growth rate of output and area in the three decades following World War II was 3.8 and 4.1 per cent respectively (World Bank, 1983).

It is clear from the data that the performance of beans and manioc left much to be desired, especially due to the fact that they are very important staple food crops for a large number of Brazilians - low earners in particular. Beans and manioc are grown all over Brazil and are typical small farmer crops. Few modern inputs are normally used in their production whose output and productivity may vary enormously from region to region. Seventy five per cent of the total bean production comes from farm units with less than 50 hectares in size. Manioc is also largely produced on holdings of up to 50 hectares in size. There is some evidence that as in the case of maize and rice, subsidized wheat prices have had a negative effect on the demand for manioc and, thus, on production levels as well (World Bank, 1983).

The annual growth rates of the areas planted with both crops fell sharply in the 1970s. The increase in area cultivated with manioc was insignificant throughout the decade while the area cultivated with beans increased only two per cent per annum. By the late 1970s, both crops had experienced an absolute reduction in output; output levels were actually similar to those of the mid-1960s.

To sum up, the performance of food crops was not good at all during the postwar years. According to Homem de Melo (1983; 1985), a number of studies have shown that favourable international prices promoted Brazilian export crops during a considerable period of the 1970s and contributed to the poor performance food crops. The composition of Brazilian agricultural production was drastically altered during this period. Export crops expanded relatively rapidly while domestic food crop production deteriorated.

Technological innovations concentrated in the export sector aggravated the bias in favour of export crops and somehow contributed to what was described as 'the critical situation of food supply in the 1970s' (Goodman, 1986). Higher food prices and supply shortages were not uncommon. In the early 1980s the situation tended to deteriorate even further. Output of staple food crops decreased by -1.9 per cent per annum during 1977-1984 and food availability declined by an annual rate of 1.7 per cent (Homem de Melo, 1985).

2.5.2 Productivity and the Performance of the Agricultural Sector

The performance of the agricultural sector was fairly poor with regard to increases in productivity during the postwar period. Despite recent improvements, the productivity level of Brazilian agriculture is still very low when compared with other countries (Albuquerque, 1985). Increases in productivity experienced during 1973-90 by crops such as rice, maize and wheat, which followed a period of stagnation between 1938-70, were insufficient to bring Brazil in line with the average world productivity levels. In the case of coffee and manioc productivity is above the world average for both crops, but the trend between 1973 and 1990 shows signs of stagnating. The productivity gains enjoyed by sugar-cane and soybean, in this same period, are mainly the result of Government subsidies which privileged these crops not because of their value as food crops but due to their importance as a source of energy (Pro-Álcool) and export revenue, respectively (Conjuntura Econômica, 1991).

Data from a study on agricultural productivity confirm that for eight of the main crops in Brazil productivity levels are fairly disappointing in comparison with the world average (Conjuntura Econômica, 1991). FAO has estimated that the world average of rice was 3,3tons per hectare(t/ha) between 1987-89, while the Brazilian average is only 1,9t/ha in the same period. The Brazilian average of 0,44t/ha in the case of the bean crop, another very important staple food crop such as rice, is below the world average which reached 0,58t/ha. Maize productivity in Brazil is 1,9t/ha and wheat productivity has not exceeded the average of 1,7t/ha. In the same period, 1987-89, the world average of maize was 4,4t/ha and that of wheat reached 2,3t/ha - both figures are better than the Brazilian ones. With regard to sugar-cane and soybean the Brazilian and the world averages are similar: 61,7t/ha and 1,8t/ha, respectively (Conjuntura Econômica, 1991).

When studying the sources of growth in the Brazilian agricultural sector, Patrick (1975) concluded that they varied considerably among different regions and even within regions. The results of his study also showed great variations within crops at the national level and among group of products in each region. Nevertheless, even in regions where agriculture is more advanced, like in the state of São Paulo, productivity levels are still low. Labour and land productivity have remained low despite the important changes that occurred in the sector after the mid-1960s. The productivity of capital, on the other hand, has declined considerably and is very low considering the level of income of the Brazilian economy (Albuquerque, 1985).

It was pointed out (Pastore, Alves and Rizzieri, 1974) that productivity levels changed for the better in the late 1960s and early 1970s. Although a large proportion of output increase continued to be attributed to the expansion of the area under cultivation, both labour and land productivity began to play a larger role in terms of increasing total agricultural production. Land productivity increased throughout Brazil with the exception of the North-East where it remained stagnant (Ferreira Irmão, 1984; Sampaio et al., 1978; Patrick, 1972).

Favourable international prices together with growing domestic demand for agricultural products forced output to expand at a rate that would be difficult to achieve only through increase of the area under cultivation. Furthermore, good and cheap agricultural land was becoming increasingly more difficult to obtain. The combined result of these and other pressures forced policy-makers to revise many of the existing policies and attitudes towards the agricultural sector and to move gradually away from the model of extensive output growth. The improvements in productivity levels may be largely attributed to the new emphasis on agricultural research which was brought about by the Federal Government with the creation of EMBRAPA and EMATER in 1973. Despite the limitations of CAR which were discussed in chapter 1, certain products, mainly export crops, did benefit from the research effort in the 1970s and then, perhaps more importantly, in the 1980s when certain research institutes tried to adopt a more systemic and participatory methodology. In chapter 4, the efforts of IPA (Agricultural and Livestock Research Institute of Pernambuco) to re-direct their research in that direction are explained in detail.

Table 2.8 gives us an indication of what has been happening in the recent past in Brazil as far as productivity is concerned. Crops are presented according to their rank in output growth during the 1970s. By disaggregating output into its area and yield components it is possible to see what the performance of those crops were in terms of yields itself. Total output growth is disaggregated into yields and area with the relative share of each shown in the parentheses.

Only cocoa production benefited from a considerable increase in productivity, particularly in the 1970s (Table 2.8 below). That was the direct result of serious research work done by CEPLAC (Comissão Executiva do Plano de Recuperação Econômico-Rural de Lavoura Cacaueira). Three varieties and several cultivation practices were significantly improved after years of dedicated research (Graham, Gauthier and Barros, 1987).

Table 2.8. Production Growth Rates (%): Yields and Area Expansion in hectares (ha), Annual Average, Brazil 1950-80.

Crop	Output Growth Rates (Metric Tons)	Disaggregated Growth Rates Area(ha) (%)		Yield(kg/ha) (%)	
Soybean	18.61	17.49	(94.0)	1.12	(6.0)
Oranges	11.81	8.79	(74.4)	3.02	(25.6)
Wheat	6.86	5.63	(82.1)	1.13	(17.9)
Sugar	6.95	4.51	(64.9)	2.44	(35.1)
Tobacco	6.80	4.13	(60.7)	2.67	(29.3)
Maize	2.60	1.30	(50.0)	1.30	(50.0)
Rice	2.73	3.07	(100.0)	-0.34	(0.0)
Manioc	-2.20	0.20	(0.0)	-2.40	(100)
Cocoa	5.59	0.37	(6.6)	5.22	(93.4)
Beans	-2.70	1.86	(0.0)	-4.56	(100)
Coffee	-3.09	-0.10	(3.2)	-2.99	(96.8)
Cotton	-4.79	-2.21	(46.1)	-2.58	(53.9)

Source: Graham, Gauthier and Barros, 1987, p.9.

Crops that presented the largest output increases such as soybean, oranges, wheat and sugar-cane register very disappointing yield increases. In the case of soybean as can be seen Table 2.8, 94% of the production increase may be attributed to the expansion of the area under cultivation. For oranges, wheat and sugar-cane area expansion accounted for 82%, 74% and 65% of the increase in output, respectively. Mainly due to the effort of the Institute of Agronomic Research of São Paulo, coffee yields rose very considerably and actually offset the decline in the area under cultivation caused by the coffee eradication programme of the 1960s. Output increased at an annual rate of 1.9 per cent in spite of the reduction in the area planted with coffee of about 2.0 per cent per annum. In other words, 100% of the growth in coffee output can be accounted for by productivity gains.

The poor productivity of important food crops such as rice, beans and manioc is clearly visible from the data in Table 2.8. Rice yields did not improve throughout the period while that of beans and manioc have actually decreased. Bean productivity is higher where the crop is combined with coffee because it benefits from the residual effects of coffee fertilization. As this kind of production has become less common, bean yields have shown a declining trend. During 1950-1980 bean growth rate in terms of yields (kg/ha) grew at a negative rate of -0.1 per cent per annum; in the 1970s alone yields decreased at an annual rate of about -3.0 per cent. The main factor behind the decreasing yields of manioc was the regional shift in production caused by the expansion of export crops (Albuquerque, 1985). Export crops, often more lucrative and easier to mechanize, have been replacing manioc in the South where its productivity was higher and, therefore, its not surprising that 100 per cent of manioc's output growth during 1950-1980 came from the expansion of the area under cultivation.

Less profitable than most export crops and largely on the hands of small and medium agricultural producers, traditional food crops have been displaced to more distant frontier lands in Mato Grosso and Goiás and onto more marginal lands in the states of Paraná, São Paulo and Minas Gerais. A recent study (Conjuntura Econômica, 1991) analysed the productivity performance of the main food crops in Brazil between 1973 and 1990 and concluded urgent action is required in order to increase productivity levels. The average Brazilian, remind us this study, would not go without black coffee sweetened with sugar-cane and a little bread in the morning. At lunch time or dinner, he or she will probably have rice, beans, manioc flour, fubá (maize), soybean for cooking or pasta. Thus, eight staple food crops were selected for the productivity study mentioned above due to their relevance in terms of food supply: rice, bean, manioc, maize, sugar-cane, wheat, soybean and coffee.

The eight crops which form part of the Getúlio Vargas Foundation study (Conjuntura Econômica, 1991) may be placed in two different groups according to their productivity performance. In the first group are the crops which showed an increase in productivity levels from 1970s vis-a-vis the previous period. Between 1973 and 1990, wheat leads the ranking of the crops which improved their performance. Its annual average increase in productivity was 6.5%; 2.6% in the case of rice and 1.9% for maize and sugar-cane. Soybean average increase was fairly modest or only one per cent annually between 1973 and 1990. In the previous period (1930-70), with the exception of sugar-cane which displayed a little improvement, 0.7% per annum, all the other crops mentioned above presented no productivity gains. In the second group we find the selected food crops which presented a negative growth or no growth at all in terms of productivity. Coffee and manioc productivity stagnated between 1973 and 1990. Bean yields fell approximately one per cent per annum in this same period (Conjuntura Econômica, 1991).

The fact that export crops performed relatively better in terms of productivity than food crops was not accidental. Most of the agricultural research and rural extension policies carried out in Brazil are directly targeted at export or cash crops. It is generally agreed that these and other Government policies such as rural credit were strongly biased against food crops (Homem de Melo, 1980). The incentives to invest in new technology may be very small in this kind of environment or simply non existent when the neglect of policy-makers towards the sector is taken into account.

According to the World Bank (1982), in a country such as Brazil, with vast land resources and cheap labour, it should not come as a surprise that for almost all crops output gains have derived mainly from the increase in the area under cultivation. That view is shared by many and especially those analysing the question from a neoclassical perspective and/or the theory of induced innovation (Santos, 1986; 1988; Ruttan and

Hayami, 1985). The relative abundance of cheap labour combined with an easily exploited frontier and the lack of investment in research made improvements in productivity less likely and attractive (Nicholls, 1972; Schuh, 1970; Smith, 1983). Within this context, the development path of Brazilian agriculture is considered logic and economically sound.

For structuralists such as Furtado and others, the low productivity of agriculture is directly related to the Brazilian agrarian structure and, therefore, directly related to Brazil's colonial history itself (Furtado, 1980; 1982; Guimarães, 1981). The highly concentrated land distribution is seen as one of the main, if not the main cause behind the low productivity and lack of technological progress of the sector (Furtado,1973; Prado Jr., 1987; Leal, 1986). Furthermore, given the abundance of human resources, the nature of the political system and the industrialization policies being pursued by the Government, rural wages were deliberately kept low offering no incentives to the adoption of modern technology and the improvement of productivity (Furtado, 1980).

In summary, the low productivity of Brazilian agriculture may be largely understood as the result of a conscious decision by policy-makers of not making the necessary investments in the sector and, thus, it should not be entirely attributed to an endogenous process within agriculture itself. In their view, agricultural output could continue growing at a satisfactory rate mainly by bringing 'new' land into production.

The focus of the Government, throughout the postwar years, was clearly on industrialization. The National Security Doctrine, as explained in this chapter, reinforced a development strategy based on the growth of the industrial sector while putting the needs of the agricultural sector and the welfare of millions of people who depended on it in second place. As a result, the agricultural sector suffered badly from a lack of long-term policies as well as investments in agricultural research that could lead to improvements in productivity.

2.6 Closing Remarks

The transformations which occurred in the Brazilian agricultural sector after World War II were fairly limited in scope. Limited in the sense that despite the degree of modernization ('technification') achieved in many sub-sectors within agriculture, very little was actually done in terms of promoting rural development in general, or supporting the very large number of resource-poor small farmers and rural workers who depend on agriculture to guarantee their livelihoods.

As discussed in the present chapter, policies which involved rural credit, minimum prices and agricultural research and extension were not designed to address, let alone satisfy the needs of the small farmer. For the vast majority of the Brazilian rural population, over 50 million people, development would mean overcoming the sheer misery arising from lack of food, health, shelter and education. It was estimated that 61.2% of the Brazilian working population lived below the poverty line (earned up to two minimum wage) in 1984. This appalling figure reaches 78.6% in the North-East alone where two-thirds of the poor live in rural areas (Jaguaribe et al., 1986).

The agricultural sector may have been modernized after the Second World War - to a certain extent - but it definitely did not develop in a broader sense. Significant increases in productivity levels or even modest gains in output growth of small producers are also hard to find anywhere in Brazil. Even taking into account the almost inevitable fact that any modernization or development strategy would have an uneven impact on different regions and farming systems in Brazil, it is still not possible to describe the process of change experienced by the agricultural sector as 'development'. As defined in this study, development is not a purely economic phenomenon and it should not be mistaken for a strategy largely concerned with increasing GNP or industrialization (Sen, 1987 and 1984). Development involves not only improvements in income, productivity and output but also changes in consumption and health patterns that would lead to significantly higher standards of living, especially due to the very low levels of the present times (Singer, 1978; Seers, 1972). Thus, in the case of Brazil, widespread improvement of the rural population's welfare may well be a viable proposition only in the very distant future.

In practice, no deliberate strategy to deal with the extremely serious problem of rural poverty was implemented. Development policy choices displayed both a combination of 'economic unwisdom and political inhumanity', as Scott have commented (Scott, 1988). Income inequalities worsened and the same seems to be true of the level of rural unemployment. It is said that rural unemployment rate rose mainly as a result of the poor performance of crop production in the 1990s. As a direct consequence of the drastic reduction in cotton output, a labour intensive crop par excellence which have been plagued by diseases, it is estimated that 260 thousand people have lost their jobs (Conjuntura Econômica, 1998). More jobs are being lost in the rural sector due to the sharp increase in food imports, a product of the recent economic policies of the Plano Real (5) which favours the integration of the Brazilian economy in the global market. The overvalued exchange rate and the high real interest rates, in addition to the trade liberalization which started in 1990, constitute a serious obstacle for the domestic agricultural producers who are not in the position of competing with foreign suppliers. These producers, besides being able to borrow money at rates far lower than the Brazilian ones, often can take advantage of a number of subsidies and other policies which protect the agricultural sector of most develop nations (Conjuntura Econômica, 1998).

A recent report on the Brazilian economy summarizes well what has been said here about the performance of the agricultural sector and refers to the sector as 'a victim of neglect'. That report corroborates what the author of this thesis discussed in this present chapter, especially when it states categorically that the poor performance of the agricultural sector 'reflects the extent to which government policies have been oriented towards industrialization and other non-agricultural activities' (EIU, 1993, p.23). It also confirms that the agricultural sector has been suffering from a long-term lack of government support and investments.

Very significantly, efficient allocation of resources in a way that would bring the fruits of economic progress to the broadest segment of the Brazilian population seems to be a forgotten goal, despite the 'development' programmes carried out by the Government and some degree of economic planning. The figures involved a very large indeed. The agricultural sector, responsible for 13.3% of the Brazilian GNP which in 1995 was larger than US$700 billion dollars, is the largest employer in Brazil (EIU, 1997). In average, 30% of the Brazilian labour force has been occupied in the agricultural sector in the 1980s and 1990s. Of a total of approximately 70 million people, the working population in Brazil in 1995, over 18 million people, or more than a quarter of the total labour force, were employed in the agricultural sector. Industry, in comparison, provided employment for about 20% of the Brazilian working population, or 13.6 million people in that same year (IBGE, 1996). In the North-East of Brazil, almost 8.5 million people are employed in agriculture, or 42.6% of the region's total labour force, or 12.2% of the Brazilian total. Figures from the Agricultural Census of 1985 confirm that the vast majority of those people were working in rural establishments smaller than 100 hectares in 1985. Of a total of about 5.8 million rural properties, 90% are smaller than 100 hectares in size and employ the bulk of those 18 million people who labour in the agricultural sector (IBGE, 1986). The vast majority of these cultivators belong to the so-called group of small farmers who, by enlarge, have been consistently neglected during the period under consideration.

As seen in chapter 1, agricultural research in Brazil until the late 1970s could offer very little to small farmers in terms of providing them with the technical means for improving their farming systems. With the adoption of new research methodologies such as FSR in the early 1980s, however, small farmers' needs began to be taken into consideration both by researchers and policy-makers. Thus, within this new situation, technological changes which are called here PTC (Participatory Technological Change) appeared to have opened up new opportunities to small farmers. The socio-economic impact of one of these technological changes will be illustrated by a case study from North-East Brazil in chapter 6. However, before moving on to discuss the specifics of the case study which will be presented in this thesis (Chapters 4 and 5), it is necessary to explain in the next chapter the methodological tools which were used in the fieldwork and to provide the reader with some definitions which shall facilitate the understanding of this study.

2.7 End Notes

(1) As pointed out by Hall: 'census data [collected by IBGE] in Brazil tend to understate the degree of land concentration since they are based on 'establishments' which are administrative units and do not reflect total ownership of property by one person' (Hall, 1987, p.96).

(2) The Peasant Leagues's main proposal was not only to promote a radical land reform which aimed at eradicating the latifúndios (large estates). They also wanted to achieve the political death of the landed oligarchies.

(3) FEB or Brazilian Expeditionary Force (Força Expedicionária Brasileira) was the first Latin American force to fight the Axis Powers in Europe (Italy) under the command of General Mark Clark. The army officers who commanded the FEB in Europe during the Second World War returned home extremely impressed by the superiority and organization of the US forces. They attributed their great success to their Doctrine of National Security.

(4) Alcohol-fuelled motor cars first came into the Brazilian market in February 1979. By 1985, 96% of all motor cars were alcohol-propelled. With the decrease in oil prices, the proportion of cars running on alcohol has fallen to below 30% in 1990 (EUI, 1993, p.24).

(5) Plano Real is the latest of a series of stabilization plans which had attempted, without success, to control inflation in Brazil in the late 1980s and early 1990s. Consumer wholesale prices rose by 697% in 1988; 1,284 in 1989 and an incredible 2,710% in 1990. In 1991, as a result of the Plano Collor , the increase was 'only' 401%. Then, wholesale prices soared to new heights: 1,130% in 1992, 2,639% in 1993 and 1,029% in 1994 (EIU, 1993 and 1997).

Between 1986 and 1991, there were five major economic plans which failed dismally to put a stop on a rampant inflation. The Brazilian currency was changed no less than four times in the period. The Real Plan also changed the currency which is now called 'real' and succeeded in what its predecessors had failed. The inflation rate dropped from a staggering 50% per month in June 1994 or 5,000% in the year ending in June, to about 2% in the last quarter of 1994. Since then inflation has been controlled. It was 6.4% in 1995, a very low figure in the recent economic history of Brazil.

CHAPTER 3

Technological Change and Its Socio-Economic Impact: Definitions and Methodological Considerations

3.1 Introduction

The present chapter will concentrate on definitions and methodological considerations that were important during the fieldwork data collection process. The main objective of the fieldwork carried out in Caruaru, North-East of Brazil, was to study the socio-economic impact of a new technological change - potato cropping - upon a group of small farmers. The technological change in question is largely a result of the interaction between farmers and agricultural researchers working within a new methodological approach; an approach which is systemic and participatory in essence, as will be explained in the next chapter.

It is the novelty of this agricultural research methodology called here Participatory Technological Change (PTC) and its possible implications in terms of improving farmers' living standards at the micro level and policy formulation at the macro level that make this study particularly relevant. The focus, however, will be on the micro level. In other words, special attention will be paid to an attempt at establishing the likely impact of such a technological change on the small farmer. The implications and extent to which the benefits of changed technology may be incorporated by people other than small farmers is beyond the scope of this thesis.

The analysis will take into account what Midgley (1986, p.3) has suggested when he said: 'The current emphasis placed on abstract ideals by many social development writers needs to be put into perspective and linked with a very real need for the provision of social services which bring tangible benefits to ordinary people. In the real world, where even improvements of this kind are realised with difficulty, the prospects of perfecting human nature and creating a Utopia through social developments must be remote' (my emphasis).

What Midgley says about the role of social development is also true for agricultural development, in my view, and therefore very relevant in the context of this thesis when assessing the possible changes caused by a technology on the life situation of small farmers. Moreover, the use of a down-to-earth approach that tries to identify and quantify socio-economic changes through concrete variables becomes more justified when the complexity of small farmers' systems is taken into consideration. 'The complexity of small farmers has its roots in the number of separate and composite activities undertaken; the number of effective constraints impinging on these activities; the crucial temporal interdependencies among activities; the poor records and information base for decision making; the number of attitudes of farm performance that enter the farm family's utility; and last, but by no means least, the inevitable lack of certainty in nearly all facets of production, marketing and life' (Anderson and Hardaker, 1979, p.13).

The specific nature of the relationship between small farmers and agricultural researchers is of great importance within the context of this work because it represents what was probably the first attempt of implementing Farming System Research (FSR) in the Agreste region of North-East Brazil. An attempt that, despite many setbacks, seems to be gradually evolving in the direction of Farmer Participatory Research (FPR), as seen in Chapters 1 and 4. Before the introduction of FSR in Brazil and in the North-East in particular, years of agricultural research and development programmes based on what has been called here Conventional Agricultural Research (CAR) had been almost completely ineffectual in terms of improving the lot of the small farmer (Carvalho, 1988; Gonçalves de Souza, 1979; Hall, 1978, 1981 and 1989; Sampaio et al., 1987).

After the failure of the CAR approach in the Agreste region, the introduction of FSR in the late 1970s raised the very important question of whether a systemic and participatory research approach could generate technologies that would be adopted and have a positive socio-economic effect as far as small farmers of the Agreste are concerned. Following a world-wide trend, few impact assessment studies have been carried out in Brazil with the objective of answering that question (Casley and Kumar, 1987 and 1988).

The present study is an attempt to fill, at least in part, that gap. One of the main hypotheses behind this study is that an agricultural research methodology such as PTC is capable of generating and diffusing technologies which foster increases in productivity, promote output growth and contribute to the improvement of the welfare of the small farmer's family. The technological innovation being discussed concerns the adoption of improved potato seeds and the use of several new farming practices in the Caruaru region, North-East Brazil (Chapters 4 and 5).

Many years after a few small farmers had introduced the potato crop in the Agreste of Pernambuco, researchers from IPA-Caruaru (an agricultural research station located in the Caruaru region) started, in the early 1980s, to work together with local small farmers. Their objective was, among other things, to improve the quality of their potato output and to increase its productivity as well as the number of farmers cultivating this tuber (IPA, 1987-1990). The practical consequences of that approach for the farmers of the region remained largely unknown (fieldwork, 1991; Geraldo M Lopes, 1997, IPA, personal communication). Only a few reports had been produced based on the observation of a small number of farmers chosen without taking into consideration proper sampling and other statistical requirements. Those reports were very limited in scope and aimed mainly at finding out whether some agronomic problems such as determining optimum fertilizer levels and controlling certain potato diseases had been overcome (IPA, 1991).

3.2 Definitions

There seems to be little doubt that technological change can play a major role in increasing productivity and promoting agricultural development (Eicher and Staatz, 1985). It is important to clarify that the term agricultural development refers to a process which is different from rural development.

Rural development is defined in this study as a broad and comprehensive process in which the main objective is to tackle the question of rural poverty and promote the well-being of farmers and their families (Harriss, 1984). Thus, the concept goes beyond the achievement of better production results through technological change. More important is strengthening livelihoods of farmers, their families and those who may help them, paid or unpaid rural workers (Thirlwall, 1983; Todaro, 1981). Livelihoods 'refer to more than just income and wealth: quality of life and of society, security, and dignity might be just as important to those whose livelihoods need improving' (Shepherd, 1998, p.3). Agricultural development, on the other hand, has a much narrower aim. It is a process geared toward the increase of total agricultural output and productivity. It is concerned with quantitative targets and rates of growth and not with the quality of the farmer's life itself.

As was pointed out in Chapter 1, it appears that in recent years significant advances have been made in developing the capacity of agricultural research systems to deliver technologies that meet the needs of the small farmer. The small farmer being discussed here is typical of those who live in the developing countries and is characterised by having access to or owning small plots of land in resource-poor areas and by possessing low levels of income. The farm is operated by its owners as a family concern, largely for subsistence consumption (PIMES, 1986; Ruthenberg, 1985).

The small farmer of the Agreste of the Brazilian North-East (Caruaru) fits this definition well, as will be shown in Chapter 5. As with most small farmers in developing countries they do not practice monoculture. They grow a variety of crops with multiple cropping and intercropping as the norm. Most farmers keep small animals such as pigs and chickens while many also keep cattle. They farm areas less than 100 hectares in size (Lopes, 1990; fieldwork, 1990).

It is becoming increasingly accepted that small farmers often avoid drastic changes in their farming systems. They generally lack capital and their risk-avoidance strategies tend to favour a cautious learning process, as pointed out in chapter 1. Consequently, small farmers proceed in a stepwise manner to adopt one or sometimes two new inputs or practices at a time. This is precisely what the small farmers of Caruaru have done regarding the potato crop (Chapter 5). As Pearse has emphasised, the 'package technological approach' exemplified by the Green Revolution and a product of CAR (Conventional Agricultural Research) is often of little use for small farmers because 'it is frequently discriminated since it calls on the cultivator to amend too many different aspects of his technology all at once, and to attempt a radical leap forward in which there is discontinuity between the existing and the new' (Pearse, 1980, p.180).

Having said that, it becomes necessary to clarify in which way the term technology is used in this thesis. The concept of technology is not limited only to machines and material. The definition used here is very similar to the one adopted by Solo and Rogers

(1972) and shares its meaning with that of Schon (1967, p.11): 'Any product or process, tool or technique, any physical equipment or method of doing or making by which human capacity is extended'. Based on this definition the technological change which is the focus of this thesis, namely potato cropping, involves the adoption of improved potato seeds and new farming practices such as: use of organic fertilizer (manure); chemical fertilizers; agro-chemicals (fungicides, pesticides, etc.); furrow sowing and ox-drawn ploughing. As already mentioned in chapter 1, the terms 'technology, 'technological innovation' and 'technological change' are used interchangeably in this study.

3.3 Brief Background

When reviewing Sheahan's 'Patterns of Development in Latin America', Scott makes the important point that recent development experiences in Latin America were characterised by 'policy choices that displayed both a combination of economic unwisdom and political inhumanity' (Scott, 1988, p.344). Sheahan's position is that Latin American development since 1950 depended on governments that largely disregarded the question of reducing inequality and eliminating poverty and were not committed to sustaining competent and coherent economic policies. Equitable growth strategies were not, it seems, the main concern of most Latin American countries, including Brazil.

Scott, in the same article, finds Sheahan's conclusion 'realistic but depressing' since according to his point of view, it reverses Friedman and Hayek's argument that free markets are a necessary institutional buttress for democracy. According to Sheahan (1987), there is an open conflict between economic policies which reflect the expression of popular preferences through the ballot box and economic policies which are designed to ensure macro-economic balance and microeconomic efficiency.

It is my view that a similar conflict is involved in the question of agricultural technological change facing most developing countries. In other words, it seems that, at least in the short-term, many of the technologies that appear to meet small farmers' needs are not as microeconomically efficient as some of the 'modern' technology available or already in place in those countries. Many development writers refer to this modern technology as inappropriate for meeting the needs of small farmers (Jéquier, 1976; Kaplinsky, 1990; Pearse, 1980; Stewart, 1985).

It was mainly the failure of modern technology created by CAR to provide small farmers with the means of obtaining additional income and long-term improvement in living standards that led to the search for a new agricultural research methodology capable of offering small farmers a technology that could contribute to finding a solution for their problem. Nevertheless, the problem facing the small farmer is not just technological; there are also financial and administrative obstacles to be overcome and perhaps more importantly, political barriers. De Janvry (1985) is one of the authors who has made the link between politics and technological development in developing countries. He argues that underdevelopment in general, and lack of rural development in particular, cannot be meaningfully analysed using the concept of 'traditional agriculture', as suggested by Schultz (1964). A concept that de Janvry points out, abstracts from the historical process of the integration of developing countries into the world capitalist system. For him, the process of rural development can only be understood in a general equilibrium framework that takes into account how small farmers are tied to the world economy.

De Janvry further argues in his article of 1985 that the conclusion that the lack of rural development can be alleviated by providing small farmers with new technologies and education is bound to be misleading. His argument is that it ignores the mechanisms by which surpluses are extracted from the rural poor and 'siphoned off' to fuel the development of metropolitan centres. This is an important point that deserves careful consideration.

In the case of Caruaru, it appears that despite adverse political circumstances, small farmers do have room to retain at least part of the profits that they are obtaining through the production and sale of the potato, as was revealed in the fieldwork survey. The data from a farmer survey carried out in the Agreste of Pernambuco for this study shows that a number of positive changes are taking place and that there is scope for improvements in terms of farmers' living condition given a more productive and efficient technology, as will be elaborated in Chapter 6.

It is probable that these changes are being hindered not only by the dependency of the rural sector in relation to urban areas, as suggested by de Janvry, but also by the development model followed by Brazil after World War II. Furtado's diagnosis (1965) of the Brazilian crisis is still very relevant today, especially as far as North-East Brazil's highly inequitable land ownership structure is concerned. Furtado then said: 'For a rapid improvement in their [Agreste workers] living conditions, it would be necessary to reorganise the existing structure of agriculture in the Agreste, with a view to increasing productivity. This would require an increase in the amount of land per family and capitalization at a much higher rate than the present one' (Furtado, 1965, p.150).

It is important to have in mind that Furtado's appeal for 'reorganisation' conflicts with the interests of large landowners, mainly because it would create serious losses for what is probably the major economic activity of the Agreste: stock-rearing. Due to its extensive character, cattle ranching in the North-East needs plenty of land and cheap labour. In this context, the large landowners can still be seen as a serious obstacle to the improvement of the technological standards of agriculture for small farmers in the Agreste region.

These landowners are usually protected by a number of politicians who defend their interests in the National Assembly or Congress. Politicians who, particularly in the North-East, still work within a clientelistic perspective (Hoefle,1985; Cammack, 1981; Eisenstadt and Lemarchand, 1981). Politicians whose political practice is the politics of favours and whose main concern is to guarantee the necessary numbers of votes to maintain their position in office. In the words of Roett (1978, p.27), the concept of clientelism means 'a system of decision making that is based on an exchange of substantive favours, legal privilege, or protection from punishment among political actors'.

3.4 Participatory Technological Change (PTC)

What I will call Participatory Technological Change (PTC) is a new agricultural research methodology which evolved from FSR (Farming System Research) but has not properly developed into FPR (Farmer Participatory Research). PTC implies, to a large extent, decentralisation of production structures and therefore, significant institutional, administrative and political changes probably in the direction of a pluralist democratic model. This entails decentralisation to the village and district (*município*) level so that plans can be adapted to variable local conditions. PTC and the main new technology it generated - potato cropping - will be further explained in Chapter 4.

Nevertheless, the situation is even more complex than one may assume because such decentralisation often concentrates power in the hands of local rural elites who, according to Paul Streeten et al. (1984), block policies that would benefit the poor. In the interests of the rural poor, decentralisation in Streeten's view needs to be well balanced by the retention of power by central government. It involves, among other things, designing an administrative and political structure which is both decentralised for adaptability and flexibility but centralised for the protection of the poor and the politically weak; such as small farmers of North-East Brazil. This is certainly difficult to achieve, particularly in a country such as Brazil which has a very strong tradition of central government control.

Streeten's proposes that government policy must be seen neither as entirely above economic and social forces nor simply as an expression of the self-interest of the ruling classes. Rather, it is in itself one of the dependent variables that can be shaped and improved by other variables of the social system, especially by reformist coalitions. The enhanced power and organisational efforts of the small farmer seem to go hand in hand with the successful introduction of a new technology. The example of the small farmers of Caruaru appears to corroborate that hypothesis, as will be shown in the following chapters.

3.5 Small Agriculture and PTC

It was not until recently that the complexity of small agriculture was truly appreciated by researchers. However, that does not mean that it is yet understood in its entirety. Small farmer's systems are characterised by variable patterns of resource endowments, production opportunities, skills, beliefs and preferences. Generalised solutions for such systems are said to be almost impossible to achieve while the number of farms is generally too large to permit analysis of all individual cases (Anderson and Hardaker, 1979).

Evidence from around the world suggests the location-specific nature of most agricultural technologies (Chambers et al., 1989; Haverkort et al.,1991). In practical terms, that means that much of the research and development work in agriculture must take place in national research centres and not at international level (Eicher and Staatz, 1985). That in turn means location-specific research that is best implemented through on-farm research methods where farmers are involved in identifying potential technological improvements which are then tested under local conditions and further developed through FPR. In the case of Caruaru's farmers, the survey will provide evidence that PTC seems to have managed, by and large, to provide farmers with the means of overcoming many of their difficulties and has thus promoted considerable benefits.

3.6 Fieldwork Methodology: Farmer Survey, Case Study, Direct Observation and Interviews

Anderson and Hardaker (1979, p.15) realistically argue that 'the contextual problems of evaluating technology for small farmers are severe and rather intractable'. However, short of nihilism they suggest that a partial analysis may be better than none at all. Taking that into consideration, it was decided that besides a farmer survey, a number of different methods would be used during data collection or fieldwork such as case study research, direct observation and interviews.

The core part of the fieldwork for this thesis was carried out between May 1990 and February 1991 and consisted of a retrospective cross-sectional structured survey with all eighty two (82) small farmers who took part in the technological change being studied. The fieldwork was carried out in Caruaru, Pernambuco, North-East Brazil.

The main objective of the fieldwork was to investigate the possible socio-economic impact of a technological change, namely, the introduction of potato cropping in that region. Its secondary objectives were: (a) to measure (whenever possible) the effect of that change through at least ten variables that will be explained in section 3.7.2; (b) to try to explain the main impacts observed; (c) to verify whether the intervention of researchers and extensionists facilitated or promoted the changes that may have occurred; and (d) to assess the role of the farmer's association (APROBACA) within the context of the technological change.

3.6.1 The Setting: An Outline

The North-East of Brazil comprises the nine states of Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe and Bahia. It is a large region of some 1.5 million square kilometres or 18.2% of the national territory. An area bigger than Portugal, Spain and Italy put together where approximately 30% of Brazil's population live (Jaguaribe et al., 1986; Hall, 1982). Brazil's estimated population in 1995 was 155 million (EIU, 1997). More than 20 million people live in the rural sector of the North-East (45% of the regional total); proportionally the largest in Brazil where over 70% of the population are urban dwellers (Jaguaribe et al., 1986).

Geographically, the North-East is very varied and is often divided into three distinct physiographic zones known as Zona da Mata, Agreste and Sertão. These zones, however, are not homogeneous and their ecological diversity causes differences in all aspects of agricultural activity as Souza (1979) carefully pointed out. According to Reddy and Amorim Neto (1984), 75% of this land is classified as 'semi-arid tropics' (SAT). The SAT includes the two major agro-ecological zones or sub-regions namely Agreste and Sertão.

- The Zona da Mata is the fertile coastal strip dominated by large sugar-cane plantations. It receives plentiful and regular rain; over 1,300mm per year.

- The Agreste, a transitional eastern upland zone between the humid coastal strip and the drought-prone Sertão, is characterized by small and medium mixed farming whose produce is primarily destined to the local market. Intercropping (*consórcio*) is the predominant farming system and a number of crop combinations are used involving mainly: manioc or cassava, maize, beans, forage cactus and cotton. Rainfall in this semi-arid region is less plentiful than in the Zona da Mata and its pattern is irregular. Annual rainfall ranges between 600 and 1,300mm. The 'winter' season (rainy period) is relatively short, lasting approximately six months between February and August. Moreover, it varies considerably from year to year making rain-fed farming difficult to plan and practice.

- The Sertão is the interior zone of the North-East, a large plateau characterized by extensive cattle ranching, cotton as well as subsistence agriculture. It is a semi-arid zone subjected to periodic droughts and extreme variation in rainfall pattern. The annual rainfall is in the range of 400 and 700mm (Lacerda de Melo, 1978; Lima et al., 1986).

In socio-economic terms the North-East is also very diverse. The class structure in the region is highly polarized (Andrade, 1987; Carvalho, 1988). It has a small rich elite and what is still probably the largest concentration of poverty in the Western Hemisphere (Webb, 1974). As it was mentioned in the previous chapter, it is estimated that over 60% of the Brazilian working population lived below the poverty line in 1985. In the North-East, where two-thirds of the poor people live in rural areas, this figure is 78.6% (Jaguaribe et al., 1986 and 1987). Income and land distribution are highly skewed; largely a legacy of the colonial era, the heritage of slave-based plantation *latifúndio* farming and a patriarchal society dominated by big powerful landowners (Furtado, 1980; Hall, 1982 and Vaughan-Williams, 1986).

According to data of the 1985 Agricultural Census (IPEA/IBGE, 1987), the last one to be published for Brazil as a whole, the pattern of land concentration remained virtually the same in the 1970s and 1980s. It can be observed that from a total of 5.8 million rural holdings in Brazil, less than one per cent of all these holdings, the largest ones, occupied 44% of the total agricultural area - 165.5 million hectares in 1985. At the other extreme, 91% of the total number of rural holdings are smaller than 100 hectares in size and are spread over an area equivalent to only 20% of the total agricultural land. As an illustration of the extremely acute land concentration that exist in Brazil, data from the Agricultural Census reveals that all the properties smaller than 10 hectares in size, 3.08 million holdings, occupy just over 10 million hectares, whereas the 61 largest properties in the country - each over 100,000 hectares in size - own approximately 12,5 million hectares; an area approximately as large as England.

The role of small farmers in the Brazilian agriculture, despite the process of modernization which have taken place over the last few decades - a process which have penalised this group of farmers (Chapter 2) - is still important in many respects. In terms of the sheer number of holdings and people involved in the agricultural sector, small farmers cannot be easily ignored. Ninety one per cent of a total of 5.8 million rural holdings in Brazil are less than 100 hectares (ha): 3.1 million (53%) are less than 10ha and 2.2 million (38%) are between 10-100ha. Of the total of number of people occupied in the Brazilian agricultural sector, approximately 30% of the country's labour force, practically 80% or 18.5 million people are working in holdings of less than 100ha. The percentages for the North-East alone are very similar. Almost nine million people or 86% of all those working in the agricultural sector in that region are doing so in holdings smaller than 100 hestares in size (IPEA/IBGE, 1987).

Very significantly, Kageyama and Graziano da Silva (1988, p.358) present data showing that in 1980, small farmers are very important also in terms of output production. Perhaps surprisingly to those who want to dismiss the relevance of the small farmer, cultivators in holdings of less than 100ha were responsible for half of the value of the total Brazilian agricultural production. With regard to the actual physical output of the main crops harvested in 1980, the list provided by the authors is quite striking as seen below.

Table 3.1. Distribution of Physical Crop Output (%) per Type of Producer according to Size of Holding in hectares (ha), Brazil, 1980.

Crop	less 10ha	10-100ha	over 100ha
Manioc	37.9	49.5	12.6
Beans	26.9	51.7	21.4
Maize	14.8	53.3	31.9
Rice	13.3	23.8	62.9
Coffee	9.9	45.3	44.8
Soya	4.0	42.2	53.8
Wheat	2.1	44.8	53.1
Sugar-cane	1.8	13.5	84.7

Source: Adapted from Kageyama and Graziano da Silva (1988, p.359).

Table 3.1 shows very clearly that small farmers are significant producers even of crops that are not considered subsistence or staple food crops such as coffee (55.2%); soya (46.2%) and wheat (46.9%). They are by far the largest producers of manioc (87.4%); beans (78.6) and maize (68.1%), traditional food crops in Brazil.

According to another source, it is estimated that 94% of rural holdings in the North-East (2.3 million) are less than 100ha in size and occupy about 30% of the region's total area. Despite the limited area at their disposal, the crop production from these small holdings in the mid-1980s represented more than 60% of the region's basic food supply (Lima et al., 1986). In the North-East, reports the World Bank (1983), crops are the mainstay of the rural economy accounting for 70% of the total primary output. In value terms, approximately half of the total crop output is of staple food such as beans, rice, maize and manioc in particular. The remaining consisting of 38% in the form of export crops such as sugar-cane, cocoa and cotton and 12% of highly perishable items, fruits and vegetables. More specific and recent data on crop production in Pernambuco, the state where fieldwork for this thesis was carried out, is presented in chapter 7 (section 7.4).

The crop distribution both in Brazil and in the North-East is summarized below (Table 3.2). Data from the Agricultural Census (IPEA/IBGE, 1987) show that the values for the North-East are still significant within the Brazilian context in 1985: 43% of the total area under permanent crop cultivation in Brazil is located in the North-East; temporary crops in the region cover an area of 10.2 million hectares or approximately a quarter of the country's total (1).

Table 3.2. Area Under Crop Cultivation in millions of hectares (ha) and percentage (%), Brazil 1985.

Crops	Brazil ha (%)	North-East ha (%)
Temporary	42.5 (81)	10.2 (24)
Permanent	9.8 (19)	4.2 (43)
Total	52.3 (100)	14.4 (28)

Source: IPEA/IBGE, 1987.

The North-East has nearly half of the total number of rural holdings in Brazil. They are spread over an area of 88 million hectares or 24.2% of the total agricultural land of the country. It is worth stressing the fact that the total area under crop cultivation in the North-East represents only 15.7% of the total area of rural holdings, and therefore, the potential for expansion of agricultural and livestock activities is considerable

(IPEA/IBGE, 1987). Although agricultural land the size of France lies idle or greatly under-utilised in the North-East, many observers have concluded that substantial returns are possible from North-East agriculture. They have considered the Agreste region, aside from the humid zones, as having the highest development potential (Sampaio, 1988; PIMES, 1975; Kutcher and Scandizzo, 1981). Moreover, small family farms and not large estates are said to be the most viable units for achieving development goals such as: employment generation, output and productivity increases and provision for adequate consumption (Andrade, 1986; Kutcher and Scandizzo, 1981). It is in the Agreste region of Pernambuco, in the municipality of Caruaru, where the small farmers being considered in this study live.

3.6.2 Farmer Survey

The small farmers who participated in the survey constitute an entire group of farmers that had introduced the technological change being investigated. A small number of farmers who had cultivated potato in only one wet season prior the fieldwork were not included in the survey. Their lack of experience and the very short period involved would have made it unreasonable to expect any significant impact of the new technology upon that particular group of farmers. Therefore, any attempt to evaluate the socio-economic impact of the technological change upon those people would come too soon for confident estimation of most variables selected for that purpose (de Vaus, 1986; Hoinville et al., 1989; Singleton et al., 1988).

As the farmer's association (APROBACA) and local agricultural research institute (IPA) had estimated that it was likely the target group consisted of approximately one hundred farmers, it was decided that despite financial, personnel and time constraints, the fieldwork survey would deal with a population and not a sample of farmers. A structured, standardised questionnaire (see appendix) with specific objectives was designed, discussed with researchers working in the region and pre-tested locally. Despite a few exceptions which are explained below, all questions were written beforehand and asked in the same order to all respondents (Fowler Jr.,1984; Sudman and Bradburn, 1983).

The author of this thesis was the only interviewer used in the survey. This was a deliberate strategy that has been chosen to minimise bias and increase the reliability of the survey and, moreover, to gain the trust of small farmers before starting the interviews. The interviewer was allowed a degree of freedom so that farmers' circumstances would not interfere with the quality of their answers. For example, on one occasion it was necessary to alter the order of the questions because of an uninvited guest who appeared when personal questions relating to income sources and investment preferences were being asked. Knowing how shy and reluctant small farmers are to openly discuss these issues, the interviewer preferred to ask less sensitive questions such as his age, number of children, main occupation and so on until his friend had left. In other instances, it was necessary to explain a question or provide farmers with a few examples so that they would understand the question. With those who hardly knew the interviewer or were more suspicious of his intentions, it was necessary to spend more time explaining who he was and what was he doing there before starting the interview. A mixture of open ended and closed questions allowed farmers to fully voice their ideas and proved very useful in satisfying fieldwork objectives (Hoinville, 1989; Sudman and Bradburn, 1983).

Ideally, in order to assess the impact of project interventions, it is necessary to isolate the project from the impact of exogenous factors either by relying on quasi-experimental and experimental research designs or by utilising powerful statistical techniques such as multivariate regression (Casley and Lury, 1981; Casley and Kumar, 1987). In practice, as Casley and Kumar (1987, p.105) have admitted, it is only on rare occasions that it is possible to use such designs or complex statistical techniques because the data available does not meet the rigorous standards these techniques demand. That was exactly the case of the data collected for this thesis. Moreover, the farmers being studied were not part of what could be called a self-contained project. Farmers adopted the technology at different times before the survey was conducted and, therefore, it was quite impractical to use a quasi-experimental or experimental research design.

In order to detect any significant change in the farmers' situation, some reliable indication of their situation before the adoption of the technology was required. As no information existed on the situation 'before', it was necessary to use a retrospective survey design that would allow establishing benchmarks with which any significant changes could be compared. These are not easy to establish precisely, particularly due to farmers' recall problems (Moss and Goldstein, 1976).

However limited this approach may have been, it was probably the most appropriate given the circumstances. The structured questionnaire used in the farmer survey was carefully designed to minimize bias caused by recall problems and to detect them whenever possible. Often, more than one question would be asked about a particularly important issue to allow the interviewer to verify the quality and reliability of the answers being obtained (Baddeley, 1976).

Survey interviews were conducted with rigour and professionalism but in an informal way in order to facilitate small farmer's answers and enable them not to be intimidated or feel suspicious about the nature of the researcher's intentions. It is well known, as Monteiro de Barros (1991) observed, that small farmers of the North-East of Brazil tend to be afraid and/or suspicious of anyone they may think is a bank official or tax inspector, for obvious reasons. An interviewer coming from outside the region is often perceived as a 'fiscal' (tax inspector).

With those points in mind, it was decided that all interviews would be conducted by a single person and start only after a period of time long enough to allow farmers to have a reasonable understanding of the survey's nature. It was only after most farmers had agreed to collaborate with the survey and had established a good degree of trust in the interviewer that the interviews were started. Informal visits were made with and without the presence of the researchers from IPA, who were familiar both with the region and the farmer. A pilot study in the area covered by the survey and participation in several meetings of APROBACA (a farmer's association for those cultivating the potato) were all essential in preparing the ground for the farmer survey. Contacting the leaders of APROBACA and allowing them to introduce the interviewer to most of the other farmers was crucial to gaining their trust, following which the interviews could be carried out without major difficulties. In hindsight, without these precautions the quality of the data collected may have been seriously affected. A couple of examples may help to clarify some of the points discussed above.

During one of the first interviews, a friend of the farmer being interviewed dropped by and stood outside the window listening to the conversation. When the farmer mentioned the amount of land he owned, his friend immediately made a joke about him having to pay rural taxes because of what he had just revealed. I was quick not to leave the comment unnoticed and used the opportunity to explain again to both of them that I was no tax inspector and did not work for the Brazilian government. In the following days I secured an invitation to a farmers' association meeting, during which I mentioned what had happened a few days ago. We all laughed as it became clear to them that I was not a *fiscal* (tax inspector). A little later during that same meeting a farmer observed referring to me: "He is not like those gringos who come here. He is one of us". It took me more than a month of intense work to bridge, at least in part, the gap that existed between us. It was only then that the survey interviews started. This is a gap that is often ignored even by local researchers working within a systemic and participatory framework.

On another occasion, a farmer was having difficulties in understanding whether he had acquired his consumer goods before or after the introduction of the potato, the technological change under consideration. His wife who was cooking nearby (and discretely following the interview closely) asked me if she could comment on it. She explained that it was easier for her to understand what I was trying to ask her husband because she was better educated than him. She added that many women in that area had benefited from the good quality of the local primary school while their husbands were likely to be illiterate due to the need to work full time in their fields. After she successfully explained to her husband what I wanted to know, the farmer replied he did not remember when he had bought the items. She (his wife) jumped at the opportunity and helped him to remember. They had bought the cooker, the kitchen furniture and the hi-fi with the money from the potato crop. "It all happened just after our second son was born. We had a wonderful potato harvest that year", she added proudly.

Following that interview, the relevance of allowing and facilitating the participation of the farmer's wife in the interviews became too obvious to be ignored. Thus, whenever possible, I tried to ensure that the farmer's wife would also be present during the interviews. These questionnaires were answered by the administrator of the farm who in almost all cases was a male. Although many women also work very hard as farmers, by their own accounts farming is not their main occupation. Nevertheless, on several occasions their participation contributed decisively to overcoming farmers' recall problems.

It is very important for an interviewer to be aware of the culture of those with whom she or he is dealing in order not to offend them. For example, the 'macho' mentality is a fact of life in the rural North-East that cannot be disregarded. Bringing a woman's opinion into the survey was possible only in a subtle and 'disguised' fashion in order not to hurt the dominant status of the man and perhaps, more importantly in the survey context, to avoid creating an atmosphere that might predispose the farmer to sabotage the interview. The women would tend to behave in a rather submissive way and leave the male figure to dominate any conversation. That attitude also needed to be understood and respected if the data collection process was to be successful.

3.6.3 Case Study

In order to gain a deeper understanding of the small farmer's real circumstances and be able, later, to properly interpret the results of the survey, a parallel case study with a few of the farmers who had already been surveyed was also carried out. The case study approach of a few farms enabled the author to go beyond the descriptive analysis level and allowed competing explanations to be offered for the socio-economic impact of the technological change to the test.

As Valdés et al. (1979) suggest, the chosen farmers were not selected mainly for their representativeness, but for their suitability for analysis. Thus, farmers who had kept better than average records (most keep no written records at all) and were more articulate or receptive towards the idea of the case study were invited to participate.

Two of the four small farmers who participated in the case study had been chosen by researchers from IPA in 1983 as part of a special FSR programme called SIP

(Integrated Production System) that will be explained in chapter 4 (IPA, 1988). Information collected by them in previous years about the two farms was made available and it was possible to use it to compare, complement and verify the data collected during the fieldwork carried out for this thesis.

The high degree of trust developed allowed farmers to spontaneously volunteer information that could be considered very confidential. As an illustration of the above it is possible to cite more than one farmer who asked me: "Do you want to know what I told the 'doctor' [official] from the bank and research station or do you want to know what is actually happening with the potato crop in the fields?".

3.6.4 Direct Observation

In order to confirm findings and explore certain hypotheses generated by material obtained from the fieldwork, and assuming that both farmers and researchers might have their own personal reasons for not providing all the information needed, I participated in a range of formal and informal activities that enabled important data to be collected.

To better understand the researchers' point of view, these activities involved:
(a) participation in the daily work routine at the local research station (IPA-Caruaru);
(b) attending many field-days (2) organized by IPA in collaboration with extensionists (EMATER) for small farmers both at the experimental station and on different farmer's fields; (c) attending some of the researcher's internal discussion meetings.

An example may help to clarify the scope of this methodology. During a routine visit to a few farmers, a rural extensionist working within a framework similar to or inspired by the FPR approach, hurriedly looked for a farmer who he needed to instruct about how to combat a serious disease that was destroying the farmer's potato crop, a problem that many farmers were facing in 1990. As soon as the farmer's wife announced he was not around, the extensionist wrote the name (in terrible handwriting) of a couple of agro-chemicals that the farmer should use to avoid losing a large part of his crop. Nothing was said or written about how and when to use these dangerous (toxic) products. Having already surveyed that particular farmer and knowing that the couple were illiterate, it was not difficult to envisage the result of that visit. The important message - from the farmer's point of view - would not be understood. Moreover, the efforts of the research team that had already organized a field-day for the small farmers about how to avoid and combat diseases and pests through the correct use of agro-chemicals only two weeks before were being completely wasted.

Carefully observing this field-day and discussing what I saw during that day with the head of IPA's research station in Caruaru, we concluded that the attempt at instructing farmers using a more participatory methodology had been a complete failure in that instance and would need to be corrected by the action of researchers and rural extensionists on the actual farmer's fields. The field-day had been a failure mainly because researchers had ignored their clients and prepared a highly technical and complex demonstration about potato diseases and how to deal with them. Even agronomists not familiar with the crop were having difficulties following their explanations. Not surprisingly, many small farmers participating in the event were distressed and confused. Chatting with them during the lunch break on that field-day and observing their reactions and comments during the explanations it became obvious to me that the objectives of the researchers were not being achieved. On the contrary, several farmers who were starting to cultivate the potato that winter (raining season) mentioned that if they had known in advance that potato farming was so difficult and risky (due to all the diseases) they would never have started. The comment of one of the most experienced farmers nearby put things into perspective and gave some hope to the beginners. He bluntly said to his colleagues: "If I believed everything that these smart 'doctors' say about agriculture, I would be working in a factory in São Paulo" (3).

The example of the extensionist's visit and of the field-day illustrates well how relevant direct observation may be used as a source of data collection. When that extensionist was later asked whether he believed farmers were able to benefit from the new agro-chemical inputs, he had no doubts: "Of course, after the disaster of the field-day we finally got our act together". Unfortunately, it was confirmed that the farmer did receive the extensionist's written instructions from his wife but it was of no use to them. The following week when I visited that farmer again, it was possible to see that a large percentage of his potato crop had been destroyed by the disease that was, according to the researchers from IPA, fairly easy to control if combated correctly and in time.

Without the use of this methodology (direct observation), it would be easier to believe that farmers experienced few problems in dealing with diseases related to the potato crop and that researchers and extensionists had finally got it right. The reality proved to be much more complex. By closely observing the small farmers in their natural environment, it was possible to undertake excellent data collection by: (a) casually visiting farmers' fields with or without their presence; (b) accepting their invitations to have a drink at the local bar after work; (c) not turning down offers to stay for a meal after the survey interview had been completed; (d) attending the farmers' association meetings.

The example given above to clarify the role of direct observation when trying to understand what researchers are doing and saying is also very useful for appreciating the type of information farmers are providing. Several farmers had mentioned that they had attended an important 'course' or field-day on potato diseases and how to use agro-chemicals. Given the circumstances, it might have been tempting (and certainly easier) just to assume that they knew how to use their modern inputs and, therefore, could not possibly be having problems with their potato crops. Or to assume that researchers and extensionists had finally succeeded in 'teaching' farmers everything they needed to know about potato diseases and pests and how to combat them. It is clear from the examples that this was not the case.

Direct observation also demonstrated its great potential for gathering unbiased information with regard to a relevant and somehow nebulous issue. In their private talks farmers often refer to the *perdão* (pardon). The *perdão* being a discount farmers receive from a bank on the repayment of the loan raised to grow the potato crop. A number of farmers were participating in a Government programme called PRORURAL or 'Potato Project' (Chapter 5) geared towards the consolidation of potato farming in that specific region of the Agreste. In recent years, farmers have been invited to join the programme and received improved seeds and other modern inputs besides technical assistance. In exchange, farmers commit themselves to pay back the Government a percentage of their potato harvest by the end of that same agricultural year. With a report from an agronomist in their hands, the State bank determines how much each farmer will need to repay to the government's coffers. If a harvest is very bad due to legitimate reasons (i.e., drought, illnesses, poor quality of seeds, etc.), the bank issues a *perdão* to the farmer, who may end up paying nothing back to the bankers. It goes almost without saying that farmers are often very 'friendly' towards the agronomist hired by the bank to write these reports. He often has a good meal when visiting farmers and at harvest time the boot of his car would probably be left unlocked (just in case a farmer can spare a little of his or her surplus). Being considered a local man by most farmers, and very sympathetic to the cause of the small farmers, that agronomist may tend to underestimate the performance of the potato crop and overestimate the problems related to it. As the farmers would if they considered you to be an outsider.

3.6.5 Interviews

Fourty six structured interviews in addition to a large number of informal ones (Forcese and Richer, 1973) were carried out with agricultural researchers, rural extensionists, academics, rural union and farmer's association representatives, as well as members of the church and others who were involved with development work in the Agreste area of the North-East of Brazil.

Unstructured or informal interviews with researchers and rural extensionists in particular proved to be a very useful tool for data collection. The flexibility of the method and the informality of the interviews allowed many communication barriers to be overcome. The agronomists' initial reluctance to provide information to an outsider (social scientist) was gradually eroded and a good dialogue could be established. A more formal, partially structured type of interview was conducted with senior officials or representatives of key organizations such as IPA, CPATSA, EMATER, PRORURAL and the WORLD BANK. The limited time these people had available for interviews, coupled with their expert knowledge, required an elaborate questionnaire design appropriate for each occasion.

To conclude the present section, it is worth mentioning briefly that in order to understand the technological change being investigated, particularly from the point of view of the small farmer, a practical experiment was also carried out during the fieldwork. With the help of IPA and a small farmer, I cultivated a small potato plot, from the ploughing of the land until the harvest of the potato approximately ninety days later. The experiment tried to use the same technologies and farming methods used by the local farmers. IPA's assistance in this respect was essential since it was their researchers together with farmers who developed the technology itself. The insights gained from the experiment proved invaluable, especially when surveying farmers. By experiencing at first hand the problems that were afflicting the farmers being interviewed, it was possible to go deeper in my observations and questioning of farmers. They soon realised that 'fabricated' answers would not be easily accepted since I had not only good theoretical knowledge but also some solid practical experience about many of the questions being posed. In the end, all the different data collection methods used during the fieldwork were very valuable methodologies in gathering sufficient information to meet the objectives of this thesis.

3.7 Variables Used to Assess the Social and Economic Impact of a Technological Change

3.7.1 Introduction

As the title of this thesis suggests, this study does not restrict itself to evaluating the impact of a technological change in terms of how it has affected crop output and productivity. It goes far beyond an attempt to quantify changes of area under cultivation and yields, two very common variables used in monitoring and evaluation of agricultural projects.

However, Casley and Kumar (1987) have rightly reminded us of the serious difficulties facing evaluators when they try to establish and measure change and the causality of change within an agricultural and rural development project context. Being more specific, these authors pointed out several fundamental reasons for disappointment when dealing with the evaluation of small farmer agricultural projects: 'the determination of yield or production trends in rain-fed smallholder farming areas (such as Caruaru) may be impossible within the implementation period of most projects' (Casley and Kumar, 1987, p.119).

If, in practice, the measurement of apparently simple things such as production levels and productivity are difficult, rigorously attributing the causality of change is virtually impossible under real-life conditions in which experimental methods and replications cannot be achieved (Casley and Kumar, 1987). Taking this into consideration, a broad range of variables was selected and four indexes created (see next section) with the objective of capturing the most important socio-economic effects of the introduction of potato cropping in the Agreste of Pernambuco (Chapter 6). Thus, it is hoped to overcome the difficulties linked to establishing causal relationships and provide a balanced view of the changes observed.

3.7.2 Variables and Indicators

Ten variables were selected as a starting point for the analysis and with the main objective of trying to identify and then assess (measure whenever possible) the socio-economic impact of a new technology developed by a participatory and systemic research methodology (PTC). Certain secondary objectives such as aiming to verify the contribution of a farmer's association (APROBACA) were also firmly in sight when those variables were chosen.

A list of these ten variables and a summary of what they try to measure can be seen below. It was on the basis of these ten variables and indicators that the survey questionnaire was constructed (Fowler Jr.,1984). A few variables other than the ten listed below may 'emerge' from the analysis or examples that will be used to clarify it in Chapter 6.

The variables used in the study of the impact of technological change on small farmers are the following:

VARIABLES	INDICATORS
1. Area	total farm unit - % owned;rented;squatted - area bought - area sold
2. Land use	planted areas: - food crops (corn;beans;manioc) - cash crops (potato) - forage crops (cactus;grasses) - pasture (native) - % arable land;unproductive
3. Production	food crops output - cash crops output - forage crops output - livestock (cattle)
4. Productivity	output(gross)/planted area
5. Labour force	schooling level - literacy level - professional skills - occupation (main) - other jobs - use of hired labour
6. Inputs	- manure - chemical fertilizer - agro-chemicals - improved seeds

7. Income	- cash income (potato) - potato income as a % of total agricultural income - income from livestock - proxy indicators of income status: farm machinery and equipment farm improvements
8. Credit	- sources of credit - credit use
9. Sanitation	- water standard/treatment - type of lavatory
10. Living condition	- housing - standard (type of floor; wall; roof) - number of rooms - consumer durables

It is accepted that income and agricultural income are extremely difficult to measure accurately, particularly in the case of small farmers such as those of Caruaru who hardly keep any sort of records (Casley and Kumar, 1987, p.132; Kutcher and Scandizzo, 1981). Therefore, no attempt will be made to measure those two variables directly. Having said that and given the relevance of the variable income within the context of this thesis, the need to find a suitable proxy or proxies for observing possible changes in income becomes paramount.

Taking into consideration secondary literature material from the region, information obtained from agricultural researchers working in the area, farmer's own opinions and last, but not least, the FAO's (1983; 1988) suggestion, four proxy indexes were created from the indicators available. They will be used to complement the analysis and try to detect changes in income or living standards. They are as follows: (a) consumer goods; (b) farm equipment/tools; (c) transport equipment; (d) housing. Each will be explained in detail in chapter 6.

As many specialists have emphasised, it was not sensible to ignore the time and financial constraints involved in this research. Thus, in most cases estimates given by farmers themselves had to be used (Casley and Lury, 1981). It would be complicated and time consuming, if at all feasible, to attempt to directly measure variables such as, for example, cultivated area of different crops, productivity of each crop, changes in income and so on.

Whenever possible, the information collected straight from the farmer was verified by comparing it with information obtained through direct observation as well as information collected during formal and informal interviews with local agricultural researchers, rural extensionists, social workers and academics. Reports from IPA also proved very useful in that respect. To sum up, the final result as far as data collection is concerned was satisfactory despite the methodological and practical limitations that have already been discussed.

3.7.3 Causality and the Survey Design

With regard to the question of surveys in social research it is worthwhile mentioning Marsh's comment on the limitations of this research method. She affirms that the frequent claims that surveys are incapable of producing any worthwhile information cannot be justified. According to her, many of the criticisms of surveys are not a product of an informed evaluation but rather a reaction against poorly designed, executed and analysed surveys. They do not constitute a fundamental criticism of the method itself (de

Vaus, 1986, p.220). However, the disadvantage of surveys with respect to their use in explanatory research such as the one carried out in the North-East of Brazil is not being denied here. Beyond association between variables, the criteria for inferring cause and effect relationship cannot be established as easily as in experiments (Singleton Jr. et al., 1988).

Survey designs are also called correlational designs to denote the tendency for such research to be able to reveal relationships between variables and to draw attention to their limited capacity in connection with the elucidation of causal processes. As has been previously said: 'Precisely because in survey research variables are not manipulated (and often are not capable of manipulation), the ability of the researcher to impute cause and effect is limited' (Bryman and Cramer, 1990, p.13).

In order to deepen the analysis and avoid misinterpreting the results of the retrospective farmer survey, the procedures involved in making causal inferences are also investigated within the context of a bivariate and multivariate analyses of relationships between variables or indicators. Despite the difficulties involved in determining causality, it is important that one perseveres in trying to find the causal links between variables. As Hage and Meeker stated: 'the success of social intervention policies depends on our knowing what the mechanisms are by which one variable changes another variable' (Hage and Meeker, 1988, p.1).

In practice, the process of drawing causal inferences from non-experimental data is usually one of slowly elaborating a relationship between two variables, testing that it contains no spurious component due to the operation of a prior variable, and testing to see if it is possible to pin down whether the cause influences the effect directly or through an intervening variable. The complexity of this process and its relativity are well illustrated by Marsh's comments: 'Ultimately, whether a cause is held to be direct or indirect is a statement about the state of scientific knowledge at the time; while one variable may provide an illuminating explanation for a puzzle at one point in time, it is likely to provoke further questions about how it operates at a later date' (Marsh, 1990, p.235).

To conclude, causality does not mean causalism and determinism in the sense that every event has a cause and all causes of a cause lead to the same event. Therefore, the events discussed in this thesis are probabilistic rather than deterministic. Moreover, it is assumed that an event may have more than one cause. As most social phenomena have a very complex set of causes, it would be unreasonable to look for single explanations when assessing the possible socio-economic impact of a technological change upon the small farmer of the Brazilian Agreste.

3.8 End Notes

(1) The main temporary crops, according to the area under cultivation in 1985, are maize, soya, beans, rice, sugar-cane, wheat and manioc respectively. In the same order of importance, the main permanent crops are coffee, arboreal cotton, cocoa, oranges and banana.

(2) A field-day is one of the methods of transferring technologies to farmers used by agricultural researchers. Researchers organize a whole day of talks and practical demonstrations about a specific technology they want farmers to adopt.

(3) São Paulo is the industrial centre of Brazil. A very large city with over ten million people a few thousand miles from Caruaru in the Southeast.

CHAPTER 4

Agricultural Research in the North-East: IPA's New Research Methodologies

4.1 Introduction

The agricultural sector of the North-East is critically backward according to most criteria. Land and labour productivity are low both in absolute and relative terms whereas the use of certified seeds, modern inputs, agricultural machinery and credit remains severely limited (Kutcher and Scandizzo, 1981). Technological innovation has been heavily biased towards export crops and has bypassed the small farmer to a large extent (Chapter 2). The consequent deterioration of the performance of staple food production had a perverse impact on levels of nutrition and income distribution of the rural population (Sampaio, 1987; Pacey and Payne, 1985).

Notwithstanding the problem of land reform, many studies have shown that the lack of technological change is a key factor hindering agricultural progress in the North-East (Kutcher and Scandizzo, 1981; CPATSA, 1985; Brandão, 1988). In spite of the relative failure of technological change to promote rural development, it is widely accepted that it is the basis for increasing agricultural productivity and promoting development. Actually, the notion of technical innovation as an engine of growth was recognized early in economic thinking, received considerable attention from all schools of thought and is an integral part of most models of agricultural development (Piñeiro and Trigo, 1983).

The core part of this chapter (4.2.2) comprises a description of the process of development of a new research methodology which was promoted by IPA-Caruaru (Agricultural and Livestock Research Company of Pernambuco). A unique methodology which would result in the generation of technologies or technological changes geared to small farmer needs and adapted to the local ecological, socio-economic and cultural environment of its users. Due to the local-specific nature of agriculture, IPA concluded, after a long learning process which gained a new impetus in 1980 with the adoption of FSR (4.2.1), that its quest for this new research methodology would be best served through local R&D activities in which producers (small farmers) themselves could effectively participate in the process of technology generation.

4.1.1 IPA: Introductory Remarks

IPA (Agricultural and Livestock Research Company of Pernambuco) was created in 1935 and is the state institution responsible for agricultural research in Pernambuco. IPA has its headquarters and main laboratory in Recife and is part of the 'Sistema Cooperativo de Pesquisa Agropecuária' or SCPA (Cooperative System of Agricultural Research) coordinated by EMBRAPA (Brazilian Agricultural and Livestock Research Company) (IPA, 1983a). In order to increase the objectivity and dynamism of its research activities, both at the problem identification and agro-ecological diagnosis level and in the generation and diffusion of technologies, IPA has three UEPs or 'Unidades de Execução de Pesquisa' (Research Execution Units) strategically located in the three physiographic zones of Pernambuco: Zona da Mata, Agreste and Sertão (IPA, 1985a).

The UEP of Caruaru (IPA-Caruaru) is the unit or research station responsible for research throughout the Agreste, an area of 19,132 square kilometres representing 19.5% of the total area of Pernambuco. Its headquarters is situated in an area of 150 hectares in the microregion called 'Vale do Ipojuca', approximately 15 kilometres from the town of Caruaru. Besides carrying out research at this location, IPA-Caruaru coordinates three 'Campos Experimentais' (experimental fields) in different agro-ecological regions of the Agreste totaling 3,254 hectares: Arcoverde (2,944 ha), São Bento do Una (255 ha) and Vitória do Santo Antão (55 ha) (IPA, 1985a).

For the purposes of this thesis, terms such as IPA and IPA-Caruaru are treated as synonymous. IPA-Caruaru was the only one of IPA's ten research stations which adopted and systematically developed the use of Farming System Research (FSR); in all the other experimental stations research activities continued to be carried out conventionally and inside the station.

What differentiated IPA-Caruaru from the other IPA stations which did not adopt a new research methodology during the 1980s was a group of younger and enthusiastic researchers - they became known as the 'FSR team'. As a member of this group explained: "We were a younger team [than the average researcher] and I was practically beginning my research career. We read a lot, studied and participated in internal seminars where we often presented our experiment results. There was competitiveness among our group and 'confrontation' between the traditional [CAR] and the FSR approach" (Lopes,G.M., 1996, personal communication).

Among this group of researchers, not more than ten agronomists, there was an environment favourable to scientific investigation and the development of new ideas. "We were innovators, daring. In the other IPA research stations, where the researchers were older and used to the traditional approach, that was not happening. They continued to do research without questioning [the limitations of the traditional approach], working individually or in very small groups" (Lopes,G.M., 1996, personal communication).

That team of young researchers from IPA-Caruaru was first introduced to FSR in 1979 by a senior researcher from IPA-Recife who had learnt about the new methodology, or FSR, at CATIE (Centro Agronomico Tropical de Investigaccion y Enseñansa), in Turrialba, Costa Rica. Then, during the 1980s, the group attended training courses on the subject at CPATSA, in Petrolina and organized weekly discussion meetings at their station in Caruaru to discuss the FSR theory and the on-farm experiments which they have started to implement. Their 'bible' at the time was the famous work by Hart, 'Agroecosistemas: Conceptos y Practicas' (1979).

IPA-Caruaru or IPA's main objectives are:

-to generate and adapt technologies that would meet the needs of small farmers and improve their standard of living;

-to promote the diffusion of these technologies with the collaboration of the rural extension services;

-to involve the small farmer in the research process;

-to provide technical assistance to agricultural producers (Antônio Felix da Costa, head of IPA-Caruaru, fieldwork 1990).

Until 1980, agricultural research methodologies largely ignored the specific problems of the semi-arid (tropics) region of the North-East related to its soil, climate and socio-economic characteristics (Queiroz, 1979). Consequently, these methodologies also ignored the small farmer who is present in large numbers and is the main producer of staple food in the region (Oliveira, 1987).

One of the main reasons behind this attitude, as explained by IPA researchers, is that the agricultural research approaches or methodologies adopted in this region of Brazil were virtually the same as those already used in temperate zones of the USA and Europe (IPA, fieldwork interviews, 1990; Chagas, 1986). As a result, most of the research effort was concerned with single crops, while intercropping is the predominant farming system used by the majority of farmers in the North-East. Hence, research in the North-East tended to concentrate on single crops such as cocoa and sugar-cane which are not grown in the semi-arid region. These crops were important for the export sector and are cultivated predominantly in large plantations and not by small farmers.

Moreover, researchers from IPA admitted that, because until 1980 they carried out their work without leaving their research station, they knew very little about the farming systems (1) which they would ultimately try to affect with their technologies. Until then, the insignificant number of technologies adopted by farmers in the semi-arid region of the North-East had been largely attributed to the 'backwardness' of the small farmer (Guimarães Filho and Tonneau, 1988). Gradually and perhaps reluctantly, however, IPA researchers began to accept the idea that one of the main causes behind the non-adoption of new technologies was the inappropriateness of the technologies which they were generating in their research stations. Or in other words, the technologies were neither suitable to the farmers' needs nor their physical environment (fieldwork interviews, 1989; 1990). Very appropriately, EMBRAPA's then president (Flores, 1991) explained that agricultural research in Brazil is still far from meeting the needs of farmers because, in a large number of cases, research priorities are determined by the researchers own personal interests or that of their superiors when it should be focusing on the requirements of producers and their demands.

Four interrelated causes are said to have determined or contributed to the failure of conventional agricultural research in generating technologies for the small farmer in the North-East:

- the researcher's traditional disregard for the problems which afflict the small farmers and their farming systems;
- the researcher's lack of knowledge of the small farmers' farming systems and practices;
- the lack of on-farm research or testing technologies on the farmers' field; and
- the lack of evaluation studies of the impact of technological change (Guimarães Filho and Tonneau, 1988).

In the specific case of IPA-Caruaru, there is a consensus among researchers that what could be called their 'conventional' research methodology has not worked. Although there is no systematic study which could account for that fact, it is accepted without reservation: "We simply verified during our visits to the field that our technologies were not being adopted and that they did not benefit the farmers. That is why in 1980 we changed our methodology and started using FSR" (IPA researcher, fieldwork 1990).

4.2 IPA and the New Research Methodologies

IPA's research work, since 1980 when they adopted Farming Systems Research (FSR) as a new methodology, can be divided into two distinct phases: 1980-1983 and 1984-1991 (IPA, 1991). The general objective remained the same throughout the period - to provide small farmers of the semi-arid Agreste with new technologies which they would be able and willing to adopt and which would improve their standard of living.

However, a remarkable methodological change is responsible for the differentiation of the period into two phases.

This methodological change, which occurred in 1984, will be carefully discussed in the present chapter because it has given rise to a new research methodology which is called here Participatory Technological Change or PTC (chapter 3). This unique methodology was responsible for the generation of an important technology - potato cropping - which seems to have benefited the small farmer of the Agreste in many different ways (chapter 6) and thus, broken with the region's historic record of failed attempts at promoting technological changes which would benefit small farmers (Dias, 1979).

4.2.1 1980-83: FSR in the Agreste

The new research methodology adopted by IPA in 1980 - FSR - distanced itself from the conventional approach which has been developed without the involvement of farmers, based on single crops or organized by discipline. One of the main assumptions behind the new methodology was that researchers needed to familiarize themselves with the farming systems of the small farmer and that this was a prerequisite for IPA to be able to generate technologies which would satisfy the needs of farmers and therefore, be adopted by them (IPA-Caruaru, 1990; IPA, 1991).

In order to get to know the farming systems of small producers it was decided that researchers would need to go out of the research station and test their technologies in the farmers' fields. This decision implied a major methodological change within IPA because, until 1979, researchers had always carried out all their research work inside the station.

"Before 1980 we were reprimanded if we were not at the station. Afterwards, we were encouraged, almost forced in the very beginning, to leave the station", explained one of IPA's researchers (Jair Teixeira, 1990).

IPA's new research methodology was largely influenced by the type of research and methodological changes that were being promoted at CPATSA (Agricultural and Livestock Research Centre for the Semi-Arid Tropics) in Petrolina, Pernambuco (IPA, 1985;1988). These changes had been taking place because, since the mid-1970s, an increasing number of agricultural researchers had reached the conclusion that the research effort in the North-East had not been able to offer the small farmer technologies that would meet their needs (Vallée et al., 1986; Queiroz, 1979; 1989-90). Furthermore, it was beginning to be accepted that a new research methodology was needed to deal with the problems faced by the small farmer who was still living in poverty and whose agricultural output and productivity were very low. FSR is the methodology in question and the one which was encouraged or promoted by CPATSA (Tonneau, Lima and Poudevigne, 1990; Queiroz, Lima, Lopes and Vallée, 1986; Silva, 1985).

CPATSA is the main public institution responsible for agricultural research in the North-East. Besides formulating new research policies, CPATSA acts as a forum of debate for the several state research institutes of the North-East such as IPA in Pernambuco. "CPATSA was created in 1975 with the objective of generating new technologies to improve the quality of life of the peasant farmers of the Brazilian semi-arid tropics (SAT)" (Lima et al. 1986, p.333).

4.2.1.1 Going out of the research station

From the type of information obtained during fieldwork interviews in 1989 and 1990, it seems clear that by the late 1970s IPA researchers reached the conclusion that they had not succeeded in providing farmers with new technologies and did not know the reality of the small farmer whom they were trying to help. It was then decided that they would need to go out of the research station not only to collect data about the environment in which small farmers lived but, more importantly, to get to know their farming systems and to test their technologies in the farmer's fields through on-farm trials.

However, not everybody approved and adopted the new FSR methodology. Many researchers believed that to work outside the research station was not a researcher's job and looked down on their colleagues who did so. To involve small farmers in the research process was inconceivable and even insulting to many researchers. In their view, to get involved with a farmer would be something that a rural extensionist and not a researcher would do. Hence, the FSR team at IPA-Caruaru research station had to put up not only with jokes but also with disparaging comments that were often made behind their backs (fieldwork interviews, 1990).

Despite these difficulties, a group of IPA researchers decided to go ahead with a FSR research project concerning the small farmers of the Agreste and Sertão region of Pernambuco. The Agreste region of Pernambuco is divided into three subregions: Agreste Setentrional, the northern part of the region; Agreste Central, in the middle; and Agreste Meridional, the southern part of the region. Between 1980 and 1983, IPA researchers set up a large number of on-farm trials to evaluate the performance of new technologies. For that purpose, IPA selected three farms from each of the subregions of the Agreste and a few others in the Sertão. Before the introduction of the on-farm trials IPA researchers conducted qualitative field interviews with farmers in order to define treatments according to current farming systems and their main production constraints (Lopes, 1990).

The on-farm trials were composed of treatments representing alternative crop systems: T= traditional crop system; T1= T plus improved varieties and selected seeds; T2= T1 plus different plant population; T3= T2 plus pest control; T4= T3 plus fertilizer (organic and chemical). T and T1 were carried out by farmers whereas T2, T3 and T4 were the full responsibility of the researchers. The plots were 1000 square metres, much bigger than those used inside the research station (Lopes, 1990). The treatments were designed to incorporate different planting systems for maize intercropped with beans and manioc intercropped with beans (IPA, 1985).

One of the objectives of this FSR project was to evaluate and compare the results generated by the researcher's technology - produced inside the research station but tested on the farmer's field - with the results obtained via the traditional methods of the small farmers. Other objectives were to promote a 30 per cent increase in farmers' incomes and to obtain their views on the appropriateness of the technologies being tested (Lopes, 1990). The technologies were those available at the research station and farmers did not participate in their generation. By the end of 1983, IPA realized that the objectives of their FSR project had not been fulfilled. Nevertheless, the experience produced important lessons according to IPA:

- the technologies that performed well under experimental conditions (inside the research station) were as fragile in relation to weather conditions as the farmer's technologies when applied on the farm. The researchers would lose their crops when farmers lost theirs and succeed when farmers did so;

- the lack of farmer participation resulted in serious communication problems between researchers and farmers. These problems jeopardized the researchers' understanding of the farming systems that they were trying to study;

- some of the farms were too far away from the research station (over 100km), making the on-farm trials difficult to manage and very expensive to conduct; and

- the planting season was very short because of the unstable rainfall pattern and it was often very difficult to set up all the experiments on time.

To conclude, IPA was overwhelmed with information that they could not process, they had diluted their meager financial resources on a vast number of on-farm trials and overstretched the limited number of available scientists (IPA, 1985). IPA did not have enough people and resources to properly cover the vast geographical area of the Agreste and Sertão which they were trying to investigate. IPA researchers could not deal with the large amount of information they had managed to collect during this first phase of the FSR project (1980-83). Their researchers did not have the time nor the expertise to process and analyze the bulk of that information. Moreover, "the results were so diverse and confusing that the group of researchers decided to abandon this strategy and concentrate all efforts on only one area of the Agreste that theoretically represented the region" (Lopes, 1990, p.23).

4.2.1.2 Farmer Participation

During the initial phase of IPA's new research work (1980-83), IPA researchers were not aware that farmers were largely being excluded from the research process. Setting up on-farm trials was mistakenly seen as working with the farmers or involving them in the research process. In fact, researchers were not clear about the relevance of involving the farmer in the research process and, thus, farmer participation was not a real concern (IPA-Caruaru, 1989). It seems that during this phase, IPA researchers were not well acquainted with the theory behind FSR. Besides, they were lacking in experience. They had never worked with small farmers or carried out experiments outside their research station. Their scientific training in agronomy coupled with their urban background made them ill-prepared for the 'new' job. Researchers admitted that they often did not know how to explain their ideas and intentions to farmers and appeared too pedantic and economical in their conversations (fieldwork interviews and direct observation, 1990). As little explanation was given to farmers about the on-farm trials, farmers often perceived those experiments as an attempt by researchers to show that they knew how to do things better than farmers. Researchers did not realize, at the time, that many farmers felt that they were competing with them and therefore, resented the researcher's attitude. As a consequence, most farmers did not think they would benefit from those trials (fieldwork, 1990).

IPA researchers assumed full responsibility for everything involving the on-farm trials: they brought the seeds, the fertilizers, the agro-chemicals, the farming equipment and even the labour force to set up the trials and do all the necessary follow-up work including the harvesting. The farmers themselves were not supposed to interfere with the experiment. All they needed to do was to provide the researchers with a plot of land. "We wanted to test our technologies against that of the farmers", explained different IPA researchers during the 1990 fieldwork.

As a result of this disregard for the farmer IPA researchers learned two or three years later, to their surprise, that they had been given the worst plots of land to conduct their on-farm trials and that farmers were inclined to ignore them. Farmers' distrust of researchers was fairly widespread during 1980-83. "Many farmers were very suspicious and did not accept it. This business of the government carrying out experiments on our property. What they really want is to take away our land. It can only be a communist idea" (farmer, in Noya, 1990, p.75). Several other farmers admitted that they thought IPA researchers were involved with a land reform programme and did not allow trials on their fields because they feared losing their land (fieldwork, 1990). Nothing was further from the truth but, as long as researchers were not paying attention to what was happening around them, these ideas were left untouched. It is clear that, during 1980 and 1983, there was a major failure in communication between researchers and farmers; farmer participation in the research process was negligible.

4.2.2 1984 to the Present: Developing Participatory Technological Change (PTC)

IPA drastically modified its research methodology in 1984 and, as a result, abandoned all their on-farm trials spread over many different parts of the Agreste and Sertão of Pernambuco. IPA decided, instead, to concentrate its research effort in a specific region of the Agreste known as Xicuru (IPA, 1985). Besides the selection of this new region where research would be conducted, the new methodology proposed the elaboration of local agro-ecological and socio-economic diagnoses, the implementation and development of SIPs (Integrated Production System), and the restricted diffusion of technologies within a pilot region (IPA, 1991).

From 1980 until the end of 1983, the focus of IPA's research work had been on testing technologies outside the research station but not on getting to know the small farmer or the functioning of his farming systems as a whole. IPA appears to have mistakenly assumed that it would be possible to become familiar with the farming systems of the small producer without trying to get to know the farmer and how he managed his farming systems. All that changed in 1984.

The 1984 methodological change may also be seen as the origin of what has been called in this thesis PTC or Participatory Technological Change (chapter 3). As defined earlier, PTC is a new agricultural research methodology developed by IPA-Caruaru which evolved from FSR. Although PTC seems to be developing in the direction of FPR, it is still far away from it. Farmers are definitely not equal partners in the research process as suggested, among other things, by FPR. Nevertheless, PTC appears capable of generating technologies which are likely to benefit the small farmer whereas the previous methodologies have not worked. One of these technologies is the focus of this case study - potato cropping.

After analysing the way IPA conducted its agricultural research from 1984, it is possible to say that PTC evolved mainly through practical experiences. It was the result of an interaction of researchers with farmers and rural extensionists which has taken a few years to develop a more recognizable form or shape. Within this context, PTC was not the result of a well defined, theoretical proposal which was carried out by IPA, but largely the result of a learning process based on the principles of FSR and at least four main initiatives. These main initiatives were:

- concentrating the research effort in one region;
- researchers working close together with extensionists and farmers;

- development of six SIPs; and
- potato research. Each of these initiatives is discussed below.

4.2.2.1 Concentrating the research effort in one region: Xicuru

Two criteria guided the selection of the new geographical area where IPA decided to concentrate its research effort. Firstly, it needed to be representative of the natural and socio-economic environment of the Agreste region. Secondly, it should be as near as possible to IPA's research station in Caruaru (Lopes, 1990). The area chosen is known to researchers as Xicuru and it is located in the 4th district of the municipality of Caruaru in Pernambuco. Xicuru comprises 13 villages and is only 25km away from IPA's research station and 15km from Caruaru (pop.250,000; 130km west of Recife)(Banco do Brasil, 1989).

This pragmatic step taken by IPA - to concentrate the research effort in Xicuru - is very important for the development of PTC because it allows researchers and extensionists to get actively involved with farmers and their properties, even on a daily basis if that is required. For an institution working on a tight budget such as IPA, it became apparent that it would not be possible to continue with the approach adopted during 1980-83 when IPA introduced experiments in a vast area of the Agreste and Sertão. In these circumstances, the large size of the area to be covered and the resulting petrol bill are significant factors in determining whether an experiment can be followed up or not. The researcher's time is also in short supply and therefore, must be optimized. It cannot be wasted in countless and long journeys unless they are strictly necessary. Traveling along poorly maintained roads and dirt tracks is not only time consuming, tiring and dangerous but it also reduces the life span of vehicles which are another important and scarce asset in any agricultural research station of the North-East.

In early 1984, IPA used the primary information available (census data, aerial photographs, maps) to start an agro-ecological classification of the Xicuru area. Researchers visited the area frequently to interview farmers and local community leaders. They also set up a number of on-farm trials in fourteen different properties which not only proved useful in helping them to understand the farming systems of the local small farmer but, perhaps more importantly, facilitated their approximation to the small farmers and the Xicuru community. As a result of these studies, it was decided that the area known as Xicuru could be divided into two sub-areas or two different farming systems according to the use of soil and pattern of production: FS1 and FS2 (IPA, 1985).

Farming System 1 (FS1) includes the villages of Lagoa de Pedra, Serrote do Boi, Japecanga, Firmeza, and Marimbondo. The main crops cultivated in this sub-area are manioc both as a monocrop or intercropped with beans; maize intercropped with beans and potato as a monocrop. The livestock system (2) consists of cattle, elephant grass, spineless cactus and native pasture. Farming System 2 (FS2) includes the villages of Lajedo do Cedro, Macaco, Cacimba Cercada, Cacimbinha, Xicuru, Lajedo Preto, Jiquiri and Salgadinho. The main difference between the two sub-areas is that manioc and potato are absent from FS2. The type of soil in FS2 is not appropriate for these two crops (Lopes,1990).

Later in 1984, to further their knowledge of the small farmers of Xicuru and complement the agro-ecological and socio-economic diagnosis of the region, IPA carried out a structured survey in the region. A total of 137 smallholders were interviewed, 80 from the FS1 and 57 from FS2. This survey provided useful quantitative information about the various farm components, their interactions and performance. It also allowed IPA researchers to select a group of four farmers or smallholdings as representatives of FS1 and FS2. These four properties, two from each sub-area, together with another two that were selected later became known as SIP (Sistema Integrado de Produção) or Integrated Production System (IPA, 1985). Before discussing the type of research that IPA carried out in the SIPs, it is necessary to examine the new kind of relationship which IPA was trying to promote among researchers, farmers and rural extensionists.

4.2.2.2 Researchers, farmers and extensionists: a new co-operation

By the end of 1983, IPA researchers had realized that it would not be possible to help the small farmer of the semi-arid region without learning about their farming systems in depth and without understanding the farmer's logic and behaviour. It was decided then that EMATER (Technical Assistance and Rural Extension Company), the state institution responsible for rural extension services in the region, would be invited to work together with IPA and play an active role in fostering a new cooperation, based on mutual respect, between these three important actors: researchers, extensionists and farmers. Moreover, researchers also concluded that they needed to involve the farmer in the research process if they were to succeed in their quest to develop a new research methodology which would allow the generation of new and appropriate technologies.

The 1984 methodological change mentioned before was based on two hypotheses which reflect these ideas:

(1) a concentrated effort by researchers in a specific geographical area would allow, through working closely with farmers, a better understanding of their farming systems; and

(2) some technologies tested and assessed on the farmers' fields could, through the frequent presence of the researchers, be more easily adopted into the farming systems of farmers within the pilot area (IPA, 1991).

From the hypotheses above it is possible to argue that IPA was committed to increasing the level of farmer participation in the research process in order to better understand the farming systems of the Xicuru small farmer. IPA acknowledged that, without a close working relationship between farmers and researchers, it would not be possible to fully understand the farming reality of the small farmer. Without this knowledge, IPA was finding it very difficult to produce the type of technology that would be adopted by the small farmers.

Researchers admitted during fieldwork interviews (1989; 1990) that the difficulties involved in trying to understand the complexity of the small producers' farming systems and the frustration of not being able to fulfil their objectives during the first phase of the FSR project (1980-83) made them realize that working together with the small farmer also meant working together with rural extensionists. That is a lesson that IPA researchers have judged very important although it is not specifically mentioned in their annual reports. The complexity of the small cultivator farming system has "its roots in the number of separate and composite activities undertaken; the crucial temporal interdependencies among activities; the number of effective constraints impinging on these activities; the poor records and information base for decision making; the number of attributes of farm performance that enter the farm family's utility; and last but by no means least, the inevitable lack of certainty in nearly all facets of production, marketing and life" (Mellor quoted in Valdés et al., 1979, p.11).

Researchers (IPA) and extensionists (EMATER)

Having concluded that the role of the extensionist in the research process was much more important than had been anticipated, IPA made an audacious move and in 1983 invited an extensionist from EMATER to join their FSR team based at IPA's research station in Caruaru. This decision reflects IPA's openness and realization that it would be necessary to work together with local extensionists and small farmers during all phases of the research process: diagnosis, technology generation, assessment and diffusion.

IPA's proposal to have an extensionist working with its FSR team was not only audacious but unique, especially within the research context of the North-East, where it was unprecedented. Traditionally, the two institutions would not work together and, even at the level of technology diffusion when the extensionist would be responsible for transferring the 'researcher's technology' to the farmer, it would be unusual for researchers to work together with extensionists (Chagas, 1986). Moreover, as the president of EMBRAPA (Flores, 1991) noted, extensionists in general were still ignoring the needs of farmers, following orders from their superiors which were divorced from the local reality and spending most of their time dealing with bureaucratic matters.

The four year experience (1980-83) of carrying out research outside its experimental station indicated that the cooperation between IPA and EMATER would be very useful during the second phase (1984-91) in several areas of IPA's new research work such as the selection of subregions for research; diagnosis or problem identification; selection of farmers for on-farm trials and SIPs; planning, implementation and follow-up of trials and SIPs; assessment and diffusion of technologies. The reasons IPA decided to work together with extensionists were very practical and may be summed up as follows:

- EMATER had an office in Caruaru. Its budget and infrastructure of technicians, equipment and cars when combined with IPA's could allow researchers to go further with their plans;

- extensionists had a certain knowledge of the Xicuru region where IPA decided to concentrate the research effort. Besides, they had already assisted approximately 20 per cent of farmers in that region (Lopes, 1990, p.51), had a limited understanding of their problems and maintained a friendly relationship with many of them, including local community leaders. IPA hardly knew the region and or people of Xicuru;

- extensionists were much more familiar with the language used by the small farmer than researchers and they knew many of the specific cultural traits that determined or influenced a farmer's behaviour and/or guided farming decisions; and

- extensionists had a long-standing experience with technology diffusion while researchers were just starting to become involved in that phase of the research process (SUDENE, 1987).

In the face of the large number of unresolved problems and the magnitude of the task of improving the standard of living of the small farmer in the Brazilian semi-arid region, the effort and merit of bringing researchers and extensionists together might easily be underestimated or go unnoticed. In this context, the comment of a director of EMBRAPA (Bezerra, 1988) sheds some light on the difficulties involved in the process of trying to bring agricultural researchers and rural extensionists together. According to him, there are a few general problems hindering this process which apply to the situation IPA was experiencing in Pernambuco. Firstly, the insufficient understanding of the importance of articulating research-extension services from both sides. Secondly, the qualitative and quantitative deficiencies related to the technical personnel of both institutions. Thirdly, the difficulties of coordinating, at the operational level, the budget and the planning of the projects of these two institutions which are often undertaken at different moments. Moreover, the frequent delays in the release of funds to these institutions can seriously compromise attempts at working together.

The farmer association (APROBACA)

Probably the best example that illustrates IPA's commitment to establishing dialogue with the small farmers, involve them in the research process and also to work together with rural extensionists, was the creation of a farmer association in Xicuru and the related construction of a refrigerated warehouse for potato seeds. APROBACA (Association of Potato Growers of Caruaru) was created in 1984 and received a great deal of support from IPA and EMATER (IPA, 1991). Due to its relevance in the context of this thesis, these two issues - the formation of APROBACA and the construction of the refrigerated warehouse - will be explained in more detail in the next chapter. The discussion of these issues is introduced below to illustrate the new form of cooperation between researchers, extensionists and farmers which began in 1984.

Helping the small farmers of Xicuru to form APROBACA was a very perceptive move by IPA researchers who realized that it would be considerably easier to work with farmers who were organized instead of trying to reach them individually, as they had done between 1980-83. From the experience gained during 1980-83, IPA researchers knew that it would be much easier to get to know the small farmers of Xicuru and explain to them their new objectives, which originated from the methodological change of 1984, if farmers had an association and thus, a place where they could come together to discuss their problems and needs. A place also where farmers could sit down with researchers and extensionists and start discussing a plan to improve farming in the Xicuru region (fieldwork, 1990). This is where the idea of promoting and developing the potato crop originated, an idea which proved to be central to the development of PTC.

The creation of APROBACA was supported by IPA and EMATER but was initiated by the farmers themselves. Very importantly, it is strongly related to the potato crop. Potatoes are grown in the Xicuru region as a cash crop and, although on a small scale, it is considered an important source of income by most of the small farmers. During their visits to Xicuru in 1984, IPA researchers were surprised to find a small group of farmers growing potatoes - a crop that in theory was not suited to the local climate and not traditionally grown in the region (Lopes, 1988). Almost as soon as they started to interact more closely with the Xicuru farmers, IPA researchers faced a number of requests that caught them by surprise too. Farmers asked IPA to help them to improve the crop and complained about both the high price of potato seeds and the lack of storage facilities for the seeds. They explained to researchers that they wanted to have their own refrigerated storehouse to keep their potato seeds. IPA researchers, although not familiar with the potato crop, soon realized its potential and agreed to assist farmers in developing the crop. Without good quality seeds and proper storage facilities, IPA concluded that it would be very difficult to overcome the problems farmers were facing and to develop that crop into something that could significantly improve the standard of living of the small farmer (fieldwork interviews, 1989; 1990). This was an ideal situation for IPA to start putting into action their ideas regarding the new research methodology.

The setting up of APROBACA demonstrated that researchers and extensionists gave considerable credence to farmer's requests and created an atmosphere of trust and mutual respect which would be essential for the progress of a participatory research approach in the Agreste. Moreover, a farmer association was needed if farmers were to receive assistance from certain government programmes - mainly financial assistance. The money from these programmes could only be channeled to farmers through a registered association (Lopes,G.M., IPA-Caruaru researcher, personal communication, 1995). EMATER helped the farmers with the drawing up of the association's statutes and its registration. Thus, with backing from IPA and the assistance of EMATER, the farmer's association managed to secure funds for the construction of a refrigerated warehouse for storing potato seeds in Xicuru. In exchange for the funds that came from a Government programme designed to assist small farmers (PAPP-PRORURAL), APROBACA provided the labour force for its construction. The refrigerated warehouse was inaugurated in 1986 and proved to be a major turning point for small farmers not only in Xicuru but also from surrounding areas of the Agreste of Pernambuco (fieldwork, 1990; 1991). This point will be further explained in the next chapter together with the role of the Xicuru farmer and APROBACA in IPA's new research methodology.

4.2.2.3 Integrated Production System (SIP)

One of the main ideas behind the 1984 methodological change was the formation of a nucleus or pilot area where the efforts of researchers, rural extensionists and small farmers could be combined in order to provide small farmers with the technologies that they needed to improve their standard of living (IPA, 1985; 1991). This nucleus would consist of six properties belonging to small farmers of the Xicuru region. Once this new research initiative had been consolidated, these properties would be able to fulfil their role as centres from which technologies would be diffused to other small farmers in the region. These six properties were labelled SIP or Integrated Production System (Sistema Integrado de Produção).

As the name SIP suggests, the different farming systems of each of these smallholdings would be studied in relation to the property as a whole (Doraswamy, Vallée and Porto, 1984). It needs to be stressed that during the first phase of the FSR project (1980-83), researchers concentrated on getting to know the farming systems of the small farmer of the semi-arid by merely comparing their own technologies (developed inside the research station) with those of the farmers through a large number of on-farm trials. In practice, despite the systemic rhetoric, those on-farm trials ended up by marginalizing the farmers from the research process and testing technologies in isolation - the interactions between the different farming systems were disregarded by researchers. In the words of an IPA researcher: "During that time, we were not really studying the property as a whole. We started studying maize intercropped with beans and then cassava intercropped with beans. We were trying to improve our knowledge of local agriculture" (Noya, 1990, p.94).

Thus, the SIP represented a fundamental change in the methodology used by IPA researchers until then. For the first time, IPA researchers would be considering a farmer's property as a whole unit and involving the small farmer in the research process. Furthermore, the level of technological knowledge of a farmer and his family or ITK (chapter 1) would also be taken into account.

The SIP was first designed and then tested in the North-East by CPATSA in the Sertão, during the early 1980s in Ouricuri (CPATSA, 1985; Doraswamy, Porto and Cerqueira 1985). IPA pioneered the use of this research method in the Agreste in 1985 at Xicuru. In retrospect, it is possible to say that the type of research work which was carried out within the SIPs was essential in order to foster close and productive cooperation among researchers, farmers and extensionists. This new initiative - the SIPs - promoted by IPA consisted of a decisive contribution to the development of the new research methodology named PTC.

Below follows a brief description of the selection process for the SIPs and the type of daily work involved in implementing this type of research method.

Choosing the SIPs

It is important to be aware of the fact that a SIP is not chosen at random. It is a property representative of the Agreste region according to the agro-ecological and socio-economic studies carried out by IPA, particularly in the Xicuru region. Besides, a SIP is selected with the participation of the local community. During 1984, IPA selected four SIPs: two farms from each of Xicuru's basic sub-areas or farming systems (FS1 and FS2). Later, IPA chose two more farms, one from FS1 and one from FS2, to complete the nucleus or pilot area already mentioned (IPA, 1991).

It should not come as a surprise that while choosing these six SIPs IPA researchers tried to select those farmers who were more articulate, willing and committed to working together with them within the new approach. Among other things, the SIP farmer would have to keep daily records of a number of his family's activities together with a detailed record of all cash receipts and expenditures (IPA, 1985; Doraswamy, Vallée and Porto, 1984). Certainly, not every farmer was willing to do all that and, therefore, it seems sensible that IPA tried to avoid certain types of farmers, especially those who are more suspicious in nature and thus, reluctant to provide information to an 'outsider'. Other small farmers, who could not read or write or do simple arithmetic, were not in a favourable position to be selected. It is also understandable that IPA would choose properties which were easy to reach by car even in the wet season when the dirt roads in the region become very difficult to use. It was also reasonable from IPA's point of view not to select a SIP from among the poorest farmers because they would be more constrained and afraid, due to survival reasons, of modifying their farming systems. In that context, it made sense to start the SIP work with those small farmers who were apparently slightly better off than the average because they faced fewer risks and tended to be more willing to introduce a few changes in their farming systems.

Taking this last point into consideration, it is possible to understand why several farmers complained during the fieldwork survey (1990) that IPA only cared and helped the 'rich farmer'. When IPA started working with the first three SIPs in 1985, their researchers lacked the communication skills needed to establish a proper dialogue with the SIP farmers and the Xicuru community. They were not very successful at explaining to the community what they intended to do in the SIP properties and the rumours that they favoured the 'rich' farmers began to spread, hindering the progress of their work. It was only gradually over the years that IPA researchers learnt, mainly through their mistakes, how to communicate and work with the small farmer. As time passed, it became clearer to a greater number of small farmers that IPA did not intend to favour any specific group of Xicuru farmers. By working with the farmer's association (APROBACA) and the local rural extensionists, IPA slowly managed to reach an increasingly large number of farmers.

SIP: the daily work

IPA selected six SIPs in the Xicuru region and started working in three of them in 1985, in a fourth in 1986 and in the last two in 1987 (IPA, 1991). The research work in each SIP would last at least five years. Within the SIP context, IPA's new objectives were to characterize, follow up and then introduce technological changes both at the agricultural and livestock level of the so-called SIP. Afterwards, if a technology were approved and adopted by a SIP farmer, that SIP would be included in IPA's strategy of 'restricted technology diffusion'. 'Restricted' in the sense that it would apply first to the small farmers of Xicuru and then, if possible, to other Agreste areas with which IPA and EMATER were already familiar.

During the initial phase of the SIP, researchers and extensionists worked closely with the small farmer and his family in order to find out in depth how their different farming systems performed on their own and in relation to the property as a whole. A survey of the natural resources of each SIP property was carried out during this phase. Very significantly, and in accordance with the new methodology proposed in 1984, researchers had planned not to introduce any major technological change in the SIPs during 1985, their first year. The reason behind this decision was fairly simple: researchers first wanted to observe and learn about the farmers' different activities and farming systems. Thus, in an unprecedented move that needs to be stressed, researchers assisted by the local extensionists visited the SIPs practically on a daily basis to get to know the farmers' living and working routine.

Besides their frequent visits to the SIPs when they would collect many different types of data, researchers also asked the SIP farmers to record on paper all their money transactions (IPA, 1985). A general objective behind this detailed investigation is to prepare IPA to be in the position of promoting biological (livestock or crop output and productivity) as well as socio-economic improvements in a farmer's property. Very sensibly, researchers hoped to avoid repeating the mistakes of the past when they would come with all the answers and impose them on the small farmers even before knowing what they needed and wanted. Nevertheless, IPA seems not to have fully appreciated that the type and volume of information which they requested could be interpreted by the SIP farmers as an invasion of their privacy and/or something which amounted to a huge change in a farmer's habits and consequently, something which could not be achieved as quickly as anticipated by researchers.

During what could be called a second phase of this investigation, the main problems and production constraints of each SIP were identified and intervention plans drawn up, always with the farmer's participation. Researchers admitted, however, that the level of farmer involvement would often be inversely related to the degree of complexity of the problem in question. After this second phase researchers, with the collaboration of farmers and extensionists, started introducing new technologies and assessing their performance and impact. Often these technologies would need to be adapted and readapted until they could be definitely adopted by the farmer. Researchers were open to suggestions and expected the farmers to actively contribute during this process (IPA, 1991). This is a very important point because it shows that IPA was committed to the new methodology and willing not to impose their own solutions on farmers as they previously used to. This is a point worth emphasizing because it meant not only a complete break with the conventional research approach but a major step forward from the on-farm type of research that IPA started in 1980.

The technologies approved by the SIP farmers would then be ready to be transferred to other small farmers in the region. Every single SIP was treated as a different experiment where IPA intended to gradually introduce technological changes which, if successful, would be suggested at a later stage to the other small farmers in the Xicuru region. In this case, the SIP was used as a type of demonstration unit where farmers could see for themselves and discuss with his fellow farmer the pros and cons of the new technology. Researchers and extensionists actively participated in this process of technology diffusion. They were responsible for organizing a number of different events, such as field trips to the SIPs, in order to promote the technological changes already approved by the farmers. During these trips, groups of farmers would be taken to the SIPs to verify for themselves what was happening on their fellow farmers' properties. Those farmers interested in adopting the new technology would then receive special training to learn how to proceed with the introduction of that technology in their farming systems.

Problems with farmer participation

IPA concluded that the main difficulty found by researchers, particularly at the beginning of the SIP work, was related to farmer participation in the research process (IPA, 1991). Researchers often blamed farmers and labelled them "suspicious and not reliable people" (IPA, 1987;1988) when describing the fact that it was not possible for them to obtain all the information they wanted, especially during the first two years of the implementation of the SIPs. "In some cases it took us almost two years to gain the trust of certain families", whined IPA researchers involved with the SIP project (fieldwork, 1990). It would probably have been more useful if, instead of blaming farmers, researchers had paid more attention to the local circumstances of small farmers, for at least two reasons. Firstly, farmers have a very busy, hard and long day and may not find the time and energy to record all the information required by IPA. Secondly, none of the 80 farmers from Xicuru surveyed in 1990 kept any type of financial record of their activities nor had they ever done that before. Xicuru farmers do not keep records of how much money they spend or earn from whatever source of income they may have. These survey results also confirmed the accepted idea that small farmers in general do not have any type of written information about what they do or how much time they spend on their different farming activities. Nevertheless, that was what IPA requested from the SIP farmers and their families from the very start of their work. It seems, therefore, unreasonable to expect that these farmers could have changed so dramatically and in such a short period in order to provide IPA with the required information. It is likely that IPA researchers would have been more successful if they had spent more time explaining to farmers why all that information needed to be collected and tried to be more active and helpful in the gathering of that data.

The following examples or quotes may help us understand the type of problems faced by researchers during the SIP work:

- "Sometimes we wanted to say something but we could not do it in a clear way" (IPA-Caruaru researcher, fieldwork 1990);

- "We talked a lot with the farmers on their properties but we were five researchers besides the agricultural technicians that were helping us. Each one of us has a different way of communicating and therefore it was very difficult for the farmer. Today, we understand each other a lot better. We understand the meaning of many words and expressions used by farmers that we did not know before. Thus, today, each one of us says things their own way and everybody understands" (IPA researcher after four years working with SIPs, Noya, 1990, p.76);

- "In the beginning we found it very strange. There are lots of words that we still cannot repeat but we can understand something now" (SIP farmer, fieldwork 1990);

- "There are many things that the researchers call by a certain name and we say it differently. For instance, there are many plants that they know by a different name. Many times we do not understand each other well" (Caruaru farmer, fieldwork 1990). It is important to note that farmers are very knowledgeable about their farming environment and have a vocabulary that although different from the researchers' is rich and precise.

The four examples above point to IPA's lack of experience in working with farmers. It is apparent that researchers lacked the communications skills to make themselves well understood and perhaps, more importantly, they show that researchers did not have a coherent strategy or a 'common voice' to explain to farmers what they wanted to achieve and how. The fact, as the second example well illustrates, that there were five different researchers working within each SIP can neither justify the inability of IPA researchers to communicate with the small farmers nor their actions which resulted in farmers receiving conflicting and therefore, confusing information or technical advice.

IPA's FSR team - five agronomists and a rural extensionist who was also an agronomist - received no specific training to help them in their difficult new task of working with farmers. They were aware that their scientific and urban background was not very helpful but felt they could do nothing about it. Besides, they thought that they needed to have professionals such as agricultural economists, rural sociologists and social workers on their team in order to fully put into practice the new research methodology that they were trying to develop (IPA, 1983). During the 1990 fieldwork, members of the FSR team expressed regret that their request to include professionals from other disciplines in their team had been denied.

During that same fieldwork it was confirmed that, despite the efforts of the research team and the experience gained in more than five years of working with the Xicuru farmers, these farmers were still finding it difficult to understand how they should handle certain technological innovations and farming problems - mainly because researchers were still using a very 'agronomic' (scientific) language to express their ideas or because they persisted in being too economical in their explanations. It seems that researchers were either unaware of their lack of communication skills or, perhaps, a little tired of working so intensely with farmers, and therefore, less inclined or willing to consider new ways of establishing a dialogue with the SIP farmers.

It is worth remembering that working outside the research station in the semi-arid conditions of the North-East is, if not more demanding and stressful, at least more inconvenient and uncomfortable than working inside the research station. The very high temperatures, the journeys back and forth along dangerous and often very dusty roads, the lack of potable water, the evening meetings at the farmer's association are all factors that, when added together, may discourage a researcher from giving farmers the time and attention they need. Besides, researchers were still having to adjust to their new working environment deprived of the comfort of their air-conditioned offices, canteen and infra-structure. Salaries, according to IPA researchers, continued to be fairly low.

The issue of farmer participation is more complex than the four examples and comments above indicate and therefore, needs to be further explored. The difficulties of involving the SIP and Xicuru farmers in the research process were also the result of a deliberate action taken by IPA and a product of other problems such as internal rivalry, paternalism and elitism, which will be discussed below.

IPA's poor communication with farmers was not merely a result of lack of skills or of a multidisciplinary research team: it was partly intentional and a product of what appears to be a misconceived idea. IPA researchers commented that at the beginning of the SIP work they were afraid that, if they explained in detail to the community (Xicuru farmers other than the SIP farmers) what they were doing and intended to do in the SIPs, everybody would demand the same treatment. Thus researchers, to avoid confrontation with the farmers, opted to say very little instead of explaining why only a few selected properties would benefit from certain improvements in the short term. IPA's decision not to let farmers know fully what was happening meant that even the SIP farmers did not totally comprehend what was being proposed by IPA, and therefore, could not cooperate and participate as expected. As the SIP project matured over time, this type of misunderstanding was gradually overcome.

Although IPA researchers were aware of at least some of the problems that CPATSA researchers had faced in the early 1980s when they were introducing FSR in the Sertão and working with SIPs in the Ouricuri region, they appear to have repeated some of the mistakes that they were trying to avoid. A CPATSA director and researcher (fieldwork interview, 1991) explained that the group of CPATSA researchers working in the SIP project in the early 1980s was in a hurry to produce and show results. They were 'competing' with another group of CPATSA researchers which was not involved with FSR and had already produced a number of studies and reports. Mainly because of that reason - internal rivalry - the SIP group decided to give for free a 'new' infrastructure to the small farmers in order to facilitate the adoption of new technologies and achieve some results. In the end, CPATSA researchers marginalized the SIP farmers and created a situation which the farmers could not sustain in the long run.

IPA researchers, in hindsight, seem to have concluded that they had made a similar mistake at the beginning of the SIP project. The infrastructural improvements such as fences, rural cisterns and small water reservoirs (*barreiros*) that IPA researchers introduced in the SIPs - entirely free-of-charge - were relatively less expensive than those in which CPATSA had invested in their SIPs. However, these improvements raised false expectations among SIP farmers and had a generally negative effect, according to researchers. It is IPA's view that farmers accepted those improvements even when they saw no value in what was being proposed. Farmers thought it would be better to please the researchers by accepting what they were being offered rather than upsetting them by saying no and risking not being offered anything else in future.

It seems that IPA's FSR team, as their CPATSA colleagues, were too eager to see visible and concrete results of their new research methodology and thus decided to disregard the fact that giving too many things to farmers could be counterproductive for the SIP project. They felt compelled to demonstrate to their colleagues, who did not believe in research outside the experimental station and in farmer participation, that the SIP project was worthwhile. As mentioned before, the FSR team was being ridiculed by many within IPA. This team of researchers also felt under pressure to justify to the different funding organizations that the new project was worth supporting. To better understand the researchers' position, it is also necessary to take into consideration the fact that a researcher needs to produce papers and attend conferences in order to further his or her career and they are, therefore, under pressure to get results. Results that may take longer to materialize if researchers are involved in the time-consuming business of working with farmers and aiming to provide them with long-term solutions to their problems.

Working with the small farmers of the Xicuru region proved to be much more difficult than IPA researchers had anticipated. They mentioned two additional problems which emerged during the implementation of the SIP project and contributed to the difficulties that researchers and farmers were having to work together - paternalism and elitism.

The issue of paternalism was raised by IPA researchers during fieldwork interviews in 1990 and is considered part of their culture. In the words of members of IPA's SIP team: "The research methodology was new but the researchers were still the same. It is not easy to work with small farmers and even more difficult to resist giving them the things we know they need. They need so much!" (fieldwork, 1990). And, "We had a certain difficulty to get it into our heads that paternalism should not exist. Firstly, because the programme says that it is for us to give everything. Secondly, we were visited by supervisors and people from other organizations, mainly from SUDENE, that arrived in the community and said, in front of all the farmers, that the programme had been designed to give them everything they needed" (in Noya, 1990, p.88). Although IPA researchers agreed, after experiencing the problems created by their 'generosity', that the SIP farmers should not be handed out free infrastructure or farming inputs, they were unsure where to draw the line. They were not clear about what costs they should share with farmers and what would be the responsibility of the research institution which, according to them, could not simply transfer all the costs and risks involved in the development of new technologies to the small farmer.

The second quotation is a good illustration of how complex is the problem of paternalism. Paternalism in the North-East is intertwined with the question of political patronage and therefore, it may be quite difficult for a state research institute such as IPA, which is subordinated to the Secretary of Agriculture of Pernambuco, to pursue a policy that would ultimately enhance the power and independence of a group of small farmers. What IPA researchers were complaining about were their 'visitors', government officials from different institutions in the example mentioned above, is a common problem in the North-East. A problem that unfortunately has no simple solution in the foreseeable future. Tendler (1993), when analysing the performance of agricultural research and extension in North-East Brazil, has described the tendency of local government or state and federal government to 'reserve for themselves the rich patronage opportunities' provided by rural development projects.

With regard to elitism being an obstacle to farmer participation, IPA researchers were very clear: "One of the biggest obstacles to the SIP project is within IPA itself, in the elitist way of thinking of the researcher" (Noya, 1990, p.91). Researchers have admitted that it is very difficult to change a belief system which is prevalent throughout the North-East and says, amongst other things, that 'researchers know better than farmers'. Even the researchers who accept the value of a farmer's knowledge or ITK (indigenous technological knowledge) recognized that, in practice, it is not easy to take it into account.

There is another side to the issue of elitism which poses a problem for those researchers involved in farmer participatory research methods. Most agricultural researchers in the North-East appear prejudiced against working outside the research station and involving the small farmers in the research process. In this context, elitism among researchers may reach unpleasant levels as the next couple of quotes illustrate. "Our colleagues here at IPA went as far as humiliating us. [They say to us, for example] You interviewing small farmers? Let us do research instead!" and "Our colleagues believe this kind of work [on-farm research] is for extensionists. Today, as a few fruits are beginning to appear, our work is a little more accepted" (IPA researchers involved in the SIP project, in Noya, 1990, p.91).

To put the last example into perspective, it is necessary to remember that rural extensionists in Brazil are often looked down upon by their professional colleagues who work as researchers. According to this view, research outside the experimental station and with farmer participation is not considered proper research. Researchers from CPATSA, who are responsible for the coordination of agricultural research throughout the North-East, confirmed that it was only a minority of researchers who were interested in systemic research involving small farmers. "Out of a total of approximately 380 PAPP (Programa de Apoio ao Pequeno Produtor) projects which CPATSA was involved with in 1989, not more than 30% were based on FSR. Perhaps 70-80% of the new projects which started after 1988 have taken farmer participation into consideration, but only superficially. The research station is still the place where everything happens. Agricultural research is still very far away from the farmer" (Pedro Gama da Silva 1989 and 1991).

4.2.2.4 Potato (**Solanum tuberosum L.**) research

In parallel with the work carried out in the six SIPs, IPA researchers were also conducting research both inside and outside their Caruaru experimental station. It was the combination of these initiatives, as has been argued in this chapter, that gradually led to the formation of a new research methodology: PTC. In this context, potato research was one of the main initiatives which contributed to the process of development of PTC and, thus, the advancement of potato cropping as a new technology or a technological change which proved to be the most important among those that resulted from IPA's work during 1980-1991, the period under consideration. Very significantly, potato research was a direct response to demands coming from the Xicuru farmers themselves and not a top-down initiative imposed by researchers.

After surveying the area in 1984, IPA identified two main constraints on production in the Xicuru region: labour shortages during the wet season and lack of forage for cattle during the dry season (IPA, 1987). Soon after that, with the intensification of farmer participation in the research process, it became clear that the lack of potato seeds and the low productivity of that crop were also major concerns of the small farmers of Xicuru (Lopes, 1990; IPA, 1991). Responding to farmers' requests and needs, IPA started a number of on-station experiments involving the potato crop: studies of new varieties of potato seeds, organic and chemical fertilization and better husbandry practices (IPA, 1989a; Lopes, 1990). Later, IPA seems to have carried out some informal experiments to determine the usefulness of agro-chemicals in pest and disease control. IPA researchers have continued to carry out experiments inside their research station in order to minimize the risks for the farmer and experiment with a wider variety of technological options. Nevertheless, researchers did not isolate themselves from what was happening outside their station. In accordance with the spirit of the new methodology, IPA researchers invited farmers to come to the research station on many different occasions and exchange ideas with them about their experiments. Since 1984, IPA has been working consistently with the Xicuru farmers - individually and as a group through their farmer's association (APROBACA) - in order to address their main problems.

Outside the research station, IPA was also carrying out important research work in the Xicuru region which was different from the SIP work discussed above. While in the SIPs researchers were paying more attention to the interactions of the different farming systems, outside the SIPs IPA started to study specific problems and test particular technologies, but without losing sight of the system as a whole. IPA researchers organized many meetings and field-days with farmers in the Xicuru region and set up experiments on several farms to test a number of technologies that could potentially be beneficial to farmers. Many of these experiments concerned the potato crop, which became a very important part of IPA's research work from 1985 onwards because of farmers' pressure and the great potential of the potato crop as a source of small farmer income.

It was through their intense contact with farmers and frequent visits to Xicuru, which began in 1984, that IPA researchers came across a small group of farmers (not more than 30) which was cultivating potato besides the usual local crops (chapter 5). That was probably IPA's most surprising finding and one which proved to be the more promising for the farmers as far as improving their agricultural income is concerned (chapter 6). To the researchers' surprise, farmers claimed that the potato crop was not only viable in the region but that it was their most profitable crop. Up until that moment, researchers did not know that the potato crop could be grown in the region given the semi-arid climate of Caruaru with its high temperatures and insufficient and irregular rainfall pattern which is not appropriate for the crop.

That small group of farmers cultivating potato was keen to improve the crop's output and requested the help of IPA researchers. Many other small farmers who were not growing potatoes explained to researchers that they also wanted to cultivate potato but had had difficulties in getting the seeds or could not afford to buy them: the seeds (variety "Aracy") that farmers could obtain from a neighbouring state (Paraíba) were too expensive and of poor quality. Broadly speaking, Xicuru farmers wanted to be able to grow potatoes, sell the bulk of their production and store their own seeds for the following year (fieldwork interviews, 1990). As farmers had already tried and failed to find an effective way of storing their highly perishable potato seeds, IPA supported, as explained earlier in this chapter, the construction of a refrigerated storage house for potato seeds which was completed in late 1986. Without the storage house, researchers and farmers agreed that the future of the potato crop in the region would have been very limited.

Apparently, as a response to farmers' continuous demands for improvements regarding the potato crop, IPA decided to carry out a special survey. Thirty three small farmers who were growing potato in the Xicuru region were interviewed in December 1986 and early 1987. Although the information of this survey was not formally processed by IPA due to lack of time and qualified personnel, researchers were able to take a closer look at the way farmers viewed the crop, cultivated it and tried to deal with the problems associated with it (Lopes,G.M., IPA-Caruaru researcher, personal communication). With the benefit of hindsight and after a careful analysis of those questionnaires, it seems that all the major problems that farmers said they were facing in that survey were gradually addressed by IPA over the years and gave rise to the so-called 'potato project', to be discussed in the next chapter.

Based on ideas and comments made by farmers, as well as IPA's scientific knowledge, researchers started experimenting with new varieties of potato seeds, first on-station and then in the farmer's fields. Gradually, a few new varieties proved well suited to the region and allowed farmers to start replacing the poor quality seeds that they had been using for a long time. Farmers' experience with the potato crop was important during the selection process of the new varieties and illustrates the relevance of involving the farmer in the research process. Among other things, farmers advised researchers not to waste any time testing potato varieties which had a pinkish skin colour. They believed, based on many years experience selling potatoes, that consumers would be very reluctant to buy these different-looking types of potato and therefore, were not willing to risk planting them. A variety called "Baraka" adapted well in the Xicuru region and was approved by farmers and researchers alike.

As a result of the exchange of information and experience with farmers, IPA researchers were also able to suggest changes in farming practices (planting in furrows, spacing of seeds, fertilization, hilling up after 30 days, etc.) which either improved the crop performance or saved on family labour; a vital component of the Xicuru farming systems that is in short supply during the reduced (six month) rainy season of the semi-arid region. Within this context, potato research led IPA to the tentative conclusion that the introduction of animal power would benefit the potato crop in particular and Xicuru farming systems as a whole. The use of ox-drawn equipment that researchers in the early 1980s thought would be very helpful to improve the manioc system (IPA, 1991) proved more useful to farmers when adapted to the potato system in the late 1980s; mainly to open furrows and facilitate the planting phase. Involving the small farmers in the research process also enabled researchers to identify common problems related to soil nutrient deficiency and to begin experiments with both organic and chemical fertilizers in 1986 (IPA, 1989). Aware of the lack of financial resources of their clients and the insufficient quantity of manure available in the region, researchers decided not to look for the optimum solution in agronomic terms but one that would significantly improve the potato crop output and still be affordable for the small farmer of Xicuru; IPA's recommendation was a combination of organic and chemical fertilizers.

In the Brazilian semi-arid region, maximization of output, as suggested by the 'orthodox research approach', may go against the principle of sustainable agriculture. In this region, as Duque (quoted in Souza, 1979, p.89) explained, there are many factors such as weeds that will reduce crop productivity, however, "...the soil deserves more care than the plant itself. The soil is permanent, the crop is temporary". To clarify this example which applies well to the farmers of Xicuru, it is necessary to note that there are justifiable situations when the farmer leaves his or her field partially covered with weeds. Output may be sacrificed to protect the soil from erosion. A 'clean' field exposes the soil to the harsh climatic reality of the semi-arid and accelerates its destruction.

4.3 Concluding Remarks

This IPA attitude regarding fertilization, the new varieties of potato seed and farming practices reflect the effort and commitment invested in the process of developing a participatory research methodology that would attend the needs of the small farmers of the Agreste. This is a very important point that needs to be emphasized. Whereas other methodologies which are not client-oriented would favour the maximization of agricultural output and therefore propose the use of a much greater amount of modern inputs - either chemical or mechanical - IPA recommendations were very much in line with farmers' expectations and their socio-economic and agro-ecological reality. In contrast, as was pointed out by Miranda (1987), a significant part of the research effort in Brazil is still concerned only with the agronomic dimension of the new technologies, omitting important economic considerations as well as their social and ecological impacts. In many cases, he suggests, what constitutes the optimum agronomic solution is far from being economically viable from the producers point of view, unless they are heavily subsidized.

The four initiatives taken by IPA from 1984 onwards and described above - concentrating the research effort in Xicuru; researchers working closely together with extensionists and farmers; developing the SIPs; and potato research - were certainly very relevant to the process of development of IPA's new research methodology or PTC. After years of hard work trying to develop and implement a participatory and systemic research methodology, IPA gradually started, in the late 1980s, to be able to promote technological changes that were acceptable to farmers and which could, therefore, be incorporated into their complex farming systems.

Potato cropping is the most important technological change that resulted from IPA's work during the period under consideration: 1980-91. As suggested in sub-section 4.2.2.4 (potato research), potato cropping is a set of technological innovations related to the potato crop which comprises: improved or certified seeds; organic and chemical fertilization; agro-chemicals and new farming practices which include the use of animal-drawn (ox) equipment. Very significantly, potato cropping is a technological change that takes into consideration the needs and financial limitations of the small farmer. Moreover, it tries to incorporate what is known as ITK or indigenous technological knowledge (chapter 1). In what are considered classic works on the North-East, the agronomist Duque (1953;1973) suggested that researchers should not ignore the technical knowledge of the small farmers and strongly recommended the careful study of the evolution of the small farmers' farming systems (*lavoura matuta*) and not its transformation. Probably a few decades ahead of his time, Duque was defending the idea that agricultural research should start at the level of the small farmers and work gradually to improve their farming systems

- respecting their knowledge and their socio-economic and environmental conditions.

Potato cropping is not the optimum technological solution that would maximize output and productivity through the excessive use of industrial inputs. Potato cropping, for that matter, may be seen as a compromise that nevertheless, appears capable of improving the agricultural output of the small farmers of Xicuru and thus, their standard of living (chapter 6). Despite its biological limitations, it is far from being a substandard or unprofitable technology. In this respect, IPA's research philosophy is in harmony with the principles of international agricultural research as stated by Oasa (1987, p. 31): "While FSR suggests to some that research may be promoting agricultural 'under-development' - low inputs, lower yields - and that it reflects a switch in research philosophy, international agricultural research has not relinquished its long-standing goal of increasing the yield per unit area of land. In this research system's view, FSR and increasing yields must be compatible. Central to getting down to the cultivator's world is the identification of the constraints which farmers face in increasing yields. New technology for resource-poor farmer, it is assumed, will be profitable to the extent to which particular constraints are eliminated either agronomically or biologically".

To end this chapter, it is necessary to add briefly that potato cropping is not what many authors called a "technological package" (Aguiar, 1986) or "green revolution technological package" (Shiki, 1991). The technological package, in that context, is a product of the dominance of the agro-industrial capital over the interests of the agricultural sector in Brazil - it is neither designed to meet the needs of the small farmers nor to take into account the resource-poor environment of the Brazilian semi-arid region (3). In this context, it is worth stressing the point that the so-called 'modern' technologies, or those which are generated within the CAR approach (Chapter 1), should not be rejected. PTC generated technologies may be closer to what Jéquier (1979) refers to as 'appropriate technology' than to CAR or 'modern' technologies and, thus, what the author says about that type of technology is also valid to PTC technologies such as potato cropping: 'Appropriate technology is not an universal substitute for the conventional modern technology. Appropriate and modern technologies are complementary rather than contradictory, and the emphasis given to the former should not rule out the use of the latter in those cases where they are particularly well adapted to local situations' (Jéquier, 1979, p.3).

This study now proceeds to examine in more detail the role the small farmers of Caruaru played in the development of the new technology (potato cropping) and how the so-called 'potato project' have become a reality.

4.4 End Notes

(1) 'The farming system is not simply a collection of crops and animals to which one can apply this input or that and expect immediate results. Rather, it is a complicated interwoven mesh of soils, plants, animals, implements, workers, other inputs and environmental influences with the strands held and manipulated by a person called farmer who, given his preferences and aspirations, attempts to produce output from the inputs and technology available to him. It is the farmer's unique understanding of his immediate environment, both natural and socio-economic, that results his farming system' (CGIAR-TAC review document of 1978 quoted in Oasa and Swanson, 1986, p.28).

(2) A farming system is formed by a number of systems, for example, a livestock system and a crop system (manioc system, potato system, beans intercropped maize system, etc.) Hence, the study of a property as a whole cannot be treated or misunderstood as a study of the whole property.

(3) For more information on the process of subordination of the Brazilian agricultural sector to the agro-industrial capital, see Kageyama and Graziano da Silva (undated); Brum (1988), Muller (1989); Wilkinson (1986) and Glaeser (1987).

CHAPTER 5
SMALL FARMERS AND THE TECHNOLOGICAL CHANGE

5.1 Introductory Remarks

The different benefits that a technological change such as potato cropping may bring to the small farmers of Caruaru (Chapter 6) are not a straightforward consequence of improved agricultural output and productivity. They are inextricably linked to the type of technology used and the way it was generated through Participatory Technological Change (PTC), in the case of this study.

Hence, these benefits cannot and should not be taken for granted. Moreover, as emphasized by Graziano da Silva et. al (1985), the technological change in itself is not a guarantee that farmers will be able to retain the fruits generated by that change. Instead, it is argued, the new technology may transform itself into a means of domination by agro-industrial capital - unless it is counterbalanced by farmers acting within the framework of an association and certain agricultural policies (commercialization, minimum pricing, rural credit, etc.). These two very important factors are present in the case of the small farmers of the Xicuru region, Caruaru and, therefore, will be discussed next. The question of the organization of the small farmers is investigated first. Then, the second point regarding agricultural policy is examined within the context of what will be called the 'Potato Project'. The relevance of these two issues here derives mainly from the fact that they have allowed the small farmers of Xicuru not only to increase their agricultural output but, more importantly from their point of view, to improve their standard of living with regard to many variables (Chapter 6).

Before discussing these two important questions, however, brief background information about the small farmers of Xicuru, Caruaru, will help clarify the context in which the technological change took place.

5.2 Farmers' Background

Small farming in Brazil, despite the many forms it can assume, presents a number of important common characteristics that were summed up by Graziano da Silva et. al. (1985):

(1) Family labour force. Small farmers production units are based on family labour. In critical periods of the farming calendar, labour requirements often exceed the potential family supply.

(2) Land scarcity. This constitutes the immediate obstacle to the adoption of technologies which require a certain minimum scale of production such as mechanization.

(3) Poor ecological environment. Very often small farmers occupy areas of low soil fertility, steep sloping terrain and with an adverse climate.

(4) Multiple cropping. Even in cases where the small farmers, due to their integration into the market economy, are concentrating on a commercial crop, multiple cropping is still the dominant feature of their farming systems. Generally, together with the main cash crop, a number of different crops are grown for either domestic consumption and/or the market.

(5) Insufficient means of production. Besides the small size and poor quality of the agricultural areas at their disposal, the vast majority of small cultivators do not have the financial resources to carry on their farming activities properly.

These five characteristics are all part of the farming systems of the small farmers of Xicuru, Caruaru. The three principal categories of small farmers in the Xicuru region, as seen by a member of the local agricultural research institute (IPA), are:

(a) smallholder: a cultivator who owns part or all of the farm where he or she resides;

(b) tenant: an agent who pays a pre-fixed amount in produce in exchange for the use of a plot of land; and

(c) wage-labourer: a worker who is informally contracted and paid on a short-term basis (Lopes, 1990, p.47).

The smallholders of Xicuru, who are the focus of this study, are typical of the Agreste in the sense that they are involved in mixed farming - food crops and livestock - both for consumption and for the market. The main crops are short-cycle or annual crops: manioc or cassava, maize, beans (more than one variety) and potato. Intercropping is the basis of their farming system and, as explained in chapter 6, cattle are raised on approximately 80% of the farms that participated in this fieldwork survey.

In an attempt to "have a broad view of the agro-socio-economic structure of the area" of Xicuru where IPA decided to concentrate its research effort from 1984 onwards, their researchers carried out a number of "quantitative interviews" (Lopes, 1990, p.46). The information collected at that time revealed that the average number of people living on farms of sub-area FS1 (Farming System 1) where the potato crop is cultivated was 6.1. In FS2 (Farming System 2) the average number of people was smaller, or 4.7.

The family structure - very relevant as far as the labour potential is concerned - was as follows:

- In FS1, the average of six people per household is represented by two adults and four children. Among the children, two are younger than 15 years.

- In FS2, the average family is composed of two adults and three children.

Everyone older than seven years normally works on the farm. In both sub-areas, FS1 and FS2, the male adult is responsible for taking decisions and managing the small production unit. Women, on the other hand, are not only responsible for the children and running the household. They also take care of small animals such as chicken and goats, tend the kitchen garden and participate in almost all farming operations.

Farmer's information obtained in the 1990 fieldwork survey supported IPA's 1984 result which indicated that the majority of the farmers interviewed had to hire workers occasionally. In 1984, over 70% of Xicuru smallholders on farms larger than 10 hectares used to hire temporary workers in FS1; mainly during the critical periods of the agricultural calendar such as soil preparation and planting. Farmers in smaller areas also paid for labour but only very occasionally and on a daily basis. Approximately 80% of the small farmers in FS2 declared that they hired rural workers, especially during the summer months, for repairing fences, pasture maintenance and cleaning water reservoirs (*barreiros*) (Lopes, 1990, p.47).

The number of totally illiterate farmers in 1984 was 46% in FS1 and 41% in FS2. The average for the whole North-East was around 44% (Lopes, 1990). In 1990, the number of Xicuru farmers who could not read nor write was 33% (fieldwork, 1990).

According to the same study which IPA carried out in 1984, the average size of holdings in FS1 is 9 hectares whereas in FS2, where cattle rearing is the dominant activity, farms are around 11 hectares. The predominant vegetation in the region is classified as *caatinga* or a hypoxerophic vegetation consisting of an association of spiny and woody plants that need little water: cacti, shrubs and small trees with shrivelled, thorny leaves (Lopes, 1990).

5.3 Potato Crop: Historical Background

For a small number of farmers living in the Caruaru region in 1990, potato cultivation was not a new activity. It all started in the late 1940s when a farmer visiting a neighbouring state (Paraíba) was convinced by a friend to take back to Caruaru a small quantity of potato seeds. The friend of the Xicuru farmer argued that the crop was not very difficult to grow and was a good source of additional income. After a few years, a small group of Xicuru farmers were growing potato and making a little profit with the new crop. However, as seeds were not available in the Caruaru region and were not cheap, the area under cultivation was fairly limited. Furthermore, they were not certified potato seeds (approved by the Ministry of Agriculture) and, therefore, their quality left a lot to be desired. Several farmers tried and gave up cultivating potato in those early days due to the difficulties involved in buying good seeds.

Nevertheless, encouraged by this new source of cash, that small group of farmers who had introduced the crop in the Caruaru region organized themselves and shared the travelling expenses for one of them to visit Paraíba (Esperança) on an yearly basis and thus, import the quantity of seeds that they could afford or were willing to buy. Gradually, other farmers decided to try the new crop but without any significant success. "After we saw our friend riding a brand new bicycle in the 1970s, we decided to start planting potato too. He bought it with the money he earned selling his potato output. It was the first brand new bicycle that appeared in the region. Everybody was talking about it, it was so beautiful" (Xicuru farmer, fieldwork 1990).

Potato cultivation received a boost in the early 1980s. Potato output in the Esperança region had gradually increased during the 1970s and, as a consequence, it became easier for the Xicuru farmers to import seeds. In 1982, the state government inaugurated a large refrigerated warehouse for the storage of potato seeds in Esperança (Paraíba) and local farmers formed an association to promote the crop. The increased availability of seeds in Esperança allowed a larger number of farmers in Xicuru (Table 5.1, below) to adopt the crop. Seeds could then be stored in the warehouse and, therefore, production costs decreased, allowing farmers to increase their profit margin and, slowly, their output as well. But not for long. By 1984, Xicuru farmers were facing the dissatisfaction of an increasing number of farmers from Esperança who were being encouraged by their local politicians not to allow farmers from a neighbouring state (Pernambuco) to benefit from their storage facilities. It was during this time that the Xicuru farmers decided to form their own association and have their own refrigerated warehouse.

According to a leading farmer, a local priest named Frei Tito was a decisive force behind this small group of farmers who were trying to innovate and improve their living standards. In the late 1950s, Frei Tito was not only preaching the Bible but strongly motivating farmers to act together and to diversify their crops. Frei Tito, among other things, was a great supporter of potato cultivation in the region. Together, they managed to bring electricity to the region and created the union of agricultural workers (sindicato rural de Caruaru) in the early 1960s. After the military coup of 1964, however, the activities of priests such as Frei Tito and real leaders of the farmer's union were not officially encouraged.

5.4 The Role of the Church

As suggested above, the Church played an important role - both directly and indirectly - in creating the right conditions to allow PTC to develop. The Church supported and encouraged farmers' willingness to innovate and work together with their fellow farmers and others. Helping one another and working in *mutirão* (a form of group work where no exchange of money occurs) were activities which were always praised and stimulated by the local priests, as was explained by many Xicuru farmers during fieldwork (1990).

The fact that Frei Tito, in the 1950s and 60s, had preached the positive aspects of the *mutirão*, agricultural diversification and technological change were no doubt a decisive influence in the farmers' minds. "Frei Tito was a very important figure in our community. He helped us a lot and taught us a number of useful things; he also brought electricity to this region and he always told me to grow potato" (Xicuru farmer and community leader, fieldwork, 1990).

As padre Paulo Crespo, secretary of CECAPAS (Centro de Capacitação e Acompanhamento de Projetos Alternativos or Centre for Capacitation and Follow-up of Alternative Projects) has explained in an interview (Crespo, 1989), the basis of the Church's activities in the North-East rests on Pope John XXIII's "Mater et Magistra" encyclical which emphasised ideas such as: 'The peasants ought to be the protagonists of their own liberation. They ought to organize themselves in associations, unions and co-operatives so that their voices may also be heard' (quoted in CECAPAS, 1988, p.8).

Paulo Crespo also explained that, year after year, the priests working in the rural areas began to realise that they were much more apprentices than educators, students rather than teachers. "We have learnt through our daily work with small producers that the more humble ones have great wisdom" (Crespo, 1989). A wisdom that small farmers have acquired not in books but through the personal experience of their immediate reality.

Very significant, within the context of a participatory technological change which IPA was trying to implement, is the Church's view that on many occasions this immediate reality is unknown and strange to outsiders (non-farmers) and that it was through dialogue and the exchange of experience and knowledge that they discovered new truths, more complete and profound because they are the synthesis of many forms of knowledge. Taking into account the Church's contribution described above, it is possible to say that IPA's work with the small farmers of the Xicuru region and then their association, in the 1980s (Chapter 4), must have been facilitated by the fact that those small farmers already knew and valued the need to engage in dialogue and to exchange experiences as well as to be organized as an association.

Another Church initiative called CECAPAS has had a positive influence on the agricultural development of the region. The president of Xicuru's farmer association (APROBACA), for example, had attended several courses at this type of agricultural training centre run by the Catholic Church and, therefore, could perform well a number of tasks that a veterinarian would do, including the vaccination of cattle and assisting the delivery of calves - a precious commodity in the region. He had also learnt about bee-keeping and organic farming through CECAPAS. Thus, he was able to earn additional income - not insignificant from his point of view - working as a 'veterinarian' and selling honey. At the same time, he helped many people in his community. Many Xicuru small farmers would pay for his services or advice the way they could. More often than not, no money would be exchanged.

CECAPAS' courses are said to be highly participatory and use a number of techniques of group dynamics and socio-drama to get farmers involved in the training courses. One of their main goals is to try to promote the idea that excessive individualism will not be helpful to farmers who, especially if organized in associations or co-operatives, could benefit from co-operation with their fellow farmers. CECAPAS's educators would be alert to avoid imposing their own views and projects on the small farmers. The core of their methodology is to avoid forms of participation which are nothing but 'disguised dictatorship' (CECAPAS, 1988, p.11).

One of the main ideas behind the CECAPAS courses is to help small farmers bring about positive change in their own interests. The methodology is not based solely on providing farmers with new techniques or tools, but is geared to engaging farmers in an educational process which can give them a broader vision and understanding of their farming systems and the socio-political context in which they live (CECAPAS, 1988, p.20).

The CECAPAS methodology involves the ideal of 'sharing among brothers' and thus, one of its important objectives is to form 'missionaries of the earth' - a farmer who would become a change agent of his or her circumstances, a farmer-technician, competent, dynamic and caring toward his fellow farmer and community (CECAPAS, 1988, p.17; Crespo, 1989). The farmers who participate in the courses organized by CECAPAS, either at their centre in Pesqueira, Pernambuco or in the local rural villages, are chosen by their own community. CECAPAS is strictly in favour of organic farming, environmental conservation and alternative technologies. Moreover, its training centre places great faith in the value and inherent wisdom of the small farmers and rural workers.

Despite its clear message and what could be described as a very forward looking and participatory discourse, CECAPAS seems to be, at least in part, patronising small farmers and somehow imposing their own vision and projects upon small farming communities in Brazil (fieldwork, 1990).

5.5 APROBACA and ATRAM: Farmer's Associations

Adding to what has already been said about APROBACA in chapter 4, it is important to know that the most relevant characteristic of this farmers' association is that it was formed by the Xicuru farmers and is run by them without any interference from local politicians, large landowners or members of government institutions. APROBACA's success in pushing forward the wishes and demands of the Xicuru farmers stems from the fact that it is an authentic grassroots organization.

Virtually the same group of Xicuru small farmers who had introduced the potato crop in the region in the 1950s and contributed to the formation of the rural worker's union of Caruaru (Sindicato dos Trabalhadores Rurais de Caruaru) was responsible for promoting the idea of the formation of a farmer's association. EMATER - the local rural extension service - supported the idea and helped farmers with the drafting of the association's charter, registration and other administrative issues.

Soon after setting up APROBACA, Xicuru farmers had not only a registered association but a refrigerated warehouse (*frigorífico*), inaugurated in 1986, where they could store their own potato seeds. The result in terms of the numbers of farmers who started cultivating that profitable crop is clearly depicted in Table 5.1. Sixteen farmers, by far the highest number for any given year, started cultivating potato crop in 1984 - when the first farmer's association (APROBACA) was created in the Xicuru region. Eight more farmers started in 1985 and another seven during the year the refrigerated warehouse was inaugurated (Table 5.1). In all, approximately 60% of farmers who were cultivating potato in the Xicuru region in 1990 began growing potato after 1983 or, in other words, after the creation of APROBACA and the potato warehouse (*frigorífico*).

Table 5.1. Year when farmers started to cultivate potato in the Xicuru region, Caruaru 1990, Brazil.

YEAR	Farmers	Accumulated	
	(n)	(n)	(%)
1940s	1	01	01
1950s	1	02	02
1960s	5	07	09
1970s	8	15	19
1980	5	20	25
1981	3	23	29
1982	5	28	35
1983	3	31	39
1984	16	47	59
1985	8	55	69
1986	7	62	78
1987	7	69	86
1988	4	73	91
1989	7	80	100

Source: Fieldwork 1990.

More significant, perhaps, is the fact that, during in-depth fieldwork interviews, farmers revealed that it was not only the number of farmers growing potato which had been increasing since 1984. The average quantity of potato seeds (boxes) planted and the area cultivated had expanded too. It is important to stress that all 31 farmers who were already producing potato before the formation of APROBACA declared that they could only plant a significant amount - from the point of view of their agricultural income - after the refrigerated warehouse started operating in 1986. "Before the warehouse (*frigorífico*) we could only plant a few boxes [30kg each] each year. Now, we can even plant twice a year. Many farmers are planting more than 50 boxes each and they are making a lot of money" (APROBACA's director and small farmer, fieldwork, 1990).

Despite what was explained above, the major turning-point that enabled farmers to really expand their potato output was the technological change - potato cropping - which came into being through what is here called the 'Potato Project'. However, before explaining what the Potato Project consisted of, it is necessary to further discuss the role of the farmers' associations as regards the promotion of PTC and the new technology, as well as the emergence of a second farmer's association in the region of Xicuru.

The fact that the small farmers of Xicuru were working together to promote certain technological changes such as potato cropping and silage (*silagem*) (Lopes, 1990), among other things, and that most of them participated in the association's meetings (even if they were not members) does not mean that there were no problems or dissatisfaction among them. As mentioned above (2.4.3), there were important differences of opinion amongst farmers. Nevertheless, in most cases, these did not interfere with the progress of the broader changes under way - specially those related to PTC and the potato crop, in particular.

Certainly, the best example to illustrate this last point is the formation of a second farmer's association in the Xicuru region. A group of small farmers, led by a very experienced, articulate and rather politicised farmer (who had worked in factories in São Paulo and participated in the labour movement) decided to create a new association: ATRAM (Associação dos Trabalhadores Rurais de Maniçoba) or the Association of Rural Workers of Maniçoba. ATRAM was born in November 1990 and very quickly started to increase the number of farmers who were adopting potato cropping.

The promotion of potato cropping was the main objective of ATRAM at that time and, at their first meeting, the 50 or so farmers who had joined the association also chose to join the potato project, which will be discussed in the next section of this chapter. The main reason for the creation of ATRAM is fairly simple. APROBACA's potato warehouse had reached its full capacity and its leadership seemed more or less satisfied or accommodated with their situation. As a few dissatisfied farmers explained: "They did not have the incentive to fight for the construction of a new warehouse or find more members for APROBACA. Their core group was doing well and, thus, lacked the incentive to continue changing things" (ATRAM's first president, fieldwork, 1990).

A very important point needs to be made here since it had major positive repercussions in the region. This 'break-away' group (ATRAM) did not oppose the existence of APROBACA nor severed links with that organization. Probably less than a handful of farmers who joined ATRAM were members of APROBACA. The vast majority of ATRAM's members were small farmers who did not belong to APROBACA, but lived in the region. Displaying a very mature and professional attitude, the leadership of APROBACA accepted the invitation to be present on the day the new association, ATRAM, was formally created and its first president elected democratically by its members. Showing that the new association was willing to work with and not against APROBACA, ATRAM's president in his inaugural speech was full of praise for APROBACA's role in improving the farmer's lot. Interestingly, if not surprisingly, ATRAM's president, during that same speech, asked APROBACA's treasurer for specific help to get ATRAM organized. The reply from APROBACA's leadership was prompt and very cordial. APROBACA's treasurer was a close friend of ATRAM's new president who was actually APROBACA's only licensed tractor driver.

Another significant fact within the context of the creation of ATRAM was the presence of the head of the IPA-Caruaru research station at the inauguration of ATRAM. Antônio Felix da Costa, despite being off-duty that Sunday morning, chose to be present at the meeting in the village of Maniçoba. This village is approximately 20km away from Caruaru and could be considered part of what is being called in this study the Xicuru region. IPA's presence at the creation of ATRAM is a clear indication of its participatory approach to agricultural research. Moreover, Antônio Felix da Costa explained to the members of the new association that IPA was committed to improving the living standards of the small farmers mainly through the promotion of technological changes such as potato cropping, sorghum cultivation and silage (*silagem*). The head of IPA-Caruaru used the opportunity to stress the point that IPA would support ATRAM's request to participate in the potato project and offered the technical assistance of their team of researchers to ATRAM, as well as to APROBACA which was already working with IPA on many fronts (Chapter 4).

The leadership of the two farmer's association were aware that despite their differences they would benefit if they worked together and co-operated with each other, particularly when dealing with the local authorities and other government officials who represented a number of public development institutions working in the region. They were also aware of the fact that a certain geographical reality could be used to their advantage. APROBACA's and ATRAM's 'headquarters' were not far away from each other but they were located in different municipalities. APROBACA is situated in Caruaru, whereas ATRAM is in São Caetano, a neighbouring *município*. It did not take long for the leadership of both associations to realize that the competing mayors would have a vested interest in promoting their own association and try to provide 'their farmers' with whatever, if not more, the 'opposition' association had. The result, in practice, was difficult to believe, particularly because it took place over a very short period.

As a consequence of this type of political competition that emerged with the creation of ATRAM, the potato project (section 5.7) received additional state government funding in 1991, and was improved to encourage the new farmers from Maniçoba to adopt the new technologies. The implementation of this project, which was in the hands of APROBACA, shifted to ATRAM. Moreover, a very modern and fairly large refrigerated warehouse with several times the capacity of APROBACA's warehouse began to be built in Maniçoba and was almost operational by December 1991. This expensive building was given by the new state government to ATRAM. These dramatic changes, which were well received by the small farmers of both associations, are easier to understand when the local political situation is taken into account. The new administration came into power in early 1991 and was very keen to promote 'new' initiatives that would boost their popular appeal. The recently elected state governor of Pernambuco at that time was a political rival of the mayor of Caruaru whose administration supported the farmers from APROBACA. Furthermore, the new Secretary of Agriculture of Pernambuco, appointed by the governor, was from the municipality of São Caetano where ATRAM is located. This explains the speed of construction and size of the refrigerated warehouse built in Maniçoba and granted to ATRAM.

5.6 Some Dangers: pests, diseases and farmer participation

The lack of a rigorous and science-based control of pests and diseases in the Xicuru region is an increasing problem as the planted area of potato expands rapidly (Lopes, 1990). Between 1984 and 1991 the area under potato cultivation increased by approximately eight to ten times. Diseases such as the late blight (Phytophthora infestans) is causing severe damage to the potato crop, mainly during the first planting period (February-May), but can be controlled with the right use of fungicides (Lopes, 1990; IPA, fieldwork, 1990). A more serious and recent disease is the common scab of the potato (Streptomyces scabies) or '*sarna*'. IPA researchers, despite their research effort, were still having difficulty in understanding and dealing with these in 1991 when fieldwork for this study was completed.

The greatest loss from common potato scab, as pointed out by Walker (1957), is brought about by the blemish to the appearance of the tuber and the consequent loss of commercial value. Besides, the scab (*sarna*) makes the tubers vulnerable to chewing insects, which further adds to the farmers' loss. This disease is world-wide and is not considered a major problem in Brazil, where 98% of the area under potato cultivation is located in the South and Southeast of the country (CNPH, 1985). In these regions the disease, which is not common, can be controlled through irrigation, fertilization and the use of certified seeds. "For this reason there is little research on the subject in Brazil", explained a leading biologist (Júlio Rodrigues Neto, Instituto Biológico de Campinas, 1990). It is, however, becoming a serious problem in the Xicuru region where the use of poor quality and, in many instances, contaminated seeds is spreading the disease.

Common scab is potentially extremely dangerous for the future of potato cultivation in the Xicuru region especially because the pathogen (a bacteria) may subsist indefinitely in favourable soils (Walker, 1957). In the state of Rio de Janeiro, for example, a large potato producing area in Campos had to be abandoned due to soil contamination; it is still contained by the common scab pathogen even though no potato had been grown in the area for more than ten years (Ivan Sampaio, UFMG, agronomist, fieldwork interview, 1990). This bacteria is distributed chiefly on infected seed tubers but, as it may survive passage through the digestive tract of animals, it can be distributed with manure (Walker, 1957; Morse, 1912). This could be an additional factor contributing to the spread of the disease in the Xicuru region, especially because the small farmers had been feeding their cattle with contaminated potato which had no commercial value (fieldwork, 1990).

IPA researchers' technical advice for farmers to grow potato only in new areas where the crop had never been grown and for farmers to use only certified seeds seems of limited practical significance given the fact that these seeds are not easily available in the

Xicuru region and are fairly expensive. More importantly, perhaps, IPA's advice is difficult to implement because the small farmers of Xicuru have very little farm land available. Their best plots have already received dosages of manure and are being used for potato cultivation. As seen in chapter 4, these farmers are determined to use their best land for the potato crop which is their most profitable.

To make matters worse, the small farmers of the North-East, in general, tend to use their own seeds for several years, rather than certified tubers. IPA researchers believe that a significant proportion of these seeds is contaminated. Depending on a number of factors such as soil acidity and level of soil moisture, the disease can manifest itself in ways that a farmer's whole harvest may become commercially worthless (Agrios, 1978). Nevertheless, as a farmer put it: "The contaminated potatoes may still be used for domestic consumption if you remove the skin. It is only the skin of the potato that is affected by the scab. Or you can use it as cattle feed" (Xicuru farmer, fieldwork, 1990). In response to these and other problems, farmers started to use agro-chemicals in the mid-1980s, but with very mixed results until 1990. They used them with no orientation, buying what was available in the market and confusing disease with pest symptoms. Consequently, IPA researchers often met farmers using pesticides instead of fungicides and vice versa (Lopes, 1990). Fieldwork observations in 1990 showed that, despite the efforts of IPA to instruct farmers in 1989 and 1990, the situation was very chaotic and farmers were putting themselves at risk by overusing a number of different toxic substances without any kind of protective gear (no boots, no gloves, no mask and often not even a long-sleeved shirt).

The head of IPA's research station in 1990 was appalled to interview a farmer who, for safety reasons, thought that it would be alright to keep all his different and valuable agro-chemicals under his bed. "This farmer had no idea that he was breathing toxic gases and poisoning himself. As agro-chemicals are very expensive and the farmer was afraid that they might be stolen, he thought it would be a good idea to hide them under his bed" (head of IPA-Caruaru, fieldwork interview, 1990). Most farmers seemed even less clear about what to use and how to use those agro-chemicals in their crops. An IPA researcher admitted after being questioned about this issue that their recommendations in the case of the potato crop were far too complex for the farmer to understand and excessive: "Too many different products and too many pulverizations are being suggested. I am sure we can decrease them and be more successful in controlling pests and diseases" (fieldwork, 1990). As regards the use of agro-chemicals by Xicuru farmers, IPA's suggestions failed to work mainly because they were too complex and had been reached without farmer involvement and, thus, disregarded their needs and socio-economic reality.

While on one hand it may be possible to say that the previous examples are probably the best illustration of how the lack of farmer participation contributed to the poor solutions designed by IPA researchers as far as pest and disease control are concerned, the following example shows clearly the positive impact of farmer participation on the successful promotion of technological changes.

In 1989, IPA and APROBACA started an experiment to produce improved potato seeds in the Xicuru region. One of the members of APROBACA, a local small farmer, offered a plot of land for the experiment to be carried out. Farmers and researchers, after consulting with each other, began cultivating that field with the intention of producing disease-free potato seeds of high quality. Every step of the process was carefully implemented by the farmers themselves and assisted by IPA researchers and rural extensionists: ploughing and opening of furrows with animal traction, organic and chemical fertilization, and several preventative pulverizations to avoid the spread of disease and pests. "We all liked that experiment very much. We could finally understand what the boys from IPA were telling us to do"; and "The way we planted the potato crop was very good. Now, I only do it that way" (Xicuru farmers, fieldwork, 1990).

IPA researchers were very careful and inventive in the way they planned and implemented the potato seed experiment, which tried to address a number of different problems. For example, instead of referring to the volume of manure needed in the potato fields in 'tons per hectare', researchers began to use the 'local language' that was used by the Xicuru farmers: '*caminhões* or *carradas por quadro*' (1). When dealing with chemical fertilization, researchers also used a language that was accessible to farmers: "You need to pour a can of oil of this fertilizer mixture in the furrow every ten steps before planting the seeds" (IPA researcher on a field-day instructing a group of Xicuru farmers, fieldwork 1990). In the past, before IPA adopted PTC (Participatory Technological Change) researchers would simply order farmers around and briefly tell them that they should use, for example, "a tone ton of NPK [a fertilizer] per hectare of potato" - an instruction that a Xicuru farmer would certainly not understand.

Other problems appear to have been dealt more satisfactorily and appropriately by IPA researchers. As a matter of fact, some of the main recommendations regarding the successful use of soil and how to avoid erosion in the semi-arid region made by one of the most senior authorities on the North-East - Duque (1973) - all seem to be part of IPA's strategy of improving the farming systems of the smallholders of the Agreste:

- use of contour cultivation in place of straight-line rows running up and down the slopes; a very common sight throughout the North-East, even on very steep slopes.

- moderate use of the plough to avoid the richer layers of soil being exposed and 'burnt' by the intense heat of the sun.

- substitution of the plough by the disc or harrow whenever possible to minimize soil loss.

- periodic alternation of crops and pasture on the same fields or crop rotation to improve soil fertility and avoid the propagation of certain diseases through contaminated soil, as in the case of the common scab of the potato and late blight disease.

To sum up, APROBACA'S demands for the improvement of the local farming systems are being heard, to a large extent, by IPA researchers working in the region. Thus, fieldwork evidence collected in 1989, 1990 and 1991 appears to confirm the hypothesis that a more participatory research approach is more likely to produce answers to farmer's problems that are easier to implement and which tend to be beneficial to farmers.

5.7 The New Technology and the Potato Project

The different innovations proposed piecemeal by IPA from 1986 to improve the potato crop assumed the form of what will be called here the 'potato project'. The project started in 1988. It was designed and then improved on a yearly basis by IPA.

The potato project was very much in line with the needs and demands expressed by farmers in the APROBACA meetings and, as it was pointed out in chapter 4, in the survey carried out by local researchers (IPA) in 1986. This survey confirmed that farmer's biggest obstacle to increase their potato output was firstly, the lack of potato seeds in the region and secondly, the lack of storage facilities for preserving their seeds for the next planting season.

The project, financed by a government agency (PRORURAL), was created mainly to address the first and most important problem, namely, the lack of good quality seeds. The construction of the first refrigerated warehouse, inaugurated in 1986, provided a temporary solution for the second problem, as seen in chapter 4. Once the refrigerated warehouse started working, farmers were very glad that they could store part of their potato output and use it as planting material in the following year. However, this was a second-best solution because those seeds were not certified or disease-free and, thus, could be infected with a number of potentially very serious diseases (see 5.6).

It is very important to stress the point that the potato project was not introduced by IPA in a top-down fashion. Perhaps more importantly, researchers did not assume that the new technology (potato cropping) alone would be sufficient to strengthen the livelihoods of the small farmers of Caruaru, as they had mistakenly done previously with regard to other technological changes. Thus, IPA designed the potato project in a participatory fashion, as will become clear once the project's characteristics are spelled out.

As the number of farmers planting potato began to increase after 1983, it became evident that the shortage of seeds would not allow the potential of the crop to be realised. There was a consensus among farmers (Chapter 6) and IPA researchers that potato was by far the most profitable crop grown in the region and the crop that farmers wanted to expand, improve or start cultivating. Table 5.1 above, due to the objective of this thesis, does not include farmers who planted potato for the first time in 1990, as already explained in chapter 3.

It is estimated by APROBACA that approximately 20 new farmers adopted potato cropping in 1990 alone. Furthermore, in December 1990, after the creation of the second farmer's association (ATRAM) in the area, no fewer than 88 additional farmers were committed to joining the potato project in 1991 and start growing potato on a regular basis (IPA, 1990d). In order to deal with the rising demand for potato seeds and various different problems that were affecting the potato crop - for example, low productivity, pest and diseases - IPA's FSR team designed the potato project which started in 1988.

IPA researchers seemed aware of the important point made by Graziano da Silva et al. (1985), among others, concerning the small farmer's inability to appropriate the profits that they might generate through increases in productivity or output. The authors argue that, in the Brazilian case, the political-institutional regime under which the process of agricultural modernization took place prevented farmer's unions from claiming a fair share of the income being generated. The increased technological level of the small farmers, according to the same authors, only guaranteed the transference of larger surpluses from the small farmer's sector to the large industrial and financial sectors which became the dominant forces in the economy. The fundamental question according to them is the organization of the small farmers in a way that would enable them to increase their bargaining power and negotiate a better deal with those who control capital. The two farmer's organizations, APROBACA and ATRAM, allowed the small farmers of the Xicuru region that extra power referred to by Graziano da Silva; a power that translated or manifested itself through the potato project.

5.7.1 1988: The first year of the potato project

It is worth emphasising from the beginning that what is called here the potato project is mainly the result of initiatives and experiments with the potato crop which the small farmers of Xicuru carried out themselves. Undoubtedly, as explained in the previous chapter, IPA's contribution to the development of the new technology - potato cropping - and the potato project itself, was essential.

Farmers' demands for specific answers to their farming problems related to the potato crop inspired IPA researchers, in the mid-1980s, to investigate its potential in the region; a crop that researchers did not expect to be cultivated in the hot weather conditions of the Brazilian semi-arid North-East. Together, IPA researchers and farmers, with the help of local rural extensionists, gradually introduced a number of changes in the way potato was cultivated in the Xicuru region - until 1988 when a more significant change took place (IPA, undated).

In 1988, IPA organized the potato project which tried to make it possible for the farmer's association (APROBACA) to offer small farmers, including non-members, a subsidized loan with which they could buy manure and potato seeds. The seeds were bought in Esperança, Paraíba. Unfortunately, they were nothing more than tubers grown for the market, not certified seeds (approved by the Ministry of Agriculture) free from disease.

The harsh reality of rural life in a semi-arid region taught IPA researchers, very rapidly, that they would not be able to take anything for granted and that their mistakes could easily place farmer's livelihoods at risk. Full of good intentions, IPA researchers encouraged farmers to use manure in their potato fields. As manure is a commodity in short supply in the region, IPA helped APROBACA to arrange for a number of large cattle ranchers to supply the small farmers of Xicuru with this very useful but expensive input. The end result was disastrous: a large part of the potato fields simply died. A local rural extensionist from EMATER estimated a loss of over 50 per cent (Mariano et al., 1989).

After the initial shock, IPA began to investigate what could have gone wrong in the first year of the potato project in which output was expected to increase by between 10 and 30 per cent. It did not take long for IPA researchers to conclude that the manure - bought with a federal loan - was contaminated with high levels of herbicides. Researchers were completely unaware that the large cattle ranchers who sold their manure to the Xicuru farmers had been spraying their pastures with herbicides. As a consequence, the potato crop, instead of flourishing, died.

In spite of this setback, IPA and APROBACA decided to continue working together and to find out ways of improving the potato crop. Improved husbandry practices were introduced within the framework of the potato project and were well accepted by the Xicuru farmers: ploughing with animal traction (oxen) and planting potato seeds in furrows opened-up with animal traction rather than using the usual planting method of opening individual holes (*covas*) with a hoe for each seed. Hilling-up (*amontoa*) on the 30th day after planting the seeds was another significant technique introduced in the region. Farmers understood that by pushing soil towards the base of the potato plant they could not only protect the growing tubers from being damaged by the sun light but, more importantly, could protect them from attack by certain pests. Hilling-up can and should be used in place of certain preventative pulverizations (pesticides) which would not be recommended because they are expensive and damaging to the farmer's health and environment.

The value of PTC may be appreciated even when things have gone wrong. If IPA researchers and farmers had not been working closely together, researchers would not have found out that the manure bought by the potato project was contaminated and had been responsible for farmers losing most of their first potato harvest in 1988. Given the favourable weather conditions of that year, farmers were able to plant a second crop before the end of the season. Moreover, by 'living' with the small farmers of Xicuru, IPA researchers were well aware of farmers' lack of capital and, therefore, were able to reach the conclusion, together with APROBACA, that the potato project could do without certain pulverizations. The fact that the majority of Xicuru farmers could count on family labour to do the hilling-up made the project's recommendation more accessible to the Xicuru farmers, explained the president of APROBACA (fieldwork, 1990).

5.7.2 1989: upgrading the potato project

As a result of farmers' needs and demands, IPA re-designed the project in 1989. A number of important changes were made to the original project and were welcome by APROBACA. Supplying farmers with good quality seeds, preferably certified seeds (approved by the Ministry of Agriculture) became a top priority, as already explained. The seed experiment, carried out by IPA and APROBACA and described in section 5.6, demonstrated to all those involved in the project that the answer to that problem would need to come from elsewhere. Xicuru farmers did not have the financial resources nor the land to produce certified seeds. For that reason, the project imported a certain quantity of certified seeds from the South of Brazil. However, due mainly to the high cost of those seeds and its short supply, it was also necessary for the project to buy common seeds from Esperança - seeds that unfortunately proved to be partially contaminated with the common scab of the potato or *sarna*.

What was really unfortunately about the contaminated seeds incident is the fact that it was not an accident. An IPA agronomist and researcher, whose specialization included potato diseases, was sent to Esperança by PRORURAL - the project's funding agency - with the sole task of accessing the quality of the potato seeds that the project would buy and distribute to the small farmers of Xicuru. That researcher declared during a fieldwork interview (1990): "The seeds were rubbish and I did not authorize the purchase by PRORURAL". For reasons that were beyond this researcher's knowledge, or discretion, those same seeds that he had rejected arrived in Caruaru and were made available to the small farmers of Xicuru. Many farmers, who were well acquainted with the potato crop, soon realized the potential for disaster and preferred not to join the project in 1989. Other farmers thought that the problem was not so serious and decided to go ahead with the purchase of the Esperança seeds. A smaller group, perhaps, was completely ignorant or totally confused about this very complex disease that they call *sarna.*

In the case of the 1989 contaminated seeds, it emerged that vested political interests spoke louder than the technical report made by one of IPA's scientists. As the only viable alternative in 1989 was to cancel the project altogether due to the lack of seeds that could replace the 'bad' ones from Esperança, it should not come as a surprise - even for those with limited knowledge of local politics in rural regions of the North-East - that the purchase of the contaminated seeds was approved on political grounds. The biological details of a disease such as the common scab do not seem to belong to the universe of the politicians responsible for authorizing the referred purchase. "You can always blame God if something like that happens", said an IPA researcher philosophically while sadly pondering the losses incurred by many small farmers in 1989.

On-farm experiments carried out by IPA (IPA, 1989) supported the idea that the use of both organic and chemical fertilization would increase the productivity of the potato crop. Researchers, after discussing the issue with Xicuru farmers, came up with the following suggestion, which was incorporated into the 1989 potato project. For a potato field of one hectare (ha) farmers would buy:

- seeds (36 boxes);
- chemical fertilizers (2 types);
- agro-chemicals (4 types);
- technical assistance (IPA and EMATER); and
- PROAGRO (an agricultural insurance).

Farmers would pay the Government (PRORURAL) with a proportion of their harvest or 50 bags per hectare (3tons/ha). IPA estimated that productivity should increase from the local estimated average of 7 tons/ha to 12 tons/ha. Thus, farmers agreed to pay the equivalent of 25% of the expected output per hectare after the potato harvest. To put things into a broader context, in Brazil the average is 10 tons/ha, one-third that of the leading European potato producing countries where productivity reaches 30 tons/ha (CNPH, 1985). São Paulo is the Brazilian state where productivity levels are higher: 16.7 tons/ha. In Rio Grande do Sul, on the other hand, the state with the largest planted area, productivity is fairly low (5 tons/ha) due to the scant use of modern inputs. In 1995, mainly because of the success of the potato project and the effort of the farmers' associations, productivity in the Xicuru region was between 12-16 tons/ha (Lopes,G.M., IPA researcher, personal communication, 1996).

5.7.3 1990: further changes in the potato project and the question of empowering the farmer

Major economic and political changes promoted by the new administration of president Collor, March 1990-December 1992 (Bresser Pereira, 1996), had a negative impact on the potato project. With the freezing of all savings accounts, the Federal Government placed a heavy burden on development agencies such as PRORURAL which was funding the potato project. As a consequence, the purchase of the project's inputs mentioned above - seeds included - were delayed. Besides, the lack of rain in the Agreste region caused IPA, the technical 'voice' of the project, to consider suspending it.

Nevertheless, many farmers, represented by APROBACA, were willing to risk planting the project's seeds in 1990. Despite IPA's position against, and after much deliberation, the project received the go ahead from IPA and the project's administrators. As many Xicuru farmers had already cultivated all their fields, mainly with other crops, there was a surplus of project seeds which IPA used to promote the cultivation of potato in other parts of the Agreste of Pernambuco. "We cannot afford to wait for the potato seeds and have to weed our fields a second time. If you do not plant anything in a ploughed field, the weeds will take over", explained a Xicuru farmer who could not plant the project's seeds in 1990 because all his land was already occupied when the seeds became available.

Despite this drawback, the project went ahead but, as IPA expected, the final result in terms of output was not very good , mainly due to the dry conditions prevalent during that agricultural year. From the point of view of the small farmer, however, the farmer's decision to cultivate potato in 1990 proved worthwhile: "The profit margin was smaller this year but I managed to make good money with the potato" (Xicuru farmer fieldwork, 1990). As already explained in chapter 1, different authors have indicated that the main objective of a small farmer is not necessarily profit maximization (Bezerra, 1986; Brandão, 1988). The small farmers of Xicuru are no different in this respect than his fellow farmers world-wide and may be quite willing to compromise, or to give up a percentage of his profit margin in exchange for a certain minimum amount of income which would guarantee their families survival. "I need to have some money in my pocket in order to go to the market. There is nothing better than the potato crop - it is good money. However, I will not stop planting maize and manioc. That is a little money for the shopping and what we eat everyday" (Xicuru farmer, fieldwork 1990).

The Xicuru farmers are more interested in increasing output and stabilizing production rather than the profit margin. Thus, Xicuru farmers, like most small farmers, do not farm their land thinking mainly in terms of maximizing their profit share as a typical capitalist entrepreneur would do (Guedes Pinto, 1981; SUDENE, 1987). Or, as Piñeiro and Trigo (1983, p.91) put it: "Because of the magnitude of risk, it appears reasonable that producers are more concerned with controlling the threats to their survival than with incorporating innovations that will maximise their income". In Caruaru, for example, small farmers, despite their enthusiasm for the potato - their most profitable crop - did not aim to maximize their agricultural income through the production of potato only. Their priorities are a complex mix of different crops and other activities which defy the logic of the large commercial, often monocrop, farms. Guaranteeing the survival of their family is probably more relevant, from the small farmers' point of view, than the extra income that one may obtain by adopting a bolder farming strategy in an environment which is not suitable for the type of rain-fed agriculture being practised in the region.

The great weather variations which characterize the Agreste region are often blamed for the large income fluctuations that a small farmer experiences even within a single year (IPA, 1985 and 1991). This income instability is, perhaps, one of the biggest problems facing the small farmers of the North-East, especially because they cannot count on significant capital reserves to soften the impact of crises caused by climatic disasters such as droughts or torrential rains. Thus, in order to guarantee their survival, small farmers behave in a manner which is different from that of a capitalist firm. It is necessary to stress, however, that Xicuru farmers are not insensitive to the idea of profit. As it will be further explained in chapter 6, they all planted potato because it was a profitable crop.

The changes and problems that hindered the project in 1990 were very important within the context of PTC because they revealed that APROBACA, the farmer's association, was listened to and respected by IPA. Moreover, it demonstrated that APROBACA had a certain political clout. APROBACA demanded in June 1990, for example, that IPA authorize the start of the project, even though researchers had concluded that it was too late in the agricultural calendar for this. As farmers accepted the higher risks of starting to plant potato as late as early July (often they begin in February or March), IPA researchers supported the farmer's decision and so did the mayor of Caruaru. It is important to add that since APROBACA's refrigerated warehouse became operational in 1986, almost all Xicuru farmers involved in the survey carried out for this study declared that they were storing part of their potato output and using it as seeds in the following year. Thus, they did not depend on the project in order to grow potato.

IPA's respect for the farmers of Xicuru became even clearer when, at a very important meeting with all the different agencies involved in the potato project, the head of IPA-Caruaru research station strongly defended the idea of transferring more power to APROBACA (IPA, 1990a; 1990c; 1990d). To avoid delays and administrative problems such as those which farmers had to face in 1990, Antônio Felix da Costa also recommended that APROBACA be given the choice of organizing its own purchase of certified potato seeds directly from the suppliers in the South/Southeast of Brazil. Very importantly, the head of IPA-Caruaru pledged to continue providing APROBACA all the necessary technical support, as well as some very essential practical help: contacts, telephone numbers of possible suppliers, and even the use of their office facilities in order to allow farmers to contact the seed suppliers and close deals.

The head of EMATER-Caruaru also stressed the same point. In his view, EMATER would be in a better position to technically assist the small farmers of the region if APROBACA, for example, could take over a number of administrative chores which rural extensionists were performing in order to help APROBACA. "By becoming more self-sufficient, APROBACA would allow the extension services to concentrate their effort on improving their technical assistance to farmers" (head of EMATER-Caruaru, fieldwork, 1990). This viewpoint was also supported by the representative of the mayor's office who attended an important meeting in November 1990 when APROBACA and all the agencies involved in the potato project sat down together in order to plan its future. In many respects these initiatives contain important elements of what is referred to as 'shift of power' (Nelson and Wright, 1997a; Chambers, 1997a), or an empowering process with a shift of power to those who are local and poor. A process which implies, among other things, loss of central power, similar to the one suggested by both IPA-Caruaru and EMATER.

5.8 Misconceptions, problems and *malandragem*

The potato project included a provision for accidental crop loss due to adverse weather conditions or other unexpected events, such as the contaminated manure in 1988 or the infected seeds in 1989. In the case of crop loss, a rural extensionist from EMATER would have to provide the local bank, which was channelling PRORURAL's funds to farmers, with a proper report which would specify the new amount that the farmer owed PRORURAL. Hence, the accidental crop loss should work, in practice, as a form of insurance for the farmer. It was certainly a very important 'safety net' that was incorporated into the potato project, but one which had a negative side that may have been unknown to those financing the project.

Many farmers apparently misinterpreted that clause (accidental loss) and began to talk about the '*perdão*' (pardon), instead. Those farmers believed that, if things went wrong with their potato crop, they would not need to pay back the bank. Moreover, most Xicuru farmers were on very good terms with the rural extensionists responsible for providing the bank with the final report regarding the amount of money that each farmer would have to pay after the potato harvest. Thus, farmers appeared to be very confident that the extensionist's report would always help him with the bank.

It is in this context that fieldwork information - collected and observed directly during 1990 - seems to corroborate the idea that farmers may be under-reporting their potato output and/or over-reporting their 'accidental' losses. Very often, during informal conversations, farmers would refer to the *perdão* as something positive that they could count on at any time and not only if and when an accident occurred. It is very likely that this belief, held by many Xicuru farmers, is largely to blame for a certain complacency shown by a number of them.

Another type of distortion which is very difficult to measure due to its very nature involves farmers who would be willing to sell, on the black market, several of the modern inputs which they would obtain - at a subsidized price - through the potato project. Inputs such as the different types of chemical fertilizer or the agro-chemicals which farmers were supposed to use in their potato fields to increase productivity, and therefore, their potato output. The effect of those sales on output is unclear. Many of these farmers who were cheating the project's guidelines, were probably not fully aware or could not grasp the complex mathematics involved in the project calculations which fixed the amount farmers needed to pay for one hectare of potato. As already mentioned, the repayment was fixed at 50 bags of potato (60kg each). IPA estimated that with the new technology, potato output should reach 12tons/ha. Researchers expected productivity levels to rise, in a good year, to 15 or even 18tons/ha. If that happened, farmer's repayments to the project would continue to be 50 bags/ha (3tons/ha). Thus, the project would become relatively cheaper as farmers became more efficient. By selling inputs on the black market, farmers might be sacrificing productivity gains that would bring them more money than the sale of those inputs once the potato crop had been harvested.

Unfortunately, the majority of farmers seemed to have genuine difficulty in understanding and dealing with the notion of increasing productivity. Farmers would talk about producing 12tons/ha (the parameter used by IPA) but would not try to obtain higher output. Furthermore, they were not behaving in a manner consistent with the idea of raising their productivity, as far as their farming practices were concerned. Selling the fertilizer on the black market (behind the researchers' backs) and having the cash in their hands was apparently much more important to those farmers than considering whether that same amount of fertilizer would generate more income in two or three months time as a result of productivity gains.

This case involving the small farmers of Caruaru does not seem to be an isolated example of small farmers trying to exploit the system. As a matter of fact, it appears similar to what is happening with small farmers in the Brazilian Amazon region. As it was pointed out by Hall (1989, p.153): 'There is no reason to suppose that small farmers, as well as large producers, will not utilise the system to their advantage whenever possible; for example, by engaging in their own form of modest but speculative ventures, selling off cleared land to incoming settlers for profit which, in their terms, may be quite handsome'.

The question of how to increase the productivity of the potato project is an important issue which all those involved in the project - IPA, EMATER, PRORURAL, Bandepe, Banco do Brasil and Caruaru Council (*prefeitura*) - needed to carefully analyse and discuss with the farmer associations. IPA researchers support the idea that there is a good potential for improving the productivity of the potato crop and, therefore, the efficiency of the potato project. A potential that may in fact exist, but one which appears underexplored due to beliefs such as the *perdão*, and the possible lack of knowledge, from the farmer's point of view, of what is involved in the concept of productivity gains. In sum, further participatory discussions with all those involved in the project are called for to improve the project as well as to put a halt to the *malandragem* (roguery) which was being practised by a number of farmers.

5.9 'Dictatorship of participation' and 'the diplomacy of the practical farmer'

Having said that it is, perhaps, appropriate to remind the reader of certain dangers of what shall be called here 'dictatorship of participation'. Within the context of the 'dictatorship of participation' farmers are involved in many aspects of the research process but, in practice, have very little or even no say at all in the most important decisions which affect them.

For an institution which was still struggling with the new participatory and systemic methodology - PTC - it would not have been surprising if IPA researchers had also behaved more in line with the Conventional Agricultural Research approach or CAR (Chapter 1) rather than with PTC. "The methodology which we are using now is new but we are the same", admitted an IPA researcher. Two examples may illustrate well the point in question. IPA researchers, despite their commitment to PTC, apparently could not avoid trying to impose two major conditionalities on the potato project:

(a) the timing of the start of the planting of the potato crop;

(b) the type of soil in which the potato crop should be cultivated.

Firstly, despite the very weak scientific evidence to support their position, IPA researchers and other project administrators from the mayor's office wanted farmers to start planting the project's potato only in May. The fact that the rainy season starts in February/March and lasts only six months was not considered important. Besides, the fact that the Xicuru farmers had many rational and/or good reasons (even on agricultural grounds) not to agree with them also seem not to have mattered as already seen in previous chapters.

To recap, farmers had explained to IPA researchers that by planting early they could not only try to sow potato twice in an agricultural year but, perhaps more importantly, they would save money on storage fees. Cold storage, in the case of the potato crop, is essential to reduce sprout elongation of seed tubers from the time the potato is harvested (August or September) until approximately planting time. Near planting time, often around February in the Xicuru region, farmers wish to quickly break the seed dormancy by switching off the refrigerated warehouse (*frigorífico*). Moreover, it is by this time, March/April, after six months of dry weather, that the Xicuru farmers are desperate for cash and need to start planting as soon as possible. "We want to get our hands on the potato money. We all need cash to go to the market in Caruaru" (Xicuru farmer, fieldwork 1990).

Probably even more significantly, IPA and all the other agencies involved in the potato project, did not seem to take into account the fact that the small farmers of the Xicuru region are paying for the potato project. The project may be subsidized but it is not free. In late 1991, when the fieldwork for this study was concluded, researchers were still strongly in favour of the idea of imposing a starting date on farmers joining the project. A suggestion rejected by farmers who need to start cultivating their fields in February/March, the beginning of the rainy season.

Contradicting its own proposition, IPA's three year experiment involving the potato crop response to different applications of cattle manure and varying planting dates (Lopes, 1990, p.88-89) appears to confirm the farmer's position that it is much better to risk planting the potato crop early in the rainy season (March) rather than in May/June as strongly recommended by IPA. In 1986, for example, when the crop was planted in early March the total amount of rainfall during the potato crop cycle was 512.6mm and the average output reached 8.5 tons/ha, according to IPA's own report (2). In 1987, when IPA waited until June to plant the potato crop results were disastrous: 'Potato production was seriously affected by poor rainfall distribution in 1987. In this year only 174.2mm of rainfall was registered during the crop cycle, when from the end of July only 9.7mm of rain fell, affecting the stage of tuberization of the potato' (Lopes, 1990, p.88). Average output reached only 6.7 tons/ha in that year of the experiment, a drop of 21% in relation to 1986 when the planting started in March - as farmers wanted. In 1988, planting started in May and, once more, the results do not support IPA's proposition that a late planting date will produce a larger harvest. 'In 1988 the water shortages occurred at the beginning of the crop cycle and [rainfall] reached only 272.0mm by the end [of crop cycle] when the crop estimated needs are between 500 and 700mm of water' (Lopes, 1990, p.89). Potato output in the IPA experiment being discussed here averaged 7.7 tons/ha, almost 10% less than in 1986.

The second example (b), perhaps more important within the context of the 'dictatorship of participation', is about IPA's determination to decide where farmers should plant project seeds. Thus, researchers created another conditionality that, in the end, would select which farmers were allowed to join and pay for the potato project and which farmers would have their application rejected. Once again, IPA researchers, with no solid scientific evidence to support their decision, excluded from the project all farmers who could not commit themselves or promise that they would only plant the 'good seeds' of the project in new soil. In other words, IPA researchers decided arbitrarily that farmers could only use the seeds that they would obtain through the project in fields that had never been cultivated with potato before.

By trying to oblige farmers to do what researchers thought would be better for the Xicuru farmers, IPA was trying to prevent the spread of a serious disease which was damaging the potato crop in the region - the potato common scab potato (*sarna*). As explained in section 5.6, there are several other ways of preventing and/or controlling the common scab. Moreover, this conditionality was totally impractical - it would have been impossible to implement because only the farmer himself could tell where he had cultivated potato or not in the past. Furthermore, farmers who had been careful enough, or lucky enough, not to have their soil contaminated with the deadly bacteria would be prohibited from growing potato in what is often their best agricultural land, or on the plots which have received manure and are used for the potato crop. Thus, researchers ignored the fact that the small farmers of Xicuru have very little land available and probably no agricultural land suitable for the potato that had not been cultivated with the tuber, at least once. IPA researchers also ignored the fact that even a certified seed may contain the disease.

IPA researchers admitted in 1990 that farmers who cultivated potato for the first time in their lives during that season - using only certified seeds from the project - were facing the problem of the common scab and, thus, have had their clean soil contaminated indefinitely. "It is not unusual to have up to ten per cent of contaminated certified seeds among the project's total supply", commented an IPA researcher (fieldwork, 1991) who was not concerned with the fact that a public research institution (IPA) and an official government project could be promoting the contamination of farmers' precious asset - their land. The question of the government having to pay compensation to those unfortunate farmers was not even considered and, most probably, would never cross an official's mind.

The farmer's response to the above impositions, looking as an outsider, appeared either very mature or skilfully cynical. Farmers agreed with everything researchers were saying and suggesting - after attempting to explain the reasons of their disagreement and being ignored - and did exactly what they thought would be best for them anyway. By using the 'diplomacy of the practical farmer' the Xicuru smallholders were able to benefit from a new technology (potato cropping) and improve their agricultural output and standard of living without having to confront the remains of the Conventional Agricultural

Research approach head on.

In sum, as it will be further observed in chapter 7, the capacity of farmers to work together and form associations that would protect their interests is a key factor in the search for technological innovations and certain agricultural policies which meet their needs and promote their well-being. In the following chapter, the impact of the technological change (potato cropping) discussed in the present chapter is examined in some detail.

5.10 End Notes

(1) One *quadro* is the equivalent of 1,2 hectares.

(2) Potato Crop Experiment with Manure Application (Mean Potato Output in t/ha).

Dosage of Manure (tons)	1986	1987	1988
0	6.94	4.38	5.85
5	6.35	6.06	7.10
10	9.32	6.86	8.21
15	8.81	8.86	9.36
20	11.07	7.43	9.36
Average	8.50	6.72	7.70

Source: Elaborated from Lopes (1990, p.88).

CHAPTER 6
Technological Change and Its Socio-Economic Impact: Data Analysis

6.1 Introduction

The main aim of this chapter is to study the socio-economic impact of a specific kind of technological change upon a group of small farmers of the Agreste of Pernambuco, North-East Brazil. The most relevant impacts of this new technology, that is, potato cropping that resulted from PTC, will be assessed in areas such as: agriculture (crop area under cultivation, land productivity), family labour (labour productivity), agricultural income, living standards, consumption (consumer goods), and investment (cattle, housing, farm equipment and transport equipment). The consequences of technological change will also be observed in other areas which were only briefly considered in this study: namely, education and health.

As already explained in Chapter 3, the main instrument of data collection consisted of a cross-sectional farmer survey with all 82 farmers who introduced the technological change. The data obtained through the survey were complemented and verified by information collected through direct observation, informal interviews with key individuals and a case study of a few farmers - all carried out during nine months of fieldwork in the North-East. The information gathered through these other non-survey means was crucial for the data analyses, especially in instances where the socio-economic changes taking place could not be quantified and, therefore, were assessed by means of closed questions (see appendix). The farmer's attitude to changes in land and labour productivity, agricultural income and living standards, for example, was probed by asking the respondent to place his or her opinion on a positive-negative scale.

In the second part of the data analysis (section 6.9) four areas which farmers tend to prioritize are investigated in more detail: consumer durable goods; farm equipment; transport equipment and housing. Furthermore, cross-tabulations, or contingency tables, are also used in the data analysis to verify whether the socio-economic changes observed could, in fact, be associated with the introduction of the new technology in the Xicuru region, Agreste of Pernambuco. Contingency tables are one of the simplest and most frequently used ways of demonstrating the presence or absence of a relationship (Bryman and Cramer, 1990). The figures which appear in many tables were rounded up or down to the nearest number in order to facilitate the reading of these tables without interfering with the results.

6.2 Changes in the Area Cropped

After the introduction of the new technology, over 80% of the farmers who participated in the survey undertook what they called 'important changes' in the area they had under cultivation with crops (Table 6.1).

Table 6.1. Farmers who Undertook Important Changes in their Cultivated Area with Crops After the Technological Change, Caruaru 1990, Brazil.

	Frequency	Percentage
YES	59	82
NO	13	18

N = 72; Missing cases = 8
Source: Farmer Survey (Fieldwork, 1990).

The high proportion of farmers (82%) who did change their farming behaviour appears to reflect the importance that they attribute to the new crop in terms of improving their socio-economic circumstances. Tables 6.2 and 6.3, below, display a summary of those changes.

Traditionally, the small farmers of Caruaru have been growing three main crops for at least two generations: beans, maize and cassava or manioc (*Manihot esculenta Crantz*). Cassava has been by far the most important both in terms of area under cultivation and agricultural income. However, as depicted in Table 6.2, more than three-quarters of all farmers considered potato their main crop in 1990. 'Main crop' in this context means the crop which is most important in terms of income. When the number of farmers that treated potato and a second crop (usually cassava) as their main crop is taken into account, that figure reaches 92%. Only five percent of farmers declared that cassava was their main crop in 1990. This is an important finding because, until the mid-1980s, most of the farmers in this study probably still considered cassava to be their main crop. Table 6.2 shows the relative importance of the principal crops cultivated in the region surveyed in 1990.

Table 6.2. Main Crop Cultivated by Small Farmers in Caruaru,1990 (farmers' opinions).

Crop	Frequency	Percentage	Accumulated (%)
Potato	62	78	78
Potato+other	11	14	92
Cassava	5	6	98
Beans	2	2	100

N = 80
Source: Farmer Survey (Fieldwork, 1990).

The changes expressed in Table 6.2 are significant within the context of the agricultural development of the Agreste region. Even the twenty farmers who started cultivating potato before 1980 explained that until the mid-1980s, or in other words, before the involvement of IPA researchers with the potato crop, the formation of the farmer's association in 1984 and the construction of the cooling-storage house (*frigorífico*) for the potato seeds in 1986, the potato crop was not important in relation to the other crops.

One of the most important aspects of the changes that took place regarding the use of the land occupied by crops concerns the cultivation of cassava. As indicated in Table 6.3, a very high percentage of farmers (92%) decreased the area they traditionally occupied with cassava after the introduction of potato cropping. At the same time, 50% of farmers decreased their area of beans and 31% their area of maize. The next sections (6.2.1 and 6.2.2) will discuss these last two changes in more detail.

Table 6.3. Changes in the Area under Cultivation with Crops Experienced by Farmers After the Technological Change (%), Caruaru 1990, Brazil.

	Cassava	Beans	Maize
Decreased	92	50	31
Increased	3	45	64
Same	5	5	5

N = 80
Source: Farmer Survey (Fieldwork, 1990).

In order to form a clearer picture of the significance of the changes described in this section, it is imperative to stress the fact that the small farmers of Caruaru are seriously constrained by the small size of their plots and their economic circumstances.

Moreover, the semi-arid climate predominant in the region makes farming very difficult. These limiting factors have forced the small farmers to adopt a farming strategy that may seem to outsiders (researchers, development workers and policy-makers, for example) as averse to change. Nevertheless, as will become evident from the survey data, farmers are capable of changing even old farming habits and are frequently carrying out their own experiments with the objective of improving their farming practices, as pointed out in chapter 1. Farmers in Caruaru are well aware of the difficulties they have to face and the need to look for better alternatives to their three traditional crops: cassava, beans and maize. They may seem very cautious when considering suggestions that they alter their farming practices but they are not averse to change, as the adoption of potato cropping that resulted from PTC illustrates.

6.2.1 Declining Cassava Cultivation and Higher Agricultural Income

One of the striking facts to emerge from the fieldwork carried out for this thesis is the sharp reduction in the area planted with cassava. Although there is no official data available, it is possible to estimate from the responses farmers provided during the survey that they have reduced their cassava fields by a factor of two or three since the introduction of the potato. Local agricultural researchers from IPA, familiar with the region, had not suspected that the impact of the new technology had been so profound in this respect.

The move away from cassava cultivation may also be considered profound because of three additional reasons. Firstly, cassava cultivation is a very traditional activity in the region and is considered an important source of income. After twelve or sometimes eighteen months of hard work, farmers are able to harvest the cassava root and then turn it into flour for sale in Caruaru market. Farmers complain that the process is laborious, time consuming, expensive and, as flour prices are often low, the profit margin is small. However, as the cassava plant is resistant to drought and can be grown in poor soils, it is highly regarded by local farmers and seen as an insurance against bad weather and difficult times. Moreover, as the root can be kept in the soil for long periods of time, farmers plant it in such a way as to be able to harvest it almost throughout the year. It is guaranteed cash for the weekly shopping (*feira*), say farmers. Cassava is considered by many to be the safest source of income available to local small farmers (Lopes, 1990). Secondly, cassava flour forms an integral part of the local diet and farmers enjoy producing their own supply. Thirdly, the cassava crop is also appreciated by farmers because the plant (stem and leaves) together with the waste pulp that results from processing the roots is used as forage for their cattle, which are highly valued in the region as a form of capital investment (see section 6.7).

Given the importance of cassava within the farming system of small producers in the Caruaru region, it is necessary to clarify why over 90% (Table 6.3) have chosen to decrease the area traditionally used for growing cassava. Farmers explained that, although cassava is an important crop, they preferred to set aside a larger area for planting potato instead of cassava. They argue that potato prices are often better than cassava flour prices and that the return to the investment is faster: three months in the case of the potato crop and twelve to eighteen months in the case of cassava, depending on the variety. A number of farmers put it very clearly: "We make more money with the potato and it is easier and quicker than cassava" or "Cassava does not even provide us with a new shirt at the end of the year". Moreover, the potato requires no processing to be sold in the local market and is considered an 'easy' (physically undemanding) and lucrative crop by farmers of all age groups. All 80 farmers who participated in the survey, without exception, declared potato to be a profitable crop.

The decrease in the area cultivated with cassava seems to be a result of the farmer's decisions to gradually expand their potato growing areas and probably their total agricultural income too. To understand this apparent improvement in income it is important to bear in mind the fact that making cassava flour is a labour-intensive process which is relatively costly for the small farmer. Hired labour to harvest and peel the roots as well as fuel-wood and electricity are important components of the cost of producing flour. Besides, during the winter (wet) season when the potato crop is grown, flour production is less profitable, largely due to the low productivity of the plant. The high water content of the roots during this period makes flour production more difficult and almost uneconomical. Even the keenest flour producer admitted that it made sense to decrease the area occupied by cassava, drastically reduce the production of flour during the winter and concentrate on the production of potato. "This is the only season when we can grow potato and make a lot of money. I stopped making flour during the winter", said a small farmer whose opinion is highly respected by local agricultural researchers and represents the general view of the farmers surveyed. Therefore, by decreasing the cultivation of cassava and the amount of flour produced during the winter months, farmers can avoid an outlay that they consider important and save precious time that they may use to better tend their potato fields and try to increase their income.

6.2.2 Changes in the Area Cultivated with Beans and Maize, and Land Productivity

According to farmers' preferences and needs, and possibly due to the extra income provided by the potato crop, the small farmers of Caruaru have also been changing their farming behaviour with regard to beans and maize, as previously shown in Table 6.3. As most farmers intercrop beans and maize (*consórcio milho-feijão*) it is not easy to understand the changes in the area cultivated with these two crops. A number of farmers declared that they believe bean cultivation to be too risky given the local climate, and started substituting it with potato. Researchers confirmed that one of the problems with the bean crop is that, even in a good agricultural year, its productivity can be drastically reduced if it rains during harvest time because the seeds would germinate before being harvested (IPA, 1985, p.12). Despite the possibility of selling surplus beans in the market, 50% of farmers reduced their production area. Others decided to invest part of the profit obtained from the potato to increase their small areas of beans and, thus, try to boost their incomes. Maize, on the other hand, is produced largely for domestic consumption and forage for cattle. Forage production is probably the main reason why 64% of farmers expanded maize growing areas (Table 6.3). "Even when I know that due to the lack of water I will probably not be able to harvest the corn-cob, I plant maize because the stubble is important for the animals", was a frequent comment. As will be seen in section 6.7, it seems that part of the profit generated by the potato crop is being invested in cattle.

Perhaps even more important than the change in the area cultivated with beans and maize is the fact that the productivity of both crops increased, according to farmers. Unfortunately, local researchers could not confirm this information since they were not involved in that type of research. Many farmers revealed during the interviews that - after they had started cultivating potato and using the new technologies associated with it- they were planting less beans and/or maize but harvesting more. Researchers working in the area agreed that the residual effect of the fertilizers used in the potato fields and the pest and disease control methods that farmers started to use in those fields and then, in their other crops as well, are bound to increase the productivity of maize and beans, as farmers suggested during the fieldwork. Previous on-farm research carried out on an operational scale in that same region of the Agreste had shown the positive response of the *consórcio* maize-beans to organic and chemical fertilization (IPA, 1982 and 1983).

6.2.3 Area Under Cultivation, Participatory Technological Change (PTC) and Local Culture

A couple of examples may help the reader to better comprehend the small farmer's attitude towards technological change and the changes in the area under cultivation with crops mentioned in the previous sections. The relevance of participatory research methods in facilitating the understanding of the small farmers' problems and thus, the generation and transference of technologies that would meet their needs, may also be depicted from the examples. Moreover, in attempting to implement a participatory research approach, IPA researchers learnt that economic and cultural considerations may play an important role in determining what and when farmers will plant and how much they are willing to modify their agricultural behaviour.

Firstly, IPA researchers revealed that, during the past few years, they have been trying, with little success, to convince farmers that they should plant potato only once during the wet season and that they should start the planting in May - the wettest month of the year according to IPA statistics. They also explained to farmers in Caruaru that the potato crop prefers a cooler climate and that it would be better to wait until May because the average temperature at that time is lower than in February. Researchers from IPA claimed, during fieldwork interviews (1990), that on-station experiments showed that potato productivity would probably be higher if farmers delayed the planting season until May. "The risk of losing the crop is smaller if farmers start planting in May", explained a researcher who could not back his statement with any scientific evidence or documentation. IPA reports are not conclusive in that respect and one of them actually indicates quite the opposite (IPA, 1989). This issue will be further discussed in section 6.9.

Nevertheless, the farmers in this particular case do not believe that they have a choice, or as a farmer bluntly put it: "We cannot afford to follow the advice of these 'doctors' who do not need to farm to be able to eat". Farmers explained during the survey interviews that by May they are in desperate need of cash to buy food. Besides, farmers also wanted the cash to pay for the celebrations of a big religious festival. "We all need money for the St. John's (São João) festival in the end of June" (farmer, fieldwork, 1990).

Thus, if farmers plant the potato crop at the end of February or after the first few rains, they know from experience that there is a good chance of earning some money by the end of May (the potato crop is harvested after approximately ninety days). Furthermore, by starting early and depending on the weather, farmers may be able to plant potato twice during the same agricultural year. They initiate the 'second planting' (*segunda planta*) immediately after the first harvest, around June, in order to maximize the chances of harvesting it again before the end of the wet season. Even if output is diminished by the lack of water (from the researchers' point of view), farmers are able to sell part of their second crop in the market and pocket the extra income. At the same time, there seems to be no clear evidence that the yield of a single crop planted in May would be superior to that of two crops. More important, according to the farmers, is the fact that it is often from the second crop that they select the seeds that they are going to store in the cooling house (*frigorífico*) and use in the following agricultural year. "The first plant we sell in the market while the second one we grow for the seeds", said many farmers during fieldwork interviews. Farmers also explained that, by planting early, they can save money in storage fees.

The new participatory research approach appears to have helped farmers to understand and even respect the researchers' point of view, although in this case they have chosen not to accept it because it was considered unreasonable given their financial needs. On the other hand, researchers, all agronomists in the case of IPA, seem to have difficulty in taking into account or understanding farmers' economic constraints. On one of the field-days organized by IPA in 1990, researchers were still insisting that farmers should plant the potato in May and only once in an agricultural year. Privately, a few researchers would admit that, after working closely with farmers, they knew that this kind of suggestion was meaningless. Others are more explicit about accepting the farmers' early-season/late season planting system (Lopes, 1990).

A deeper involvement with the farmers and a sincere desire to penetrate and understand the complexity of their farming system could increase the efficiency of the research effort. The use of a participatory research approach can, in many instances, overcome the researchers' lack of understanding of the small farmer's situation. However, a new research approach will not be sufficient on its own, especially if the researchers continue to disregard the farmers and, consequently, their needs. It would certainly help if researchers spent more time with farmers, particularly if they were willing to listen to them and, perhaps, even learn from them, as Farmer Participatory Research (FPR) theory suggests (chapter 1). The small farmers of Caruaru are experienced cultivators who know very well that farming is very difficult and risky in that region. They also know that they cannot afford to practice an ideal type of farming as is sometimes suggested by researchers. "And if we wait to plant the potato crop and it does not rain in May?", asked a number of farmers.

A second example may illustrate how cultural considerations influence the small farmer's attitude towards technological change and highlights the relevance of participatory research methods. Data collected by IPA researchers (Jair Teixeira, personal communication) reveals that the failure rate of maize is very high in the Caruaru region (7 in 10 crops are lost). That finding prompted intense debate and research into alternative crops such as sorghum to replace maize. However, it was only when IPA researchers became more familiar with the participatory research approach and started actually listening to farmers that this type of issue was fully understood. In this case, after somehow bringing farmers into the research process, researchers admitted the uselessness of pursuing 'sound' agricultural solutions (in technical terms) that would result in farmers giving up maize altogether, because of its value as cattle forage, and its very important place within the farmer's diet and culture.

A local tradition exemplifies well the role played by culture and indicates how complex is the decision-making process that leads small farmers to change their farming practices or technology. As with the case of small farmers in Ecuador mentioned by Garett (1985), the festival of St. John shows that the decisions of the Caruaru farmers may be influenced by religious considerations. In Ecuador, Garett clearly stated: "In many instances, rites and religious festivals are determining factors of great importance within the agricultural calendar" (1985, p.155).

In the case of the small farmers of Caruaru, their planting decisions are shaped by the tradition of consuming 'green maize' (*milho verde*) during the celebrations of this very important religious festival. "We plant on St. Joseph's day [19 March] to harvest just before St. John's day [24 June]" (small farmer, fieldwork interview, 1990). Not having maize to harvest just before St. John's day is not easily accepted. Eating and dancing is an important aspect of the celebrations of this festival which in the Caruaru region lasts for at least a week. The several dishes that are made from maize are highly regarded by rural and urban people alike. Hence, farmers' decisions on how much to grow of the other crops is partly influenced by the need to produce a certain amount of maize that they intend to harvest by mid-June. As the plant cycle is approximately ninety days, farmers must start planting maize in March, despite the risk of losing the crop and despite what researchers may think about it.

Moreover, farming is very dear to the vast majority of Caruaru farmers. "Farming is in our blood", explained many farmers during the fieldwork. Thus, they will probably continue to start cultivating their fields at the beginning of the rainy season - February or March. Or as a farmer vividly explained: "We are like frogs. When we see water [rain] we jump to the fields. Nobody stays indoors during the wet season".

6.3 Agricultural Revenue

The survey figures in Table 6.4 reveal that 42% of respondents claimed that their total agricultural revenue had 'increased a lot' after the introduction of potato cultivation. A further 55% reported that their revenue had 'increased'. Thus, an overwhelming majority of the farmers (97%) experienced a significant improvement in their total agricultural revenue after the adoption of the new technology. Only three per cent of farmers suggested that their situation had remained unchanged, while not a single farmer thought he or she was worse off.

Table 6.4. Changes in Agricultural Revenue After the Introduction of Potato Cultivation, Caruaru 1990, Brazil.

	Frequency	Percentage
Increased a lot	32	42
Increased	42	55
Same	2	3
Dropped	0	0
Dropped a lot	0	0

N = 76; Missing cases = 4
Source: Farmer Survey (Fieldwork, 1990).

The figures from Table 6.4 may provide an overview of the possible impact of the new technology on farmer's total agricultural revenue. Moreover, this data supports the proposition made in a previous section (6.2.1) that the decrease in cassava cultivation - the traditional cash crop in the region - did not have a negative effect on farmers' total agricultural revenue. There is an universal consensus among the small farmers of Caruaru that they are better off as a result of potato cropping.

In order to try to provide a clearer view of the significance and magnitude of the changes referred to here, it may be useful to look in more detail at the sort of income being generated by the potato crop. The average potato output sold (not total output) in the wholesale market of Caruaru in 1990 reached 113 bags (60kg each) or 6.8 tons per farmer. That total was slightly less in the previous year: 105 bags or 6.3 tons per farmer. The result seems to confirm what researchers and farmers had said about the gradual yearly increase in potato output. Thus, it can be estimated that the average income obtained by a farmer from the sale of potato reached the approximate sum of 29 minimum wages in one season. Considering the fact that a rural worker in the Caruaru region would not be paid more than a minimum wage per month (Conjuntura Econômica, 1990, p.97), it becomes obvious why the majority of Caruaru farmers said they were very satisfied with the potato crop. According to IBGE, one third of the Brazilian working force earns up to one minimum wage a month (one minimum wage averaged US$80 in 1990). Therefore, for a small farmer in North-East Brazil to earn the equivalent of 29 minimum wages within less than six months is a considerable income.

Having seen what happened with total agricultural revenue, it is appropriate now to look at the possible changes in agricultural production costs that might have occurred with the introduction of the new technology.

6.4 Agricultural Production Costs and Profit

Despite the improvements in agricultural revenue discussed in the previous section, it is possible that farmers' net agricultural income might have suffered if the costs of using the new technology exceeded the extra revenue being generated and if potato cropping were, thus, not a profitable activity. When asked about these two issues -costs and profit - farmers' answers leave little room for doubt. From Table 6.5 below, it is possible to see that approximately half of the farmers saw their total agricultural production costs go up, largely as a result of the process of technological change. Thirty one per cent observed no significant change while 20% declared a reduction in total production costs. This information is difficult to verify because the small farmers of Caruaru keep no written records of their accounts.

Table 6.5. Changes in Agricultural Production Costs Due to the Introduction of Potato Cropping, Caruaru 1990, Brazil.

	Frequency	Percentage (%)
Dropped	15	20
No Change	23	31
Increased	36	49

N = 74; Missing Cases = 6
Source: Farmer Survey (fieldwork,1990).

As all farmers, with no exception, declared that growing potato was a profitable activity (Table 6.6), it is plausible to assume that the increase in revenue brought about by the new crop outweighed the additional costs involved in the process of adopting it.

Table 6.6. Farmers who Considered the Potato Cropping Profitable, Caruaru 1990.

	Frequency	Percentage (%)
YES	79	100
NO	0	0

N = 79; Missing Cases = 1
Source: Farmer Survey (Fieldwork,1990).

Although an economist may question a farmer's own definition of what profit is, it appears from the fieldwork that farmers have a good idea of all the relevant revenues and costs involved in their different agricultural activities. Within this context, it is illustrative to mention here the decrease in some important agricultural production costs incurred by farmers, because it reveals the acute degree of economic awareness of most farmers. As was explained earlier (section 6.2.1), small farmers in the Caruaru region have been reducing their cassava fields and replacing them with potato. This resulted in a number of important changes that affected agricultural costs, as the following three examples demonstrate. Firstly, by reducing the output of cassava flour, farmers could save the money needed to buy the firewood used during the processing of the cassava roots and also the money paid to rural workers who skin the roots. Secondly, many farmers also claimed that they were saving money on hired labour used to harvest and weed the cassava fields. Thirdly, farmers who have access to wooded areas are well aware that they can reduce their production costs and increase income by selling the firewood they are not using because of the reduction in the output of flour.

Given the examples above, among many others, it is possible to conclude with a fair degree of certainty that farmers' notion of profit is valid from the economic point of view. Or as was well put somewhere else by Valdés: 'We must recognize that, although they [small farmers] may be illiterate, they are not stupid, and, although education may be limited, they are often shrewd in knowing what is profitable and what is not. Former U.S. Secretary of Agriculture Orville Freeman once remarked that he had encountered many farmers who could not read - but none who could not count' (Valdés et al., 1979, foreword).

6.5 Living Standards, Potato and Other Sources of Income

The figures in Table 6.7 help us understand why the small farmers of Caruaru often refer to the potato crop in a positive light. Not a single farmer thought his or her living standards had got worse after they started cultivating potato, and only two per cent reported that their situation continued the same as before. The vast majority of farmers, 98%, considered that they were better off after the technological change.

Table 6.7. Changes in Living Standards After the Introduction of Potato Cultivation, Caruaru 1990, Brazil.

	Frequency	Percentage (%)
Worse Off	0	0
Same	2	2
Improved	78	98

N = 80
Source: Farmer Survey (Fieldwork, 1990).

When asked to explain a little further how they perceived the contribution of the potato crop, a large number of farmers admitted that they would not have been able to continue working in the agricultural sector (or working their land) and feeding their families if they had not started potato cultivation. "The money we can get from our traditional crops is not sufficient to cover our basic expenses, especially now that the price of cassava flour is so low. The income from potato is very helpful", said many farmers during the survey. The two farmers who said their living conditions had remained the same after the introduction of the potato and many farmers who pointed out that the improvement they had experienced was not large, in their own view, explained that they could only afford to plant a small amount of potato. Therefore, farmers believed that they had not yet been able to fully benefit from the potato crop.

Nevertheless, despite their limited financial and land resources, the small farmers of Xicuru were planning to gradually expand their potato fields. As was pointed out in chapter 1, small farmers tend to introduce technological changes only gradually, on a step by step basis, and often after carrying out their own small-scale experiments. Within this context, it is worth bearing in mind the fact that, if a new technology is to be successfully applied to the existing farming system of the small farmer of the semi-arid region, particular constraints need to be taken into account: a short rainy season, high variability of annual rainfall, high evapotranspiration, the low infiltration capacity of the soil, considerable water erosion, lack of credit facilities and seasonal labour shortages at peak times (Queiroz, 1979). As a matter of fact, nearly 90% of all farmers replied during the survey that they were willing to increase the area cultivated with potato. That, in my interpretation, can be seen as further indication or confirmation that farmers do consider the technological change (potato cropping) beneficial.

The next table reveals the relative importance of the new crop within a farmer's budget and why it is so highly regarded not only by small farmers but also by those involved in agricultural research (IPA) and rural extension (EMATER) in the region.

Table 6.8. Relative Importance of the Potato Income (Farmers' Opinions), Caruaru 1990.

	Frequency	Percentage
Very Important	63	81
Medium Importance	14	18
Little Importance	1	1

N = 78; Missing Cases = 2
Source: Farmer Survey (Fieldwork, 1990).

As presented in Table 6.8, 81% of farmers consider the income obtained from potato as being 'very important' in relation to their total income. Eighteen per cent estimated that it was of 'medium importance' while only one per cent answered it was of 'little importance'. It is interesting to note that, even among the cultivators whose main occupation (source of income) is not agriculture, it was possible to find farmers who recognized that the income obtained from the potato crop is very important. This may be an indication of the growing importance that potato cropping is assuming among the small farmers of Xicuru, Caruaru. Perhaps it would be appropriate to clarify here that the small farmers of Caruaru have many different sources of income outside the agricultural sector, as presented in Table 6.9.

Table 6.9. Farmers' Main Occupation, Caruaru 1990, Brazil.

	Frequency	Percentage (%)
Agriculture	43	55
Livestock	16	20
Agric./Livestock	9	11
Commerce	5	6
Other	6	8

N = 79; Missing Cases = 1
Source: Farmer Survey (Fieldwork, 1990).

Table 6.9 shows that agriculture is the main source of income for 55% of the farmers interviewed. Livestock (cattle), on the other hand, is the main occupation of one-fifth of the farmers, while another 14% of farmers (commerce and other) did not consider agriculture their main occupation. Thus, one-third of farmers declared their main occupation or source of income to be outside of agriculture. Some of those farmers are shopkeepers, others are traders (in flour or meat) in Caruaru or truck and taxi drivers, for example.

It is during the summer season (September to February), when farmers cannot rely on their agricultural activities to generate enough income, that they intensify their search for other sources of income. Many farmers work locally as brick-layers, electricians or plumbers. Others prefer commerce (trading) while there are those who go to the town of Caruaru to look for a temporary job. Several farmers mentioned that, in the past, it was not uncommon for at least one member of a family to travel to big cities such as São Paulo and Rio de Janeiro, in the Southeast of Brazil, in search of employment. However, with the recent but gradual improvements in living conditions, farmers suggested that the need to leave their homes in search of a summer job has diminished. Instead of having to travel a few thousand miles in the hope of finding a job, many small farmers in Caruaru revealed that they are able to use the profits from the potato crop to diversify and invest in other activities that allow them to create additional revenue. Cattle (section 6.7) is the favourite second main occupation as can be seen in Table 6.10.

Table 6.10. Farmer's Second Main Occupation, Caruaru 1990, Brazil.

	Frequency	Percentage (%)
Livestock	24	37
Agriculture	23	35
Agric./Livestock	1	2
Commerce	10	15
Other	7	11

N = 55; Missing Cases = 15

Source: Farmer Survey (Fieldwork, 1990).

For almost 40% of farmers, livestock or cattle is the second main source of income (occupation). Approximately 15% have chosen commerce as their second occupation, whereas 11% of farmers are involved in other businesses such as the development of their own small chicken farms which, apparently, are prospering and are attracting increasing attention among the more enterprising farmers.

The powers of patronage are still very marked among rural people and may provide farmers with an additional source of income. The existence of a conservative patronage machine explains why interior-based politicians, who represent the traditional agrarian elite, have continued to dominate state politics in the North-East of Brazil despite increasing urbanization and the growth of light industries and services in the region (Hoefle,1985). It should not come as a surprise that patronage, in a country where the welfare system is not well developed, and particularly in the North-East where poverty is widespread, is often seen as a form of social benefit available in the rural areas to allow the 'harnessing' of voters. Within this context, pensions become another source of income that may be important to some farmers, but one that they were understandably reluctant to talk about openly. A few farmers briefly referred to their pension during the fieldwork conversations, however, they were quick to change the subject when they realised what they had done. Only one farmer was open about the subject and said: "With the money I get from my pension and from the potato crop I have decided not to kill myself with cassava cultivation any longer. If the local politicians want my help, they must give me something in return". In other words, 'pensions' may be granted to farmers (who are young and healthy) who have certain political connections.

The extent of the improvement in living standards that farmers say they have achieved is very difficult to quantify although the nature (quality) of the change seems clear: it was beneficial to farmers in various ways as will be further explained in the next sections of the present chapter. It is even more difficult to establish a causal relationship between the changes discussed in this chapter and the new technology (potato cropping). However, despite all the different sources of income that the small farmers have available to them, it is important to bear in mind the fact only one single farmer thought the potato income was not relevant when considering his total income (Table 6.8, above). There seems to be a consensus among the farmers surveyed about what constitutes the main force behind the new investments and the socio-economic changes that are taking place: the profit generated by the potato crop. The next few sections will try to investigate in more detail some of these main changes.

6.6 Farming Workload and Labour Productivity

Farmers admitted during the survey that they had made a significant change with respect to the use of labour as a result of the introduction of potato. Non-paid family labour is the main source of farming labour among small farmers in the region. Hired labour is sometimes used to complement certain types of work that the family cannot do on their own. Table 6.11 depicts changes in this area.

Table 6.11. Changes in the Use of Family Labour for Farming as a Result of the Technological Change (farmers' opinions), Caruaru 1990, Brazil.

	Frequency	Percentage
Decreased	54	73
Increased	7	9
No Change	13	18

N = 74; Missing cases = 6

Source: Farmer survey (Fieldwork,1990).

The changes regarding the use of family labour were quite widespread, as seen in Table 6.11, since 82% of all the farmers interviewed replied that they had experienced an 'important change' in the use of family labour as a result of the new technology, or potato cropping. Of that total, 73% reported a decrease in the family farming workload while 9% of farmers said they had experienced an increase. Eighteen per cent declared no important change in the use of family labour.

One farmer, for example, was very enthusiastic about the change and said: "Together with potato cropping I also started to plough my fields with an oxen. What takes me one hour with the animals used to take me more than a day with the hoe". Another farmer caused a certain embarrassment to the local researchers when his comments were taken out of context and misinterpreted by a visiting researcher. "The boys [researchers] from IPA are teaching us to be lazy", repeated the farmer. The farmer, a key figure in the community, meant that he was being very successful with the new technology and, as a consequence, had significantly reduced the area occupied by cassava. As a result he could be 'lazy' or spend less time in the fields while his family could enjoy a decrease in their farming workload. In fact, besides working hard on his farm he was using his 'new' spare time to make money in the commercial sector of Caruaru. To sum up, it appears that the decrease in the family farming workload is largely the result of the shift from cassava to potato cultivation. The consequent reduction in the production of cassava flour referred in section 6.2.1 also contributed to the decrease in the overall family farming workload.

The small percentage of farmers (11%) who reported an increase in their farming workload explained that they were satisfied with that change. They are among the farmers who, due to their previous limited economic resources, could not cultivate as much land as they wanted or needed. With the alleged increase in income provided by the potato crop, farmers could expand their agricultural production and, therefore, increase the use of family labour.

The changes in the use of family labour suggest an increase in labour productivity that cannot be disregarded even though it could not be measured directly. "We are working less and making a lot more money with the potato", was a frequent comment that farmers made during the survey interviews and other meetings. Or, "Potato cropping is the best thing that could have happened in our agriculture. It is easy when compared with cassava and it is good money". When questioned about this issue, IPA researchers stated that the new technology should improve labour productivity although they had not tried to verify this in their studies. They confirmed that the changes related to the new technology, such as the use of animal traction or the decrease in the area cultivated with cassava were significant and would probably improve labour productivity.

Farmers, in general, had been complaining about the shortage of labour available in the region. This shortage was said to be creating difficulties for those willing to expand their output, particularly of potato. Ninety per cent of farmers declared in the survey that they wished to increase the area cultivated with potato. As could be expected, the paucity of labour drove local wages upwards and put a strain on small farmers' limited budgets. According to a recent study, the shortage of labour during the wet season is one of the main constraints on production in the Caruaru region (Lopes,1990). Nevertheless, despite the farmers' dissatisfaction with the situation, it is already possible to see a positive reaction to the problem. Labour shortages had a distinct effect on farmers production considerations insofar as it motivated many of them to concentrate on the most profitable of their crops, potato, and to adopt certain technological innovations that are associated with it such as animal traction, use of fertilizers and better husbandry practices. Faced with the difficulties of expanding agricultural output through an increase in the area under cultivation, farmers are gradually thinking in terms of increasing productivity.

The shortage of labour is attributed mainly to three factors: one endogenous to the agricultural sector and two exogenous. Firstly, the difficulties of making a living from agriculture in the harsh environment of the Agreste have always tempted farmers, especially the young, to leave the countryside. Secondly, the 'pull effect' that the city of Caruaru exerts on farmers and rural workers through its busy and expanding commercial centre and emerging industries. Thirdly, the presence of a few large chicken-battery farms that moved to the region in the recent past and can afford to pay wages above the local rural market average. Farmers and researchers confirmed that these farms are attracting farmers and rural workers onto their payroll. This information was confirmed, during the survey, by several young farmers who had worked on those large chicken farms. They said that it was only the success of the potato crop that had brought them back to agriculture.

6.7 Cattle Stock

Small farmers consider cattle to be a form of capital investment. For different reasons, which are not relevant within the context of this study, most small farmers in Caruaru (over 90%) do not have bank accounts. Instead, they prefer to use cattle as a medium-term savings account to protect them against the traditionally high Brazilian inflation rates. The Consumer Price Index (INPC) rose 2,938 % in 1990 (year of the fieldwork) alone (EIU, 1993). As cattle is a fairly liquid asset in the region - the weekly cattle market of Caruaru is fairly busy and developed - the animals can be easily sold when the need arises. According to farmers, income from cattle is often used to cover debts caused by unexpected crop failures or to provide for special expenses such as marriages, funerals, clothes for a new-born baby, and so on. Fieldwork data indicates that 79% of farmers owned cattle in 1990.

Although difficult to measure due to the reluctance of farmers to talk about the precise number of animals (cattle) that they have, and particularly due to the high fluctuation in the number of animals kept even within a single year, it seems that the average number of cattle owned by farmers increased as a result of the extra income generated by the potato crop. Once the potato harvest had started, the number of animals in the region tended to increase. On Tuesdays, cattle market day, it was difficult to arrange interviews with farmers because they all wanted to visit the market. On those afternoons, driving along the narrow dirt roads that led to and from the farmers' small holdings became a dangerous task as farmers would be walking back home with their new animals.

When this issue was presented to farmers, a large number admitted that they could only afford to increase their cattle stock after they started cultivating potato. Others, who had no cattle before introducing the new technology, were enthusiastic about the possibility of investing in cattle acquired as a result of the additional income obtained from potato. A less obvious way through which that additional income affected cattle investment was through an increase in the area of pasture that farmers could rent. Potato income allowed small farmers to rent pasture in the hilly areas (*brejos*) nearby and, therefore, improve the quantity or quality of their cattle.

There are three basic types of cattle investment that farmers undertake in the region, depending on their preferences and means. First, short-term investment or speculation; second, medium-term investment and third, cattle sharing (*parceria*). For those farmers who see cattle as a short-term investment opportunity, a poor winter (rainy season) such as the one they had in 1990 hardly constituted a problem. They like to feed the animal for a while and sell it after no more than six months, preferably at the beginning of the dry season when the price of the '*boi gordo*' (fat cattle) is often better than in the wet season. The shortage of good animals during the summer tends to drive prices upwards. It also motivates a small group of farmers to speculate in cattle in the short term. Farmers with more capital and more pasture available prefer to keep their animals for longer periods to increase their profit margin. They are likely to keep an animal for three to four years as a medium term investment. However, they are always very alert to what is going on at the cattle market and will not miss a good deal. The third type of cattle investment is not very common. Farmers, without sufficient cash to buy an animal but with enough pasture to feed it, may choose to 'buy' cattle in partnership (*parceria*). The farmer with the cash will buy the animal and the one with pasture will take care of it. They will then sell the animal when it reaches a pre-determined weight, and share the profit equally (fifty-fifty). The cattle referred to here is a mixture of Zebu breeds (an undefined breed) well adapted to the semi-arid conditions of the Agreste, while the cattle rearing system is considered as semi-extensive with a low technology level (Lopes, 1990).

6.8 Schooling and Health

Besides the changes seen so far, potato cropping seems likely to have had a beneficial effect upon schooling and health. These are less tangible but involve important changes in farmers' welfare. They involve an apparent increase in school attendance by farmers' children and some health gains felt by farmers and their families. No attempt was made to try to measure these benefits precisely because they were neither anticipated nor detected during the pilot study; and ultimately because they were not objectives of this study. However, once the point was raised by a few farmers during the survey, it was possible to verify through unstructured interviews with a number of others that the same thing could be happening with a large number of cultivators.

A good example was given by a committed potato grower who was quite clear about the quality of the changes he has been experiencing since he started cultivating potato: "Even if my financial situation had not improved, I would be very happy because after the potato, my two youngest children can go to school". He then explained that when he was a child he did not have the time to go to school because he had to spend the whole day helping his father with the cultivation of cassava. As pointed out earlier in section 6.2.1, cassava cropping is hard work and very time-consuming. After that farmer had substituted a large part of his cassava crop for potato, the family workload diminished considerably, and he could afford to send his youngest children to school. Other farmers also volunteered the same type of information.

Many farmers also praised the new technology for the positive effects they perceived it had on their health. They emphasized the point that growing potato was less strenuous and time-consuming than cassava or even beans. They reported in particular that back problems and related injuries had decreased and that fatigue became less of a problem. Apparently the decrease in the family farming workload, as seen in Table 6.11, also contributed to the general wellbeing of children and elderly people that were, at least in part, released from heavy farming duties. The long hours under intense heat that farmers need to work in their cassava fields throughout the year is considered, by local doctors, as being detrimental to their health and particularly dangerous for the very young and elderly farmer (personal communication). In the Caruaru region, most children over seven years of age normally works on the farm (Lopes,1990, p.47).

It is being suggested by IPA researchers working in the region that, given the limited purchasing power of the farmers in Caruaru, even a small improvement in farmers' income could have a positive impact on the family's food intake. Moreover, the small farmers of Xicuru started to supplement their basic diet with potato. They estimate that they sell approximately two thirds of their potato output. The smaller or slightly damaged potatoes have little market value and are therefore, not sold. After selecting the seeds for next year's crop, farmers keep the remainder for domestic consumption. "In the beginning we did not know how to cook or what to do with the potato but now everybody likes to eat it", observed the wife of a farmer during an interview.

It is also being suggested that the nutritional value of the potato may contribute to the general improvement in the health of the farmer and his family. Besides being a very important source of starch (calories), the potato also contains a reasonable amount of proteins, minerals and vitamins, mainly B and C (Schenatto, 1986). In comparison with beans, a very important food crop in Brazil as a whole and a staple food in the North-East, the biological value of the potato is 58% higher than beans; containing two per cent of proteins and 360 calories per 100 grams. In relation to wheat, beans, rice and cassava, the potato presents the highest production levels of protein/ha/day (1.4kg) and energy ($55x10^3$kcal). Thus, the potato, from a nutritional point of view, is a good option for human consumption (CNPH, 1985).

It is well established that increased agricultural production such as that taking place in Caruaru could be translated into enhanced food consumption as a result either of the income obtained from the sale of the additional output or increased food availability. Moreover, increases in farmer's income may translate in better conditions of hygiene and, therefore, improved health and nutritional status (Casley and Kumar, 1987). Unfortunately, there seems to be no specific studies or data in the Xicuru region that could confirm these findings. Given the relevance of the topic, it is suggested here that future research could attempt to clarify these issues.

6.9 Technological Change and Its Economic Impact

In order to better understand the extent of the economic impact of the technological change that has been discussed so far, it is necessary to investigate in more detail a number of areas in which the impact of that change would be more likely to manifest itself. In other words, if the hypothesis that the technological change has a positive effect on farmers' economic situation holds, it is plausible to assume that agricultural income would improve and that farmers would have extra income available to spend in these areas. These are the areas that farmers tend to prioritize and in which they invest any additional income. They may also reveal negative changes in the farmers' circumstances; it is not being taken for granted that the new technology is automatically beneficial to farmers.

Thus, four areas were selected on the basis of extensive interviews with researchers familiar with the small farmers of the Agreste, and a pilot study carried out with farmers in the region just before the start of the survey and secondary analysis. The four areas investigated were: (a) consumer durable goods; (b) farm equipment;(c) transport equipment and (d) housing.

In the case of consumer goods an eight-fold classification was used: cooker (gas), fridge, liquidizer, food mixer (*batedeira elétrica*), radio, cassette player, hi-fi system and television set. The main five farming implements used in the region were classified under the label farm equipment: plough (animal-draft), cultivator, thresher (*forrageira*), sprayer (manual) and ox chart. Transport equipment comprised four items: truck or pick-up van, automobile, motorcycle and bicycle. Housing consisted of a four-fold classification involving the number of rooms, type of roof, wall and floor.

It is accepted, as Casley and Kumar (1987) have explained, that the economic benefits of a development project are often expressed in terms of income. However, in the case of small farmers, income is not only a difficult variable to define, but one that is difficult to measure accurately; in practice, it has rarely been satisfactorily achieved, as the above-mentioned authors point out. Therefore, instead of looking at income, the following analysis focused on expenditure, a variable which is commonly used as a proxy for income in evaluating change (Casley and Kumar,1987; Kutcher and Scandizzo, 1981). Fieldwork data collection has confirmed that, even if expenditure and income do not always coincide, changes in expenditure seem to reflect changes in income rather well.

6.9.1 Consumer Durable Goods

All small farmers who participated in the survey were asked whether both before and after the introduction of the technological change they possessed any of the selected consumer goods. Then, they were classified according to whether they had improved, remained the same or worsened their situation in relation to those consumer goods after the introduction of potato cropping. 'Improvement' in this context means two things. Firstly, farmers who did not have the consumer good and purchased one or more items either new or second hand. Secondly, farmers who bought an additional item that he or she already had. As the objective is to try to establish the changes promoted by the new technology, farmers who received a consumer good as a gift or inheritance were not classified as having 'improved' their situation.

The situation before and after the technological change as well as the number and percentage of farmers who did improve can be seen in Table 6.12. All eighty small farmers who were interviewed during the survey are represented below. No single farmer reported that his or her situation after the introduction of potato farming was worse in relation to the eight consumer goods selected.

Table 6.12. Ownership of Consumer Goods Before and After the Introduction of Potato Cropping, Frequencies and Rate of Change (%), Caruaru 1990, Brazil.

	Before	After	Improved
Cooker	48	69	21 (44)
Fridge	32	54	22 (69)
Television	32	63	31 (97)
Hi-Fi	14	36	22 (157)
Liquidizer	32	60	28 (88)
Radio	38	52	14 (37)
Cassette Player	2	10	8 (400)
Food Mixer	5	17	12 (240)

N=80
Source: Farmer Survey (Fieldwork, 1990).

In the case of the two most expensive consumer goods of the chosen group, cooker and fridge, the number of farmers who improved their situation was 21 (44%) and 22 farmers (69%), respectively. Thirty one farmers (97%) improved with respect to television and 22 farmers (157%) with respect to hi-fi. Twenty eight farmers (88%) improved their position in relation to liquidizer, 14 (37%) in relation to radio, 8 (400%) in relation to cassette player and 12 (240%) in relation to food mixer (Table 6.12).

Considering the typically very limited purchasing power of the small farmer of Caruaru, the number of farmers that improved their situation after adopting potato cropping is significant. Moreover, the figures in Table 6.12 which show the number of farmers that 'improved' are likely to be underestimates. This is because the farmers who had a consumer good before and after and therefore were classified as not having improved were not asked whether they had replaced that consumer good with a better or new model. This assumption that the figures might be underestimated is based on the fact that a number of farmers volunteered such information during the course of the interviews, particularly with regard to fridge and television: "The fridge is the same but I changed its motor after the potato", explained six farmers. "Thanks to the potato crop I managed to replace my television set with a new one" or "I bought a colour TV and gave my black-and-white one to a relative", said a number of farmers. Thus, it is not unreasonable to assume that the same thing could be happening with other farmers and with respect to other consumer durables but went unreported and, therefore, unrecorded.

Another way of looking at the changes in consumer durable goods is through an indicator called here 'GOODS'. This indicator was designed to capture the overall picture of what happened to each farmer in relation to consumer goods generally before and after the new technology had been adopted. Farmers who have increased the number of items (consumer durables) which they owned after having adopted the new technology (potato cropping) were classified as having 'improved' in relation to the indicator 'GOODS'. As it has been explained before, farmers who had increased the number of consumer durables which they had but clearly declared that this change was not related to potato cropping were classified as 'no change'. By considering all consumer goods together it is possible to observe that a high percentage of farmers (two thirds) improved in relation to at least one consumer good as indicated in Table 6.13. It is worth underlining the fact that not a single farmer believed that he or she was worse off after the technological change.

Table 6.13. Changes in Consumer Durable Goods (GOODS) After the Introduction of Potato Cropping, Caruaru 1990, Brazil.

	Frequency	Percentage
No Change	26	33
Improved	52	67

N = 78; Missing cases = 2
Source : Farmer survey (Fieldwork, 1990).

The information in Table 6.13 is consistent with farmers' answers during the survey about where they had invested the profit obtained from the potato crop both in 1989 and 1990. A significant number of farmers answered that they had invested in consumer goods. Furthermore, as farmers also declared that potato cropping is one of their main sources of income, it is plausible to assume that those who produced a larger potato output would be in a relatively better position to purchase consumer goods.

6.9.2 Farm Equipment

The second area where the economic impact of the technological change may be observed is in farm equipment. Only the most important and relatively expensive implements in use by the small farmers of Caruaru were selected for this purpose because it would be very difficult, if at all possible, to try to find out when and how farmers had acquired small tools and other farm equipment.

The criterion used to define 'improvement' with regard to farm equipment is the same as in the case of consumer durable goods (see 6.9.1). For example, farmers who did not have a plough and purchased one after the introduction of potato cropping were classified as having improved. And so did farmers who owned that equipment and bought an additional unit, a second plough in this case. The focus is on 'improvement' because, as in the previous case (consumer durable goods), no farmer declared that he or she had become worse off or had to dispose of any equipment after the introduction of potato cropping or as a consequence of adopting the new technology. Table 6.14 shows the situation before and after the introduction of potato cropping and the variation that occurred with each one of the main items of farm equipment, both in terms of frequency and percentage.

Table 6.14. Ownership of Farm Equipment Before and After the Introduction of Potato Cropping, Frequencies and Rate of Change (%), Caruaru 1990, Brazil.

	Before	After	Improved n (%)
Plough	20	30	10 (50)
Cultivator	8	15	7 (88)
Thresher	22	40	18 (82)
Sprayer	9	50	4 (456)
Ox Chart	23	31	8 (35)

N=80
Source: Farmer Survey (Fieldwork, 1990).

As may be seen in Table 6.14, ten farmers (50%) improved in relation to the plough. Seven farmers (88%) improved in relation to cultivator, 18 farmers (82%) in relation to thresher, 41 farmers (456%) in relation to sprayer and 8 farmers (35%) in relation to ox chart.

A second way of looking at the changes taking place with respect to farm equipment is to treat the five items of equipment as a group (for each farmer) instead of individually, as seen in Table 6.14. Those changes could then be measured by an indicator labelled 'EQUIPMENT' which was created in a similar fashion to GOODS (see 6.9.1). Thus, it was possible to classify the farmers into three categories according to changes which occurred in the ownership of the farm equipment measured through EQUIPMENT (Table 6.15). In the first category we find farmers who did not experience change. In the second, farmers who improved by one unit of farm equipment and are classified under the category 'slight improvement'. In the third, farmers who improved by between two and eight units appear under the label 'major improvement'. For practical reasons, the five different types of equipment were treated as having the same importance or weight.

Table 6.15. Changes in Farm Equipment (EQUIPMENT) After the Technological Change, Caruaru 1990, Brazil.

	Frequency	Percentage
No Change	27	34
Slight Improvement	27	34
Major Improvement	26	32

N = 80
Source: Farmer Survey (Fieldwork,1990).

After the introduction of potato cropping, only a third of the farmers maintained the same level of farm equipment that they had before the adoption of the new technology, as depicted in Table 6.15. The two-thirds that improved their situation are divided into two groups: 27 farmers (34%) improved by one unit while the remaining 26 farmers (32%) improved by between two to eight units (each unit represents a piece of farm equipment). They appear under the category 'Slight Improvement' and 'Major Improvement' respectively.

Among the farmers who declared that their situation had not improved, there is a significant number that can count on the use of their families' equipment. Because it is easy for these farmers to borrow the equipment they need from their extended family or even friends, they have chosen to invest elsewhere the profit obtained from the potato crop. Over 80% of all farmers declared that it was easy to borrow farm equipment.

This type of co-operation among small farmers in Caruaru was also noticed by Monteiro de Barros (1991) when discussing the behaviour of another group of small farmers in the Agreste of Pernambuco. He refers to forms of mutual assistance within the extended family which include, among other things, exchange of labour among relatives and the collective use of farm equipment owned by one of them. Therefore, contrary to what may be expected, farmers may feel less inclined to purchase farm equipment and more to buying a consumer durable good, for example. Another alternative available to farmers who do not possess the right piece of equipment and are unwilling or unable to buy it is to hire that equipment from local farmers. Several paid for their fields to be ploughed in 1990, for example.

It may be revealing to investigate what the second category of farmers depicted in Table 6.15 (slight improvement) decided to buy. These are the farmers who improved their situation in relation to only one item of farm equipment. Given the information obtained during fieldwork, it might be expected that farmers would be more inclined to buy equipment that was closely related to the new technology, or potato cropping; that is, a sprayer. This assumption is based on the following four points: (1) farmers are paying special attention to the potato crop; (2) farmers have been adopting a number of technical innovations related to the potato crop aimed at increasing output; (3) farmers often hear from agricultural researchers that it is very important to spray their potato fields with agro-chemicals; and (4) farmers find that the sprayer is not easy to borrow because: "When you need to spray your crop you cannot afford to wait and the problem is that everybody is using it at the same time". The result is that 21 farmers, or 78% of the farmers who improved only one unit (farm equipment), bought a sprayer. This somehow confirms the observation that farmers are hopeful with regard to the potential of the new technology and are actively trying to improve potato output while apparently benefiting from it.

6.9.3 Transport Equipment

Transport equipment is the third area where the economic effects of the technological change may be observed in more detail. The main transport equipment owned by farmers were selected for the analysis: truck or pick-up van, automobile, motorcycle and bicycle. Whether farmers improved their situation after the technological change was decided according to the criteria discussed in 6.9.1 (consumer durable goods).

Table 6.16 displays the situation before and after and the changes that occurred in the area of transport equipment after the small farmers adopted the potato crop.

Table 6.16. Changes in Transport Equipment After the Introduction of Potato Cropping, Caruaru 1990, Brazil.

	Before	After	Improved n (%)
Truck/Van	2	6	4 (200)
Automobile	4	9	5 (125)
Motorcycle	2	23	21 (1050)
Bicycle	35	41	6 (17)

N=80
Source: Farmer Survey (Fieldwork,1990).

Survey data reveal that four farmers purchased a truck/van after adopting the potato crop (Table 6.16), a 200% improvement. Five farmers (125%) acquired an automobile, while six farmers (17%) bought bicycles. By far the biggest change occurred in relation to the motorcycle. The number of farmers that bought a motorcycle after the adoption of potato cropping reached 21, or an improvement of 1,050% on the pre-potato situation.

It was rapid growth in the number of small farmers riding motorcycles that impressed observers and indicated to several researchers who visited the Caruaru region that something different was happening there. "I have been working with small farmers in the North-East for fifteen years and I have never seen anything like it", said a visiting researcher. This is an important change considering the size of the farmer group (80 altogether) and their limited purchasing power. This limitation is reflected in the very low number of transport equipment depicted in Table 6.16. Thus, in the case of the truck/van and automobile, the rate of change is difficult to interpret given the very small number of farmers who own these equipment.

Table 6.17 looks at the changes in transport equipment from a different perspective than that presented in the previous table. It provides a summary of the survey results concerning what happened in the area of transport equipment after the introduction of potato cropping when the four items of equipment are treated as a single group. As in the case of GOODS (see 6.9.1), an indicator named TRANSPORT was created so that it would be possible to find out the total number of farmers which had improved their situation. Thirty four farmers, or 43% of the total number that participated in the survey, improved their situation after they had adopted potato farming, whereas no farmer reported that his or her situation had worsened.

Table 6.17. Changes in Transport Equipment (TRANSPORT) After the Introduction of Potato Cropping, Caruaru 1990, Brazil.

	Frequency	Percentage
No Change	46	57
Improved	34	43

N = 80
Source: Farmer Survey (Fieldwork,1990).

As public transport (bus service) is fairly limited in the region, the small farmers of Caruaru believe that transport equipment is an area in which it is worthwhile investing their money. However, it is important to appreciate the social context in which they live in order not to misunderstand the fact that they seem to consider investing in transport equipment less important than investing in consumer durable goods and housing and of course, farm equipment. Family ties among the small farmers of Caruaru are strong and, as a consequence, farmers know that they can count on the support of their extended family. This appears clear in the case of transport equipment, perhaps even more so than in the case of farm equipment seen in the previous section. For example, a farmer will not feel that he has to buy a car if his father already owns one. "Transport is not a problem in our family. I can borrow my father's van whenever I need to and so can my brothers", commented a farmer when explaining why he had no car. He added that he was very satisfied with the fact that he was making good money from the potato crop and had preferred to buy a colour TV and a few more things for the house instead of investing in a car. In other instances, the owner of the vehicle proved to be a younger member of the family and he too would have no reservations in lending his car or driving the members of his family wherever necessary. Young farmers in their early twenties, single or married farmers or even relatively well off farmers in their forties can share what could almost be called a family vehicle.

6.9.4 Housing

This is the fourth and last area that was selected to investigate in more detail the economic impact of the technological change upon the small farmers of Caruaru. To recap, the other three were consumer durables, farm equipment and transport equipment. Before presenting the results of the survey, it is important to make it clear that, due to the criterion being used here regarding improvements in housing, only the 54 farmers who had a house before adopting potato cropping were considered in this analysis. Thus, for the remaining 26 farmers interviewed, the question of whether they had improved their housing conditions after the introduction of the potato does not apply because they did not own a house before adopting the new technology (most of these farmers were teenagers living with their parents).

As in the case of consumer durable goods, special attention was paid to verify whether factors other than the technological change being studied here could have been responsible for the changes related to housing. For example, a considerable number of farmers (more than 38 out of 54) had built a toilet in their houses after the adoption of potato cropping. However, it was discovered during the survey that this important change was the product of a specific local government programme and involved almost no costs for the farmers. Thus, this and other improvements experienced by farmers that could not be associated with the technological change under consideration were excluded from the analysis.

Two types of housing improvements were taken into account when trying to assess the possible impact of the new technology on the housing situation of the small farmer. Firstly, major changes which involved building at least one additional room. Secondly, simpler and less costly improvements such as replacing a roof (often the wooden structure and roofing tiles), concreting the floor, plastering the walls or building a cistern (a large cement tank used to store rain water). A cistern is an important asset in a semi-arid region such as Caruaru where farmers do not have access to piped water and where farmers' water reservoirs (*barreiros*) often dry out during the summer season. Once they are without water, those farmers that have a cistern can either buy water to fill their cistern or try to arrange with the local government for water to be delivered free of charge. The emphasis is on improvements because not a single farmer reported that he or she had become worse off after the technological change with respect to the indicator 'housing'.

The survey results show that 20 farmers, or 37% of those who owned a house before the technological change, answered that they had built one or more additional rooms after they started cultivating potato (Table 6.18). Building an additional room was classified here as a 'major improvement' due to the nature of the building work and expense involved. A further 19 farmers (35%), carried out what was classified as a less costly improvement or 'slight improvement': built a cistern, cemented the floor or changed the roof of their house. These improvements may be relatively less expensive than building a new room but they are by no means a small investment for any of those farmers. On the whole, almost three out of four farmers did improve their situation with regard to the variable 'housing' - an impressive outcome considering the amount of resources or capital needed to carry out these improvements.

Table 6.18. Changes in Housing Conditions After the Introduction of Potato Cropping, Caruaru 1990, Brazil.

	Frequency	Percentage
No Change	15	28
Slight Improvement	19	35
Major Improvement	20	37

N = 54
Source: Farmer Survey (Fieldwork, 1990).

'The quality of housing and related facilities indicates the economic circumstances of a household; it is said that we can reasonably assume that an improvement in the economic conditions of a family will be reflected in a better dwelling and improved facilities' (Casley and Kumar, 1987, p.134). That statement proved to be true in the case of the small farmers of Caruaru. As a matter of fact, given the information provided by farmers during the survey interviews and data collected through direct observation, it is possible to conclude that the small farmers of Caruaru care a great deal about their housing. Thus, farmers are keen to improve their houses and work hard in order to raise enough money to carry out the changes they have planned. Often a small farmer in the region, due to his or her limited financial resources, will build a house taking into account the fact that it will be expanded and improved at a later stage.

Establishing a causal relationship between improvements in housing and the technological change is not a straightforward task, particularly due to the multiple sources of income of the small farmers and the effects of a few government initiatives designed to improve the living conditions of the rural people, such as the toilet construction programme mentioned previously or the São Vicente Project, which contributed to farmers' capitalization . Occasionally, there have been special (subsidized) bank loans provided to small farmers to invest in cattle (draft power) or cassava cultivation that may have been used by farmers for other purposes such as improving their housing. Although farmers were not asked directly about the origin of the money that they had used to improve their houses, many farmers commented during the survey interviews that the income provided by the potato crop had played an important role in supplying them with the necessary means to improve their housing. "Without the contribution of the potato crop it would have been impossible for me to build a new room on my house" and "It was mainly the income from the potato that allowed me to change the roof of my house", were typical comments that farmers made during the survey.

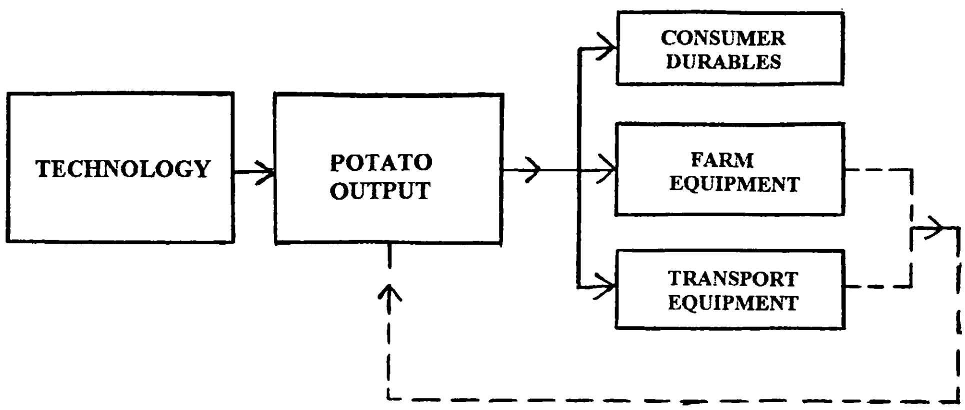
6.9.5 Cross-tabulations or Contingency Tables

Technology (TECH 1 and TECH 2) and Potato Output (OUTPUT)

To complement the data analysis presented in this chapter, it is appropriate to look at a few important cross-tabulations or contingency tables. They are used here to investigate further how far some of the economic changes that the small farmers of Caruaru have experienced can be explained by the introduction of the new technology. It would be more difficult to sustain the hypothesis that the technological change was beneficial to small farmers if no association between technology and potato output were found.

Assuming that there is a relationship between the new technology and the main economic variables discussed in this section (consumer durable goods, farm equipment and transport equipment), farmers with a higher level of technology are more likely to produce a higher output of potato and, therefore, a higher income that would enable them to improve their socio-economic situation compared with farmers with a lower technological level. In other words, the relationship between the new technology and these economic changes is an indirect one, if it exists at all. In this case, the technological change can only affect the farmer's economic situation through the output of the potato crop as suggested in Figure 6.1.

Figure 6.1. Relationship between the new technology and economic change.



Thus, in order to verify whether the economic changes are associated with the introduction of the new technology it is possible to examine, first, a couple of cross-tabulations between technology (independent variable) and potato output (dependent variable). Then, cross-tabulations between potato output and the main indicators of the socio-economic changes used in this study are also presented to verify whether the apparent link between these two variables can be confirmed. Two variables are associated when the distribution of values for one variable is associated with the distribution exhibited by another variable or when the variation exhibited by one variable is patterned in such a way that its variance is not randomly distributed in relation to the other variable (Bryman and Crammer, 1990).

In order to carry out the cross-tabulations, two indicators of technology were created on the basis of the survey data, denominated TECH 1 and TECH 2. Both indicators are divided into three subgroups: low, medium and high level of technology. In the case of TECH 1, the level of the adoption of the new technology is measured by a five-fold classification: manure, fertilizer, agro-chemicals, crop rotation and furrow planting. Farmers who have not changed their farming practices or who have adopted only one of the five farming techniques mentioned above are labelled here 'LOW' in relation to the technology indicator called TECH1. Farmers who have adopted two or three of these new techniques are classified as 'MEDIUM', and those farmers who have adopted four or five techniques are classified as 'HIGH' level of technology.

The second indicator, TECH 2, is a more 'subjective' indicator since it tries to capture whether farmers knew how to use the technology they had adopted. As in the case of TECH 1, this indicator is also divided into three sub-groups: low, medium and high level of technology. Several questions of the survey were carefully analysed and combined in order to create these three TECH 2 sub-groups. Farmers who had used a chemical fertilizer, for example, but applied it incorrectly (in the wrong dosage or in an inappropriate time of the planting cycle), according to IPA recommendations, did not score in relation to this variable. Within this context, farmers who declared in the survey having used agro-chemicals but revealed no specific knowledge of the different pests and illnesses affecting their potato crop and the different manners of applying those agro-chemicals available in the 'potato project' also did not score with regard to TECH 2. Even though many of these farmers had scored according to the previous technological indicator (TECH 1), they are not in the position to score in relation to this rather more qualitative indicator (TECH 2) which also attempts to measure their technological level. Thus, those farmers who knew how to apply the fertilizers and agro-chemicals used in the potato crop did score in relation to TECH 2, as well as those farmers who showed (in their survey answers) a clear understanding about furrow planting, crop rotation and contour cultivation. Similarly to what have been done in the case of TECH 1, farmers are classified as 'LOW', 'MEDIUM' AND 'HIGH' technology users according to how they scored in relation to TECH 2. Farmers who did not score more than one, or in other words, farmers who appeared to know only how to use (in agronomic terms as suggested by IPA) one of the new inputs (fertilizers or agro-chemicals), or one of the other three farming practices (furrow planting, crop rotation and contour cultivation) are classified under the label 'LOW' TECH 2. Farmers who adopted and correctly utilized two or three of these practices or inputs are classified as 'MEDIUM' and those who adopted four or five are classified as 'HIGH' TECH 2.

Potato output, on the other hand, is classified in two subgroups: 'LOW' (output less or equal to the median output) and 'HIGH' (output greater than the median). Table 6.19 and 6.20 depict cross-tabulations between these two different indicators of technology and potato output.

Table 6.19. Relationship between Technology (TECH 1) and Potato Output (OUTPUT), Caruaru 1990, Brazil.

OUTPUT	TECH 1					
	LOW		MEDIUM		HIGH	
	N	%	N	%	N	%
LOW	6	75	28	67	8	27
HIGH	2	25	14	33	22	73

Chi-square = 13.03; p = 0.0015
Source: Farmer Survey (Fieldwork, 1990).

Table 6.19 suggests that there is a statistical relationship (association) between technology and potato output. Thus, farmers whose level of technology is high tend to produce a higher output of potatoes. In other words, 73% of those who experienced a high technology level have produced a high output. On the other hand, only 25% of the farmers who presented a low technology level produced a high output.

By using a second indicator (TECH 2) for the variable technology to create Table 6.20, it is possible to try to replicate the result obtained in Table 6.19 and, therefore, increase the level of confidence in that result.

Table 6.20. Relationship between Technology (TECH 2) and Potato Output (OUTPUT), Caruaru 1990, Brazil.

OUTPUT	TECH 2					
	LOW		MEDIUM		HIGH	
	N	%	N	%	N	%
LOW	20	69	11	55	9	31
HIGH	9	31	9	45	20	69

Chi-square = 8.50; p = 0.014
Source: Farmer Survey (Fieldwork, 1990).

The result of this second cross-tabulation confirms that there is an association between technology and potato output. Sixty-nine per cent of farmers who enjoyed a high level of technology produced a high output whereas only 31% of those who are classified as having a low level of technology achieved a high output.

The investigation of relationships, as indicated by de Vaus (1986), is an important step in the task of explanation and, consequently, can contribute to demonstrating that many of the socio-economic changes experienced by the small farmers of Caruaru, North-East Brazil, may be attributed to the new technology. However, as Everitt (1986, p.10) pointed out, 'the finding of a significant association by means of the chi-square test does not necessarily imply any causal relationship between the variables involved, although it does indicate that the reason for this association is worth investigating'.

Thus, as there is an association between technology and potato output, it is possible to suggest that farmers with higher levels of technology are more likely to produce a higher potato output. Consequently, these farmers would be in a better position to improve their socio-economic situation compared with those farmers who enjoy a low technology level as indicated in the analysis carried out in the previous sections of this chapter.

Potato Output (OUTPUT) and the Main Economic Changes

The fact that technology (TECH1 and TECH2) and potato output (OUTPUT) are associated supports the conclusion that the socio-economic changes experienced by the small farmers of Xicuru are the result - at least in part - of the new potato cropping technology. Nevertheless, to double-check the consistency of these results, it is worthwhile investigating whether potato output is also associated with the main socio-economic changes seen earlier: consumer goods (GOODS), transport equipment (TRANSPORT) and farming equipment (EQUIPMENT). As the hypothesis that potato cropping contributed to the promotion of positive socio-economic changes and benefited the small farmers of the Caruaru was validated by the previous analyses carried out in this chapter, it is expected that the cross-tabulations between potato output and these socio-economic indicators will show that they are also associated.

Table 6.21 shows the cross-tabulation between potato output (OUTPUT) and consumer goods (GOODS). The result indicates that there is an association between these two variables. The majority (79%) of the 38 individuals who produced high potato output improved their consumer goods situation. On the other hand, 48% of people who express low potato output have not improved.

Table 6.21. Relationship between Potato Output (OUTPUT) and Consumer Goods (GOODS), Caruaru 1990, Brazil.

GOODS	OUTPUT			
	LOW		HIGH	
	N	%	N	%
No change	20	48	8	21
Improved	22	52	30	79

Chi-square = 5.08; p = 0.024
Source: Farmer Survey (Fieldwork, 1990).

Table 6.22 displays the relationship between potato output (OUTPUT) and transport equipment (TRANSPORT) while table 6.23 examines whether potato output is associated with a variable representing farming equipment (EQUIPMENT).

Table 6.22. Relationship between Potato Output (OUTPUT) and Transport Equipment (TRANSPORT), Caruaru 1990, Brazil.

TRANSPORT	OUTPUT			
	LOW		HIGH	
	N	%	N	%
No change	29	81	12	38
Improved	7	19	20	62

Chi-square = 11.38; p = 0.0007
Source: Farmer Survey (Fieldwork, 1990).

Both tables (Table 6.22 and Table 6.23) indicate that potato output is statistically associated with transport equipment and farming equipment, respectively. The results are useful and very important because they support the main hypothesis of this thesis.

Table 6.23. Relationship between Potato Output (OUTPUT) and Farming Equipment (EQUIPMENT), Caruaru 1990, Brazil.

EQUIPMENT	OUTPUT			
	LOW		HIGH	
	N	%	N	%
No change	16	45	6	19
Low	13	36	10	31
High	7	19	16	50

Chi-square = 8.25; p = 0.016
Source: Farmer Survey (Fieldwork, 1990).

6.10 Closing Remarks

The socio-economic changes which occurred after the introduction of the technological change in the Caruaru region were quite widespread. To start with, over 80% of the farmers undertook what they considered to be an important change in the area cultivated with crops. The main change in this respect was, without doubt, the reduction in the area occupied by cassava as a consequence of the gradual expansion of the area under cultivation with potato. That appears to have contributed to an increase in labour productivity and higher agricultural income. This rise in income has in all probability been translated into an increase in the average number of animals (cattle) owned by the small farmers, as explained in section 6.7. There are signs, although scant and inconclusive, that school attendance by farmers' children has improved as the farming workload decreased. The same might be said about the gains in the health standards of farmers and their families.

Farmers also experienced improvements in four areas which they tend to prioritize. Table 6.24 below summarizes the changes in housing, consumer durable goods, farm equipment and transport equipment which occurred after the introduction of the technological change. The results reveal a significant improvement in all areas: 72% of farmers improved in relation to housing; 67% in relation to consumer goods; 66% and 43% in relation to farm equipment and transport equipment respectively. It is important to underline the fact that no farmer has become worse off in relation to any of these indicators. Given these results it should not come as a surprise that 98% of all farmers considered that their living standards had improved.

Table 6.24. Frequency and Rate of Change (%) of Farmers that Improved their Economic Situation, Caruaru 1990, Brazil.

	Improved (n)	Improved (%)
Housing	39	72
Consumer Goods	52	67
Farm Equipment	53	66
Transport Equipment	34	43

Source: Elaborated from Tables 6.13; 6.15; 6.16 and 6.18.

Despite the difficulties of rigorously attributing causality when dealing with a process of technological change geared to the small farmer in rain-fed areas, the evidence presented suggests that these changes were, to a large extent, a result of the introduction of potato cropping. However, it is important to stress that it is not being argued here that the new technology was the only factor responsible for the socio-economic changes experienced by the small farmers of the Caruaru region. As discussed above, the small farmers have a number of different sources of income which are not clearly distinguishable from one another and are very difficult to measure. Therefore, it is reasonable to assume that these other sources of income might also have contributed to the promotion of the changes described in this chapter.

As many authors such as Lin (1976) and Marsh (1990) have pointed out, there is always the possibility that a relationship between two variables is spurious in that it is due to other factors. By 'partialing out' the effect of other factors that may have an impact upon the farmer's living conditions such as inheritance, gifts, government projects not related to the technological change being studied such as the toilet construction and the São Vicente project, particular credit policies which encouraged the improvement of manioc cultivation and the partial mechanization of flour production, it is possible for the researcher to be more confident that the relationship between the new technology and the socio-economic changes discussed in this chapter is not spurious. Moreover, as explained in chapter 3, the task of establishing causal relations becomes easier due to the fact that the farmer survey did not deal with a sample of farmers but a whole population of adopters.

To conclude, the data collected during fieldwork carried out in Brazil in 1990 suggests a promising future for this type of technological change generated by PTC, especially because the small farmers were not only able to adopt a new technology but appear to have benefited directly from it.

CHAPTER 7

Main Findings, Conclusions and Policy Implications

7.1 Main Findings

Fieldwork data analysis presented in the previous chapter suggest that the main hypothesis put forward in this thesis is valid. In other words, the findings support the proposition that an agricultural research methodology such as Participatory Technological Change (PTC) may generate and diffuse technological changes which increase agricultural output, foster increases in productivity and contribute to the improvement of small farmers' livelihoods.

These findings, shown in chapter 6, refer to data collected from a group of small farmers of the Caruaru region, North-East Brazil, using four different methodologies: a cross-sectional survey, a case study, direct observation and structured interviews. Details of these methodologies are explained in chapter 3. The core part of the information needed for this thesis was collected through a retrospective cross-sectional survey conducted with an entire group of small farmers which have adopted the technological change (potato cropping) being investigated. A total of 82 farmers participated in the survey. As the total number of farmers was not high and they were accessible, the use of a sample survey was unnecessary. Working with the entire population of small farmers rather than with a sample improves the quality of the results obtained, besides avoiding the possibility of dealing with a non-representative sample which could have arisen by chance, even if a randomly selected sample had been used.

Despite the difficulties of rigorously attributing causality to the process of technological change geared to the small farmer in rain-fed areas, the evidence presented suggests that these changes were, to a large extent, a result of the introduction of potato cropping. However, it is important to stress that it is not being argued here that the new technology was the only factor responsible for the socio-economic changes experienced by the small farmers of the Caruaru region. As discussed in chapter 6, these small farmers have a number of different sources of income which are not clearly distinguishable from one another and are very difficult to measure (section 6.5). Therefore, it is reasonable to assume that these other sources of income might also have contributed to the promotion of the changes described in that chapter. Moreover, as explained in chapter 3, the events or socio-economic changes discussed in this thesis are likely to have more than one cause. Most social phenomena often have a very complex set of causes and, therefore, it would be unreasonable to look for single explanations when assessing the possible socio-economic impact of a new technology.

As many authors such as Lin (1976) and Marsh (1990) have pointed out, there is always the possibility that a relationship between two variables is spurious in that it is due to other factors. By 'partialing out' the effect of other factors that may have an impact upon the farmer's living conditions it is possible to be more confident that the relationship between the new technology and the socio-economic changes discussed is not spurious. Examples of these factors found among the small farmers of Caruaru are inheritance, gifts, theft, government projects not related to the technological change being studied such as the toilet construction and the São Vicente project, particular credit policies which encouraged the improvement of cassava cultivation and the partial mechanization of flour production.

The socio-economic changes which were observed after the introduction of the new technology (potato cropping) were largely beneficial to small farmers and could be seen in a number of areas, such as agricultural revenue, area under crop cultivation, land and labour productivity, ownership of consumer goods, cattle, investments in housing, farm equipment and transport equipment, among other things.

Significantly, the vast majority of farmers (97%) experienced what they considered to be an important improvement in their total agricultural revenue after the introduction of the new technology and 98% of those small farmers who participated in the survey concluded that their overall living standards had also improved (sections 6.3 and 6.5). This improvement can be clearly seen in four areas which the small farmers of Caruaru prioritise and in which they tend to invest any additional available income. These are consumer goods, farm equipment, transport equipment and housing. Sixty seven per cent of farmers improved in relation to ownership of consumer goods; 66% improved in relation to farm equipment; 43% improved in relation to transport equipment and 72% improved their housing. Details of how each of the variables which compose these indicators varied are presented in Chapter 6 (section 6.9).

Cattle rearing is another area in which the effect of the new technology may be observed. Cattle, as explained in chapter 6 (section 6.7), is considered an important form of capital investment in the Caruaru region where 98% of farmers declared that they do not have a bank account. Cattle are often treated as a savings account for protection against inflation, and to cover debts caused by unforeseen crop failures or special expenses such as medical treatments, funerals and marriages. Although very difficult to measure due to farmers' reluctance to speak openly about the issue, as well as the high fluctuation in the number of animals kept within a year, it appears that there is enough evidence to suggest that the higher income generated by the potato crop was translated into an increase in the average number of cattle owned by farmers.

There were significant changes in the area under cultivation with crops which may also be largely attributed to the new technology. The main crops referred to here are cassava, maize and beans. Eighty two per cent of farmers reported that they had undertaken important changes in the area cultivated after the adoption of potato cropping. The most profound change refers to the reduction of the area planted with cassava, a very traditional crop in the region and a source of income (section 6.2.1). Ninety two per cent of farmers decreased the area cultivated with cassava and gradually expanded their potato fields. The reduction in cassava cultivation seems to be a direct consequence of the farmer's decision to adopt potato cropping. The potato was considered a profitable crop by all farmers who, at the same time, complained about the very low profitability of cassava. The changes in the area cultivated with maize and beans are also discussed in chapter 6 (6.2.2). Together, those changes in the area cropped appear to have contributed to a decrease in family workload and an increase in productivity. These, at the same time, may have contributed to the apparent improvement in school attendance and gains in health perceived by farmers and their families.

7.2 The New Methodology and Technological Change

Potato cropping is the main technology which resulted from PTC and, therefore, it is the socio-economic impact of this new technology upon a group of small farmers of Caruaru which was investigated in this study. Potato cropping involves the adoption of improved potato seeds and several new farming practices: use of organic fertilizer, two types of chemical fertilizers, agro-chemicals, ox-drawn ploughing and furrow sowing.

As pointed out in chapter 4, this new technology is not the 'technological package' generated by the traditional or conventional research approaches (CAR) discussed in chapter 1; potato cropping is a product of PTC.

PTC, as defined in this thesis, is a new agricultural research methodology which was developed by IPA (Agricultural and Livestock Research Institute of Pernambuco) in Caruaru, North-East Brazil, during the 1980s. One of the main assumptions behind IPA's new research methodology is that researchers ought to familiarise themselves with the farming systems of small farmers if they were to succeed in helping them. Significantly, IPA researchers acknowledged that in the past they hardly knew the farming systems or the farmers they had been trying to reach through their technological innovations. At the same time, IPA researchers also admitted that CAR-generated technologies (Chapter 1) had not been adopted mainly because they were inappropriate for meeting farmer's needs and demands. In this respect, PTC may also be seen as the result of researchers' frustrations at not being capable of delivering solutions to small farmers' problems. Moreover, scientists together with farmers realized that without farmer participation in the research process it would be very difficult, if at all possible, to promote the technological changes which would meet farmer's needs and contribute to the betterment of small farmers livelihoods in a sustainable manner.

PTC is basically a systemic and farmer participatory research approach which emerged from what was probably the first attempt at implementing Farming Systems Research (FSR) in the Agreste region of Brazil. The development of PTC was not the result of a well defined, theoretical proposal which was consistently implemented by IPA. It was largely the result of a complex and time-consuming learning process which evolved mainly through practical experiences and involved a considerable degree of commitment, flexibility and improvisation on the part of researchers, farmers and rural extensionists alike; flexibility and improvisation that gave PTC a crucial capacity to overcome obstacles. When discussing a vision for sustainable agriculture, Pretty and Chambers also emphasised the point made here regarding the need for flexibility or a certain degree of improvisation. The authors argued in favour of participatory approaches and methods which support 'local innovation and adaptation, accommodate and augment diversity and complexity, enhance local capabilities, and also are more likely to generate sustainable processes and practices' (Pretty and Chambers, 1994, p.188).

As explained in chapter 4, the development of PTC was based on the principles of FSR (Chapter 1) and four main initiatives: (a) concentration of the research effort in a small geographical area representative of the Agreste; (b) close co-operation among researchers, extensionists and farmers; (c) Integrated Production Systems (SIPs); and (d) potato research. To sum up, PTC is concerned with small farmers, their circumstances and problems from a systemic point of view. Its focus is on applied research and on improving farmers' livelihoods taking into consideration their current needs, farming knowledge, culture and traditions. Within this context, PTC aims not merely to provide farmers with new technologies which might increase their agricultural output but with the means of improving their standard of living as well. In order to achieve their objectives, IPA researchers concluded that on-farm research should be an essential component of their new agricultural research methodology or PTC.

On-farm research, in this case, does not simply mean researchers carrying out their own experiments on farmers' fields rather than on the research station. It is a form of co-operation, a partnership between researchers and farmers, strengthened by rural extensionists' active assistance. It starts at the farmer's level but not necessarily with the farmer, as it has been suggested (Souza, 1991). Furthermore, it centres on the identification of problems and potential technological improvements which are subsequently tested under local conditions with the participation of farmers. It is important to stress that it was only gradually that IPA researchers learnt about the value of involving farmers in the research process and about the importance of taking farmers' indigenous technological knowledge (ITK) into consideration. In the end, farmer participation proved to be very relevant in the development of PTC and new technologies such as potato cropping (Chapters 4 and 5).

The novelty and relevance of this new research approach (PTC) and IPA's audacious initiative could be underestimated if the Brazilian historical context is not taken into consideration. Chapter 2 provides the reader with an overview of the post-war period and the role of the agricultural sector in Brazil. It is clear from the arguments presented that agricultural research had clearly disregarded the needs and demands of Brazilian small farmers and had a strong bias which favoured large landowners who were in charge of the export sector. This bias was probably sharper in the North- East where sugar-cane, cocoa and cotton were by far the main concern of the local research institutions. These crops are not cultivated by the vast number of small farmers who are the main producers of staple food crops in the region. Thus, IPA's efforts in developing PTC, even if still not completely successful in practical terms, is an important step forward in the direction of providing this historically neglected group of farmers with the means of improving both the regional supply of agricultural produce and their livelihoods.

It is important to emphasise that the success of IPA researchers in servicing small farmers in Caruaru, as described in this thesis, is not an isolated example. Similar research approaches developed in other developing countries confirm the proposition (hypothesis) that participatory agricultural research methodologies are capable of generating technologies which are appropriate to the needs of small farmers' farming systems and which, perhaps more importantly, help improve farmers' livelihoods. Recent examples from different parts of the world can be found in a number of publications such as: Guijt and Shah (1998); Holland and Blackburn (1998); Blackburn and Holland (1998); Nelson and Wright (1997); and Scoones and Thompson (1994). In Brazil, Shiki (1991); Souza (1991); Monteiro (1991) and, more recently, Macedo (1997) have all shown that different small cultivators farming systems are viable (in agronomic terms) and potentially profitable, especially when the main actors (farmers, researchers and policy-makers) work together and in co-operation or within a more systemic and participatory framework.

Despite what has just been said about the merits of PTC in providing farmers with technologies that meet their needs, it is worth stressing here, in this final chapter, a point which was clearly made elsewhere: 'the assumption is neither that in order to be successful agricultural research must necessarily involve both farmers and researchers, nor that farmer participatory approaches will be appropriate to all situations. Whether farmer participatory research is used or nor clearly depends on a number of issues including the nature of the specific research problem, the inclination, or attitudes of the researchers, the resources available and the degree of interest or skill which the community has in carrying out research. One can assume, however, that all agricultural research must be directed towards meeting the needs of some specific group of clients' (Okali, Sumberg and Farrington, 1994, p.96-7). Within this context, it is also useful to recall that the author of this thesis disagrees with those apparently over enthusiastic writers who are in favour of systemic and participatory research methods but who intend to do away with everything that comes from the developed world, or with what Chambers (1997) referred to as 'first technologies'. It is not being advocated in this study that complex, capital-using technology does not have a role to play in helping small farmers to improve their farming systems and combat rural poverty.

To be more specific and avoid misunderstanding with regard to this last very important point, it should be added that what Chambers stated when discussing the changes which are necessary for researchers and policy-makers to succeed in meeting small farmer's needs applies well to PTC: 'This is not a rejection of modern scientific knowledge, of research stations and laboratories, of scientific method. These remain potent, have their own validity and will always have their place' (Chambers, 1994, p.xv). Or, 'Scientists must continue their normal science, in laboratories and on research stations. In addition, they will have to learn from and with farmers, and so serve diverse and complex conditions and farming systems' (Pretty and Chambers, 1994, p.185).

The new participatory research methodologies referred to in this thesis imply new roles for farmers, researchers and agricultural scientists and extensionists. These new roles require a new professionalism which involves scientists working either in multidisciplinary teams or closely with other disciplines, dialogue with farmers and co-operation with rural extensionists, among several other things which are detailed by Chambers (1986, p.168-189). Nevertheless, scientists, as clearly seen in the Caruaru case, must also continue their very useful 'normal' scientific work - in laboratories and on research stations, as Pretty and Chambers (1994) also suggested.

7.3 Farmer Participation

Farmer participation is not easy to achieve and, thus, should not be taken for granted. Neither should it be treated as a panacea, as is frequently suggested in the Farmer Participatory Research (FPR) literature. The practice of participation involves, among other things, hard work, trust and willingness on the part of all those involved: researchers, extensionists and, of course, farmers. The end result cannot be easily predicted, as illustrated in the section about destructive and constructive participation in chapter 1 (1.4.3). Participation does not necessarily or automatically lead to the solution of farmers' problems.

Moreover, even inside the IPA research station in Caruaru, on-farm research and agricultural research methodologies such as PTC are still not generally accepted. It is probably a minority of researchers which is committed to approaches such as PTC and recognises the value of farmers' knowledge and its contribution to the research process. Many researchers believe that conducting research outside the experimental station is not their job, as they see little value in working together with small farmers or outside the research station. They often take it as given that they have nothing useful to learn from small farmers or rural extensionists.

These researchers feel a class apart and find no prestige in getting involved with those two groups of people: small farmers and extensionists. Neither do they seem concerned with the practical implications of their research in terms of benefiting small farmers, but prefer to concentrate their efforts on furthering their careers, which involves among other things, publishing papers and attending conferences. In Brazil, just to cite a specific example, EMBRAPA personnel appeared to be, in the words of Macedo: '...concerned much more with internal affairs such as internal power and wage distribution than with the relationship between the agricultural research organization, farmers and rural extension agencies' (Macedo, 1997, p.304).

Within this context, it is possible to say that Brazilian agricultural researchers in general are in tune with their international colleagues. As pointed out in the book 'Beyond Farmer First', many researchers and rural extensionists are 'still trapped in top-down, centre-outwards institutions and transfer-of-technology (TOT) thinking and action, where "we" [scientists] determine priorities, generate technologies and then transfer them to farmers, and where farmers' participation have been without substance' (Scoones and Thompson, 1994, foreword). As has been well documented in many recent farmer participatory research (FPR) initiatives, farmers are merely offered the chance to participate in the researcher's projects and very little, if any, of what is called 'collegial' participation (Chapter 1, section 1.4.2) takes place.

However, contrary to what some enthusiasts of FPR have indicated (Chambers 1997; Souza, 1991), small farmers are usually not interested in assuming control of the research process or in shouldering most of its responsibilities and costs. Evidence from Caruaru strongly suggests that small farmers are not willing to perform a researcher's job and see no reason for doing so. In other words, small farmers did not support the idea that researchers should play only a secondary role in the research process. They were not interested in being in full command of the research process, from design to evaluation of innovations. The small farmers of Caruaru are very practical and realistic people who know from experience that without expert help from researchers and extensionists and without rural credit the improvements that they could achieve would be very limited.

It is important to remember, in this context, that the small farmers of Caruaru are extremely busy people (Chapter 6, Table 6.9) who have little time to spare for extra activities such as research, especially during the short rainy season when they often experience shortages of labour, a major problem in the region. They are likely to continue experimenting as part of their farming activities (see 1.4.4) but admit that they have neither the knowledge nor the research expertise, time or financial resources to solve all their problems alone. Thus, they agree that working in collaboration with researchers and extensionists who are willing to improve their farming systems through a framework such as that one provided by PTC is a good proposition.

7.4 Agriculture in Pernambuco: Recent Trends and the Relevance of the Small Farmer

Data from the most recent Agricultural and Livestock Census (Censo Agropecuário 1995-1996) published in mid-1998 (IBGE, 1998) confirm the technological backwardness of the agricultural sector in the State of Pernambuco, where fieldwork research for this thesis was carried out. Census information also indicates that the production and productivity levels of the sector are still low and declining in certain important instances.

Below, a few indicators which illustrate the case in question and strongly suggest that further investments must be made in agricultural research in order to promote an improvement of the agricultural sector in general, and of small farmers, in particular. Small farmers, a low income group of cultivators farming resource-poor areas no larger than 100ha in size, are important agricultural actors, especially in terms of food crop production, as the Agricultural Census figures which will be presented here demonstrate.

Reflecting the poor performance of the Brazilian agricultural sector which was already discussed in chapter 2, the main crops produced in the state of Pernambuco decreased both in terms of physical output (Table 7.1) and area harvested (Table 7.2), according to the latest Agricultural Census (1985 and 1995).

The reduction in physical output of ten of the main crops grown in Pernambuco, depicted in Table 7.1, leaves little room for complacency. New investments need to be channelled to the agricultural sector. Harvested output of the three main food crops - manioc, maize and rice - fell sharply in the decade under consideration. Even export crops such as sugar-cane and coffee, which tend to be favoured by government policies, saw their output reduced by 28% and 36%, respectively. Disease drastically cut the production of both types of cotton. Only grapes, a new crop in the North-East and grown largely in the irrigated lands of the São Francisco valley, showed an increase in output (900%). However, this large percentage increase may disguise the fact that grape output levels in 1985 were extremely low. The crop was being introduced into the region, at that time, and the area harvested in 1985 was negligible: a mere 479 hectares, as shown in Table 7.2, below.

Table 7.1. Main crops grown in Pernambuco: harvested output in tons (t) and percentage output change (%) between 1985 and 1995, Brazil.

	Harvested output (t) 1985	1995	Output change (%)
Manioc	686,555	296,102	-57
Maize	272,334	207,007	-24
Rice	28,067	12,868	-54
Tomato	219,719	178,772	-19
Banana (1)	37,183	32,912	-11
Coffee	7,333	5,313	-28
Cotton (*herbáceo*)	15,560	1,483	-90
Cotton (*arbóreo*)	16,135	24	-100
Sugar-cane	23,764,059	15,319,302	-36
Grapes	3,360	34,342	900

(1) Output in 1,000 *cachos.*
Source: Elaborated from *Censo Agropecuário1995-6*, IBGE (1998), Table 5.

Table 7.2. Main crops grown in Pernambuco: area harvested in hectares (ha) and percentage change in harvested area (%) between 1985 and 1995, Brazil.

	Area Harvested (ha) 1985	1995	Area Change (%)
Manioc	109,285	54,311	-50
Maize	537,806	338,551	-37
Rice	11,849	4,088	-65
Tomato	9,804	7,927	-19
Banana	32.518	31,606	- 3
Coffee	17,383	7,985	-54
Cotton (*herbáceo*)	46,804	3,479	-93
Cotton (*arbóreo*)	91,961	109	-100
Sugar-cane	465,463	355,789	-24
Grapes	479	1,682	251

Source: Elaborated from *Censo Agropecuário1995-6*, IBGE (1998), Table 5.

Additional information obtained from the Census and summarized in Table 7.2 presents a disappointing picture of the performance of the agricultural sector. Even important staple food crops saw their harvested area reduced by considerable margins. While the Brazilian population was growing at an estimated 1.4% per annum and Pernambuco's at 4.8% in 1994 (EIU,1997), the harvested area of manioc in Pernambuco fell by 50 per cent in 1995-6 when compared with data from the previous Agricultural Census of 1985. At the same time, the area of maize, from which a large variety of highly appreciated dishes is prepared, dropped by 37%. The area harvested with rice was reduced by a large margin, or 65 per cent. All other crops presented in Table 7.2 also show declining rates of area harvested.

The reduction in output shown in Table 7.1 is not a mere result of a decrease in the area harvested (Table 7.2). More significantly, perhaps, yields from certain crops, which are not high by international standards, declined in the period covered by the last two Agricultural Census, as shown in Table 7.3.

Table 7.3. Main crops grown in Pernambuco: yields (kg/ha) and productivity change between 1985 and 1995 (%), Brazil.

	Yields (kg/ha)		Change
	1985	1995	(%)
Manioc	6,282	5,452	-13
Maize	506	611	21
Rice	2,369	3,147	33
Tomato	22,411	22,552	1
Banana(1)	1,143	1,041	-9
Coffee	422	665	58
Cotton (*herbáceo*)	332	426	28
Cotton (*arbóreo*)	175	109	-38
Sugar-cane	51,055	43,057	-16
Grapes	7,015	20,417	191

(1) Output in 1,000 *cachos*.
Source: Elaborated from *Censo Agropecuário1995-6*, IBGE (1998), Table 5.

The disappointing performance of the agricultural sector in Pernambuco, reflected in the tables above, is also evident from a number of technological indicators elaborated from data collected during the Agricultural Census which was carried out in 1995-6 (IBGE, 1998). Only 1.3 per cent, or 3,291 establishments of a total number of 258,630 rural establishments in Pernambuco declared having used rural credit to develop their activities in 1995-6. No more than a meagre 1.5% of the total number of these establishments have a tractor (5,645 units). The percentage of those using animal draught power (plough) reached only 21% in 1995-6. A very low percentage of rural establishments, about 26%, used fertilizers (chemical or organic) while, only around 40%

of them implemented some sort of measure to control pests and diseases, or in other words, utilised agro-chemicals or biological products. The 1995-6 Census also revealed that only an insignificant number of establishments, or five per cent of the total, count on technical assistance (public or private).

Unfortunately - due to its implications for the overall domestic supply of food and employment levels - but not surprisingly, if one is aware of the indicators mentioned above and the typical or historical government neglect of the agricultural sector, the total number of rural establishments in Pernambuco decreased from 356 thousand to 258.6 thousand in 1995-6, a fall of 27 per cent. Their total area shrank from approximately 6.7 million hectares to 5.6 million hectares, a reduction of about 17% when compared with Census data from 1985.

Very significantly, the overall area under crop cultivation decreased from 1.8 million to 1.2 million hectares. Three of the main staple food crops produced in Pernambuco - manioc, maize and rice - showed a reduction in the area harvested, as seen in Table 7.2 above. The area harvested of these three crops together fell from nearly 660 thousand hectares (658,940ha) in 1985 to less than 400 thousand hectares (396,950ha) in 1995-6. Physical output of these same food crops decreased from a little less than one million tons (986,956t) in 1985 to just over half a million tons (515,977t) in 1995-6.

Nearly one million people (975,288) are working in the agricultural sector in the state of Pernambuco alone (IBGE, 1998). Over 85% of those employed in the agricultural sector may be classified as small farmers on properties of less than 100 hectares (ha) in size: 570,414 people (58,8%) in properties smaller than 10ha and 260,352 (26,7%) in properties larger than 10ha but smaller than 100ha in size. This large contingent of people is responsible for the production of a very significant proportion of the total output of food crops in Pernambuco (Table 7.4).

Table 7.4. Crop output harvested and sold in farms smaller than 100 hectares(ha) in size: per cent of total output (%); tons (t); hectares (ha), Pernambuco 1995, Brazil.

	Output Harvested			Output Sold	
	(%)	t	ha	(%)	t
Manioc	92	271,986	51,414	92	148,317
Rice	81	10,379	3,327	80	8,866
Beans	93	109,329	290,167*	93	62,884
Maize	86	177,671	294,888	86	98,820
Tomato	71	126,065	6,177	70	125,339

* Does not include the 2nd and 3rd harvest which were very small.
Source: Elaborated from *Censo Agropecuário1995-6*, IBGE (1998), Tables 53, 54 and 56.

Given the figures above, it is difficult to understand why some authors have suggested that small farmers are no longer important in economic, or even agricultural terms. Their argument seems to lose credibility when it is revealed that, in the state of Pernambuco, 92% of the harvested area of manioc comes from small cultivators working on farms smaller than 100 hectares in size. Moreover, other important staple food crops are also largely in the hands of small farmers who produced 81% of the rice harvested in Pernambuco; 93% of beans output; 86% of maize and 71% of tomato. The Agricultural Census (IBGE, 1988) provides an interesting breakdown of these statistics which allow us to see what is the output share of *minifúndios*, or farming areas smaller than 10 hectares. Cultivators in these diminutive areas produced almost two thirds (178,884 tons) of the total amount of manioc harvested; 35% or 4,484 tons of rice; 61% or 71,136 tons of beans; 45% or 93,103 tons of maize and 88,920 tons or 50% of the tomato output harvested in Pernambuco in 1995-6.

Perhaps more surprising is the high proportion of these food crops which are produced by small farmers and sold in the market place. Suggestions that small farmers produce mainly for their own consumption are shattered by the statistics gathered by IBGE (1998). Of the total output harvested, 92% of manioc output was sold. The figures for the other main food crops are no less impressive. Eighty per cent of rice; 93% of beans; 86% of maize and 70% of all tomato harvested in farms under 100 hectares in size, in Pernambuco, were also sold in the market place.

It is due to the sheer magnitude and socio-economic relevance of these figures that further investments in the agricultural sector and on small farmers especially is not only justifiable, but necessary. The Caruaru case, presented in this study, illustrates well the developmental potential of investing in small farming. In a country such as Brazil, which still has a very large proportion of its population living below the poverty line and in great need of foodstuffs, agricultural research needs to be further encouraged and well financed because technological levels are fairly low, as well as productivity levels and food crops output. The *Cruzado* Plan in 1986 (Bresser Perreira, 1990; Braga et al., 1986), for example, clearly showed that there is a huge latent demand for food produce in Brazil that would be easily 'awakened' if real wages increase and the standard of living improves. Thus, it is necessary for the agricultural sector to be prepared to fulfil this potential demand for foodstuffs in the future while providing farmers with the means of improving production and productivity levels - in a profitable manner and in the short-term, as well as in the long-term.

7.5 Conclusions and Policy Implications

There are, at least, four main conclusions that can be drawn from this study and from which relevant policy implications and recommendations may be derived. They are as follows:

(1) PTC (Participatory Technological Change) is capable of generating technologies that can increase small farmers' agricultural output and productivity and help them improve their livelihoods. Although the educational and organisational processes of the participatory method appear time-consuming, this investment pays off in terms of more efficient technology generation. The end result is an increase in the number of farmers who gain more control over the processes required for improving their farming systems. Moreover these farmers, as reported in the case of Caruaru, may lose the immediate economic incentive to leave their farms and the rural areas and move to the large urban centres in search of employment. This search for jobs in the cities very often ends up increasing the number of unemployed and creating various social problems.

Thus, it is recommended that a research policy which strongly supports PTC-type initiatives or which values systemic and participatory research approaches should be seriously encouraged in Brazil. This would involve, among other things, the promotion of close co-operation between researchers and rural extensionists. It also means providing researchers with specific training which would allow them to acquire the new skills necessary to work with small farmers and outside an experimental station. A training programme which has been developed by FAO (Mathur, 1988) contains the elements which provide useful guidelines for the training being suggested here: (a) to overcome the tendency of viewing agricultural development as a series of separate, disconnected actions; (b) to promote the coming together of all concerned organizations; (c) to define and make objectives known to all and to place emphasis on communication and sharing of experiences; (d) to view the process of technology development as dynamic or something that is changing constantly and requires frequent adjusting or readjusting; (e) to consider training as a continuous process and not a one-off proposition.

In-depth knowledge of the small farmers' complex farming system is essential for the process of technological development, as is a good understanding of their economic, social and political environment. It is, therefore, further recommended, as agreed by IPA researchers in Caruaru, that an interdisciplinary research team be formed which would bring together agronomists with professionals from different social sciences (development economists, rural sociologists and political scientists, for example). It is believed that this type of research team could improve the quality and probably speed up the process of technological change. However, even where this new research team is in place, further training will probably be necessary. Researchers are often not prepared to work with colleagues from other disciplines, as discussed elsewhere in this study, and even agronomists from the same research institution, but with different specialisation, may find it difficult to work together, as exemplified by the IPA-Caruaru case.

In a very illustrative paper which deals mainly with the interaction of biological scientists (including agronomists) with economists and anthropologists at the International Potato Centre (CIP) in Peru, one of the agricultural research centres which make up the Consultative Group of International Research (CGIAR), the authors explain in some detail the difficulties facing an interdisciplinary team and observe that the assumption that true interdisciplinary research work means interaction and that interaction leads to synthesis and synergism is not necessarily true: 'However, it is our frank and sincere admission that our [interdisciplinary] team most of the time resembles the Three Stooges at their best (or worst, however you choose to look at it). Instead of "synthesis" we spend an enormous amount of time in what we euphemistically call "constructive conflict" which at the moment it occurs can be deeply personal and difficult interaction' (Rhoades, Horton and Booth, 1986, p.22).

In the Amazon region of Brazil, the Agricultural and Environmental Centre of Tocantins (CAT) in Marabá has put this idea of an interdisciplinary research team working with farmers to the test. There, a group of peasant unions from eastern Amazonia representing thousands of small farmers has joined with academics and agricultural technicians in an innovative initiative to develop agroforestry systems which reduce deforestation levels. The result is a project which appears to be helping farmers to limit the burning of the Amazon rainforest and is enabling farmers to stay on their land through a new fruit farming strategy, among other things (Matheson, 1996).

Given what has been discussed here, it seems to be a natural conclusion that researchers working within the context of a participatory and systemic approach - such as PTC - will need to acquire new skills to deal with their new working environment, especially because they are supposed to go out of the research station and work in co-operation with farmers and on their fields. Furthermore, the case of IPA-Caruaru illustrates that when it is not possible to count on an interdisciplinary team such as that from the CAT project, a multidisciplinary research team composed mainly of agronomists, but from different disciplines, can learn to work together and with small farmers and reach positive results.

(2) A new technology or technological change alone is not sufficient to allow small farmers to improve their standard of living, even if the new technology meets their needs and is adapted to their circumstances.

Despite being a key factor in the process of development, it is very important to note, especially because of its policy implications, that the new technology (potato cropping) was introduced in the Caruaru region together with at least three crucial initiatives which enabled cultivators to enjoy the benefits generated by the technological change. These initiatives were:

- First, subsidised credit in the form of new inputs which could be repaid with part of the potato harvest.

- Second, constant technical assistance provided by researchers and rural extensionists working closely together and with the participation of small farmers.

- Third, formation of a farmers' association which besides representing the interests of small cultivators is actually run by farmers themselves.

It is suggested that these three initiatives should be present in any agricultural policy which aims at supporting small farmers. In eastern Amazonia, for example, CAT seems to do just that and with positive results. This is a unique example of inter-institutional co-operation which aims to improve small farmer's livelihoods by 'introducing farming and agroforestry systems which offer greater income-generating potential than the slash-and-burn agriculture which typifies most settler cultivation, while preserving forest cover and natural resources' (Hall, 1997, p.178). This project (CAT) is funded by the British Government, European Union and Christian Aid, among others, and is supported by agronomists and technicians working in co-operation with farmers (Matheson, 1996). In another part of Brazil, the Brasília carrot project, not a typical EMBRAPA research initiative, was described as 'a "collaborative" process between agricultural researchers, farmers and rural extension agents and attended to farmer's and consumer's requirements' (Macedo, 1997, p.300). The project, promoted by the Brazilian Government and carried out in the Cerrado (savannah) region, is said to have been a success.

Within the context of the policy recommendation presented here, it is important for policy-makers and agricultural researchers, in particular, to be aware that a good programme of technological change may appear 'successful' for the wrong reasons. A technology innovation, as reported by Mellor (1986), may be adopted 'not because of direct economic benefits from the innovation itself, but because acceptance of innovations brings ancillary benefits of favor from personnel agencies and agencies fostering the innovation. The tying of extension programs with programs of government subsidized inputs, including credit, is an important case in point' (Mellor, 1986, p.74-5).

The potato project discussed in this thesis (Chapters 4 and 5) appeared to act upon a small number of farmers as an example of what Mellor has stated. Going back to sections 5.8 and 5.9 of this thesis where it was shown that a number of Caruaru farmers were quick to seize the opportunity to re-sell inputs included in the potato project, it is possible to say that a combination of *malandragem* coupled with what is being called 'diplomacy of the practical farmer' may have contributed or resulted in farmers adopting the new technology without ever intending to fully use it. This action can easily have a negative effect on farmer's agricultural output and, therefore, distort performance and evaluation of the programme. Due to this reason, among many others, it is further recommended that any technology development programme include mechanisms to detect these types of activities and be prepared to deal with them.

(3) A farmers' association is a key element in the search for technological innovations which are likely to meet farmers' needs and facilitate the development of an agricultural research methodology such as PTC.

As the case of IPA-Caruaru has demonstrated, it is virtually impossible to provide small farmers with any significant assistance in terms of technological change and rural extension services when dealing with them individually. During 1980-83, for example, IPA researchers set up a large number of experiments on farmers' fields that were spread out over a large geographical area (see Chapter 4). Farmers were treated individually and the result was a lack of clear priorities, confusion about the definition of farmers' main problems and serious logistical difficulties in collecting the information from those experiments and on acting upon the information gathered.

By working with a farmers' association, IPA researchers were able to identify farmers' needs, prioritise their demands and then work together towards a solution for their problems. Researchers and extensionists, often in short supply in the North-East, could then use the farmer's association to meet with up to eighty farmers, in the case of Caruaru, all at once. The long and time-consuming journeys carried out by researchers in the Agreste region, sometimes to visit a single farmer or experiment, became a thing of the past. The farmers' association became, among other things, a forum for debate where even farmers from remote areas could exchange ideas with their fellow farmers and researchers; time and money is saved while a dialogue between scientists and small farmers is established.

A very significant finding drawn from this study is that the farmers' associations (APROBACA and ATRAM) allowed the small farmers of the Caruaru region a certain presence or bargaining power (Chapter 5). The associations were able to lobby local politicians and put pressure on IPA researchers, while small farmers acting individually would have been powerless. In their meetings, a number of different projects supported by different government agencies could be agreed upon and all parties involved had the opportunity to participate in the process of technological change. In addition, government funds, earmarked to promote small farming projects that could not be given to individual farmers, could reach them via their associations.

The Caruaru case study shows that farmers may discuss among themselves and then meet with researchers and policy-makers to explain their problems or make their demands heard through their associations. At the same time, scientists had the opportunity to present their proposals to that community and learn from farmers, among other things. Significantly, an association enables farmers to meet on a regular basis and try to clarify with their colleagues what is necessary for them to improve in their agricultural production. In Caruaru, small farmers were able to learn from their fellow farmers about solutions to their problems and could work together with researchers and extensionists towards overcoming more challenging constraints.

Based on the Caruaru case and examples from other parts of Brazil (Macedo, 1997; Souza, 1991; Shiki, 1991) and the developing world already mentioned in this work, it is recommended that government agencies promote the formation of farmer's associations, facilitate their registration and contribute to their consolidation, but without interfering in the management of these associations. A rural development strategy must pay special attention to strengthening the organisational structure of a community.

As a further illustration of what has been argued in this thesis, the relevance of a farmer's association may also be clearly seen in the Amazon region of Brazil. According to Hall, the core of an important alternative development project involving small farmers was the presence of farmer's associations: 'At the heart of CAT's approach is the notion that a well-organized peasantry must form the basis of any process of sustainable development in the region' (Hall, 1997, p.178). A second example, also from the Brazilian Amazon, is perhaps a better illustration of small farmers mobilization and capacity to participate constructively in the creation and development of projects and initiatives which aim at improving their livelihoods, or as it was explained by Hall, a programme which is 'attempting to develop their own productive conservation alternatives to the slash-and-burn farming normally practised by new settlers in Amazonia' (Hall, 1997, p.176). The Programa Agro-Ecológico da Transamazônica (PAET), based in Altamira, 'is a partnership between a group of foreign and Brazilian researchers (the Agro-Economic Laboratory of the Transamazon Highway - LAET) and an umbrella organization representing farmer interests (the Movement for Survival of the Transamazon Highway - MPST)' (Hall, 1997, p.189). It is sufficient to say here, within the context of this thesis, that farmers have participated actively in the programme since its very beginning by discussing with researchers their main priorities. The programme appears to be less 'institutionalised' than CAT and that facilitated the development of a flexible system of collaboration between researchers and various farmer's organizations which have reached positive results, as detailed elsewhere (Hall, 1997).

(4) Evidence from the Caruaru region corroborates the location-specific nature of most agricultural technologies, leading to the conclusion that national and particularly regional research centres, rather than international centres, may be better suited to conducting much of the research work necessary to meet the needs of small farmers. Within this context, it is relevant to mention that IARCs (International Agricultural Research Centres) have been experiencing, in recent years, a process of transition which includes a larger preoccupation with issues such as poverty, sustainability and national research systems and a tendency towards decentralization (Ravnborg, 1992).

As pointed out in chapter 3, PTC implies decentralisation of production structures and institutional and administrative changes. The case of IPA-Caruaru, described in this thesis, demonstrates how decentralisation to the village and district level is important for plans to be adapted to variable local conditions and to farmer's problems to be addressed satisfactorily. Decentralization at these levels is very important due to a simple fact that is peculiar to agriculture and often disregarded. As pointed out by Bunch (1991), in the ever changing world of agriculture - seeds degenerate with time, unforeseen pests may spread or develop resistance to agro-chemicals, new diseases can suddenly appear, weather variations that cannot be controlled often have dramatic effects on crop performance, soils get exhausted - no solution is a guarantee of long-term success. It is, therefore, important that regional research institutes such as IPA-Caruaru continue to receive the financial and political support necessary to improve and develop its research activities. More Federal or state funds are needed to develop research facilities and laboratories as well as infrastructure. Investments in human resources or training of researchers should also be encouraged and supported by a long-term national agricultural research policy centred in regional research institutes. Long-term policies seem particularly essential when the changing and location-specific character of the agricultural sector is seriously taking into consideration.

Other conclusions and policy implications or recommendations:

(5) The type of crop is a crucial factor in the process of technological change. The successful technological change described in this study involved a food crop (potato) which the small farmers of Caruaru consider profitable and with a good development

potential, because it is not difficult to cultivate and could be easily sold in the local wholesale market.

It was revealed during fieldwork that these same small farmers are less willing to adopt innovations which involve crops which they do not consider profitable, such as manioc. It is thus recommended that researchers pay special attention to develop crops which farmers are willing to expand or adopt and perhaps more importantly, crops which the small farmers can sell, preferably in the local market. Government agencies should support programmes aiming to promote this type of crop, as exemplified by the case of the potato crop in Caruaru.

(6) The development of a new technology (potato cropping) was largely a response by IPA researchers to a demand formulated by the small farmers of Caruaru who were, own their own, unable to solve several problems associated with the potato crop. It is important to be alert to the fact that the new technology was not an imposition by outsiders, as is often the case with researchers and extensionists. The small farmers, determined to improve their potato output, asked researchers for expert help and agreed to participate in the research process. They were very keen on trying a number of innovations which could result in higher production levels and, therefore, facilitated field trials, adaptation and dissemination of innovations.

It is recommended that any agricultural research policy should seriously take into consideration the demands from their clients (farmers) before generating new technologies. These new technologies ought not to be imposed on small farmers but, whenever possible, developed with their participation and co-operation.

(7) The new technology (potato cropping) did not involve the introduction of a new crop and, therefore, was easier to adopt because it was not something completely strange to local cultivators. The potato crop was already cultivated by a number of small farmers in the Caruaru region and, therefore, it was not unknown in the region. The crop was part of their complex farming system and seemed compatible with that system.

Changes involving the introduction of new crops in a region, such as sorghum in Caruaru, on the other hand, proved very difficult to attract the interest of those same small farmers which had adopted potato cropping. Cultivators in the Caruaru region explained that it takes at least three years for them to be able to assess the impact of a new crop. Moreover, as they do not assess the performance of a crop in isolation but in relationship with all their other farming activities as a whole, the introduction of a new crop cannot be treated lightly as it is surrounded by uncertainties and risks which may have serious repercussions for their livelihoods.

Although not totally averse to risk, as explained in chapter 1 (see 1.2.1), small cultivators are careful, rational business people or small entrepreneurs. Given the fact that the vast majority of Caruaru farmers have only small savings and no access to the banking system (loans), it is only natural for these farmers to avoid drastic changes, especially because they have to work in a difficult natural environment which is prone to droughts that may completely destroy their main source of income: agriculture and livestock.

Not surprisingly, the vast majority of small farmers in Caruaru preferred to avoid technological changes which involve the introduction of a new crop which was unknown to them. This is an important conclusion that policy-makers are advised to take into consideration when proposing their development strategies or certain technological changes, especially if they expect to see results in the short or medium-term.

(8) An additional conclusion to be drawn from the experience of IPA in the Agreste region of Pernambuco is that any project which is introduced into a community of small farmers may have to confront the farmer's lack of confidence in outsiders. This attitude is due to many historical factors such as the general disillusionment with government projects which have promised much and delivered little throughout this century.

Furthermore, it is important not to overlook the huge social, cultural and economic gap that needs to be bridged if researchers, extensionists, policy-makers and others are going to succeed in understanding the small farmers and their complex farming systems and, thus, succeed in working together with them. If farmers, for example, are unable to understand what researchers are saying they want to do on the farmers' land, to start with, it is to be expected that these same farmers will treat those outsiders (researchers) with a certain distance, or suspicion, or even fear in more extreme cases. To illustrate this last point, it is only necessary to recall the case involving a number of small cultivators in Caruaru who completely misunderstood IPA researchers and thought that they wanted to 'mark' or select their plots to promote a land reform programme. In other words, agricultural researchers trying to work within a new research methodology - systemic and more participatory - and who were looking for plots on which to set up their on-farm experiments were mistaken for individuals who were going to 'rob' farmers of what is probably their most treasured possession: land.

A simple but significant policy implication may be derived from this conclusion. Research institutions willing to adopt a new systemic and participatory research methodology, such as PTC, must be prepared to implement on-farm research methods and work closely and constantly with a group of small farmers for several years without interruption. Short-term productivity goals should be avoided as well as fomenting high and often false expectations regarding improvements that can be achieved in terms of agricultural output and standards of living, also in the short-term. Researchers can gain small farmers' confidence by being committed to understanding their complex farming systems and trying to satisfy their needs and demands. Co-operation and mutual trust will only develop with time and openness.

(9) Research results must be communicated in ways which are easy for farmers to understand and this is something that may be difficult for researchers or scientists to do, as exemplified by the Caruaru case and others from different parts of the world that have already been mentioned in this study. A research team must, therefore, learn how to effectively communicate with farmers and, also, learn how to speak with 'one voice' in order to avoid providing farmers with conflicting information. In the Caruaru case, for example, a researcher would, in certain situations, provide farmers with specific technical advice which would contradict the information given to this same farmer by a member of his research team.

More attention also needs to be given to the process of informing farmers of relevant research results. It is not uncommon for researchers to keep information to themselves or to delay the release of that information, even when it is relevant to improving farming systems. Moreover, researchers have to be aware that, for different reasons, some farmers may not be inclined to share information more widely with other farmers. Pottier (1994), for example, discusses why small farmers often keep their agricultural knowledge secret. Jéquier (1976) also noted the difficulties surrounding the process of transferring technologies among small farmers. The author points out that '...knowledge about appropriate technology can take years to travel a hundred miles and farmers in one village often do not know about the technological innovations which have been developed or introduced by a neighbouring community' (Jéquier, 1976a, p.62). Thus, researchers cannot take for granted that a farmer will spread the news, good or bad, and facilitate the diffusion of technology process.

In addition, 'beyond-farmer-first' advocates have shown that small farming communities are not necessarily places where people share common goals nor access to natural and other forms of resources. Small farmers, like any other group of people, hold many different, divergent and conflicting views, interests and goals. Or, as Guijt and Shah (1998, p.1) explained: 'community has often been viewed naively, or in practice dealt with, as a harmonious and equitable collective. Too often there has been an inadequate understanding of the internal dynamics and differences that are so crucial to positive outcomes. This mythical notion of community cohesion continues to permeate much participatory work, hiding a bias that favours the opinions and priorities of those with more power and the ability to voice themselves publicly'.

Given all the above, it is suggested, as a policy recommendation, that researchers join forces with rural extensionists and farmer's associations in order to create new forms of transmitting relevant information back to farmers. The farmer association itself could be used as a powerful vehicle of communication. A successful technological innovation or a solution to a farmer's problem must be rapidly and clearly explained to all farmers of that community or region. Farmers also need to be informed of experiments that have not generated answers nor positive results.

A further recommendation is for research institutions to organise courses or workshops to develop and improve their researchers' communication skills. Researchers must be aware that they need to learn how to communicate specialised information in a down-to-earth language. Thus, a learning process is called for: a process in which researchers need to be willing to acquire new skills and be open to criticism, even if it comes from small farmers. Specific communication training courses could be designed taking into consideration the social, economic and cultural characteristics of the group of farmers involved. In the case of Caruaru, the Integrated Production System or SIP (Chapter 4) might be used in a more dynamic way to show groups of farmers how a new technology is working. Fieldwork data analysis revealed that the group or community must be incorporated in this process of technological change as soon as possible, or there will be a tendency for the individual farmers to acquire an advantage over the group as a whole. The result is widespread resentment, waste of scarce resources and further social and economic differentiation within the community.

7.6 Recommendations for Further Research

Investments in systemic and participatory research methodologies are likely to generate desirable results in terms of providing small farmers with the means of improving their agricultural output and livelihoods, as exemplified by PTC (Participatory Technological Change) in the Caruaru case discussed in this thesis. However, the task ahead is a very complex one and should not be oversimplified nor underestimated. New technologies may be the key factor in fostering the development of the agricultural sector and improving farmer's livelihoods but, as already explained, technology alone is not enough. A consistent and long-term agricultural policy which would also provide the sector with accessible rural credit, good quality technical assistance, infrastructure and markets are all essential inputs which need to be available to all farmers. To end this chapter, a number of specific research recommendations can be made based on the findings of this thesis:

(1) Investigate the sustainability of existing farming systems after the adoption of the new technology (potato cropping). The importance of short-term changes cannot and should not blind those involved - farmers, researchers and extensionists in particular. The harsh environment of the semi-arid (Agreste) requires the practice of a 'safer' type of agriculture that would help preserve the fragile resources available, as suggested by Duque (1973). Both, the short and the long-term interests and needs of farmers must be taken into consideration and preserved when developing agricultural policy for the region.

Sustainability must be a serious consideration not only in environmental terms but in economic terms too. As far as small farmers are concerned, preserving their resource base may be as important as guaranteeing that his or her farming system remains profitable and any technological change should generate positive income returns in the medium and long-term if it is to be permanently adopted by the farmer.

(2) Further research into the potential and effectiveness of PTC for delivering technologies which meet farmers' needs would be welcome. Other technologies, besides potato cropping, could be developed by IPA-Caruaru and tried out in the Caruaru region and elsewhere.

(3) A rigorous study of the impact of the use of agro-chemicals in Caruaru on the health of the farmer and his family should be carried out as soon as possible. There is some indication that the use of these toxic substances, especially in the potato crop, may have a negative impact on their health. A study which would assess the effects of these agro-chemicals on the environment is also strongly recommended given the potential problems involved.

(4) The effect of potato cropping on access to schooling, especially of children under twelve years of age, could be further investigated. A number of farmers suggested that the increase in productivity brought about by the new technology enabled the younger children to attend school instead of working in the farm.

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Appendix

Survey Questionnaire

PARTE I - AGRICULTOR: INFORMAÇÕES GERAIS

A- Agricultor

Número do entrevistado: ....

Condição do entrevistado (se diferente do proprietário): ....

Sexo: 1. Masc 2. Fem

Idade: .... anos

Estado civil: 1. Casado 2. Solteiro 3. Viúvo 4. Separado/divorciado

Origem (cidade/estado): ....

1. Da região 2. De fora

Grau de escolaridade: 1, Analfabeto 2. Assina o nome 3. Lê e escreve

Estado de saúde: Tem doença séria que o impediu de trabalhar normalmente no último ano? 1. Sim 2. Não

E quanto a outra pessoa que desempenha função importante na unidade de produção?

1. Sim 2. Não

Ocupação (atividade principal) 1. Agricultor 2. Outra ....

Profissão (advogado, padre, etc): ....

PARTE II: EXPERIÊNCIA DO PRODUTOR COM BATATA E A SITUAÇÃO ANTERIOR A SUA ADOÇÃO

Em que ano começou a plantar batata? 19.....

Tem plantado anualmente desde então? 1. Sim 2. Não ( ) Explique ....

....

Por que começou a plantar batata? ....

....

Como ficou sabendo da batatinha? ....

Antes de introduzir a batata, quais eram suas principais dificuladades para manter sua lavoura (produção vegetal, animal)? ....

....

Tem alguma cultura que é mais importante para o senhor? 1. Sim 2. Não

Em caso afirmativo, qual? ....

Da atenção especial a esta cultura? 1. Sim 2. Não

Por que? ....

PARTE III- IDENTIFICAÇÃO DA UNIDADE DE PRODUÇÃO (UP)

1. USO DA TERRA - INFORMAÇÕES GERAIS (ANTES/DEPOIS)

É proprietário? 1. Sim 2. Não ..../..........

Tem título de propriedade? 1. Sim 2. Não ..../..........

Área total da propriedade? ..../.......... ha (....../.......unidade local)

Área propria: ..../.......... ha

Arrendada: ..../......... ha

Parceria: ..../......... ha

Meia: ..../......... ha

Área total explorada: ..../......... ha (definir)

Área impropria para agropecuária: ..../............ ha

Pastos nativos: ..../......... ha

Pastos plantados: ..../......... ha

Matas e capoeiras ..../......... ha

Terras cedidas: Arrendamento: ..../............ ha

Parceria: ..../............ ha

Moradia: ..../............ ha

Como teve acesso a propriedade/terra: 1.Compra 2. Herança

3.Compra e herança 4. Outra ....

Tem outras propriedades? 1. Sim 2. Não ..../............

Comprou/adquiriu outras terras depois de ter começado a plantar batatinha?

1. Sim 2. Não Área: ...... ha Quando? ....

Em caso afirmativo, por que? ....

O senhor vendeu terras depois de plantar a batatinha?

1. Sim 2. Não Área .... ha

Motivo principal da venda: 1. Pagamento de dívidas 2. Oferta vantajosa

3. Pretende migrar 4. Necessidade de recursos para financiar outros negócios.

5. A terra não era boa 6. Problemas relacionados com a batata 7.Outra

Explique: ....

2. CULTIVO DA BATATA

Área cultivada em 1989: Primeiro plantio .... ha (.......... quadros)

Segundo plantio .... ha (.......... quadros)

Escolhe a área para plantar a batata: 1. Sim 2. Não

Planta sempre no mesmo local: 1. Sim 2. Não

Onde planta: 1. Terra descansada 2. Parte mais plana 3. Terreno que não alaga

4. Terreno arenoso 5. Outro ....

Explique: ....

Faz rotação de cultura? 1. Sim 2. Não Por que? ....

Quantas caixas de batata-semente plantou em 1989? Em 1990? Quanto colheu?

[caixas peso (30 kg/caixa) , Área (ha), produção sacos (60 kg/saco)]

Primeiro plantio ....

Segundo plantio ....

Por que planta (apenas) esta área? 1. Não dispõe de mais terras

2. Não dispõe de recursos 3. Não compensa plantar mais

3. É arriscado plantar mais 5. Outro ....

Quanto guardou para semente? (1989/1990) ..../..............

Quanto da produção de batata é vendido comercialmente: 1. Bem pouco (até 25%)

2. Menos de 50% 3. Mais de 50% 4. Quase tudo (mais de 65%)

Primeiro plantio .... Segundo plantio ....

Qual a semente que o senhor usou? Batata / Tipo / Origem

Primeiro plantio ..../..................../....................

Segundo plantio ..../..................../....................

Efeito da batata:

a) Em outras culturas (consórcio) Antes/Depois

Tipo	Área	Produção	Produtividade/tecnologia
Milho/feijão	......../......	....../......	......../........
Feijão/mandioca	......./.......	....../......	......./........

b) Em outras culturas (solteiras)

Tipo	Área	Produção	Produtividade/tecnologia
Mandioca	......./.......	....../......	......./........
Forrageiras	......../......	....../......	......../........
Palma	......./.......	....../......	......./........
Capim	......../......	....../......	......../........
Outras	......./.......	....../......	......./........

c) Na pecuária/animais

Número de vacas leiteiras ..../........

Número de bovinos de corte ..../........

d) Na mão de obra:

A introdução da batata teve algum efeito importante no uso da mão de obra?

1. Sim 2. Não

Qual?...

Número de trabalhadores remunerados ..../........

Número de trabalhadores não remunerados ..../........ (familiar)

3. EQUIPAMENTOS E IMPLEMENTOS AGRÍCOLAS

(Quantidades) Antes/Depois (ano) A= tração animal M=tração mecanica

É proprietário:

Arado	A=...../.....	M=...../.....	Grade	A=...../.....	M=...../......
Sulcador	A=...../.....	M=...../.....	Cultivador	A=...../.....	M=...../......
Pulverizador	A=...../.....	M=...../.....	Forrageira	A=...../.....	M=...../......
Triturador	A=...../.....	M=...../.....	Debulhadeira	A=...../.....	M=...../......

Outros:

Carroça de burro ...../...... Carroça de boi ...../......

Caminhonete ...../..... Trator ...../..... Bomba p/irrigação ...../.....

4. BENFEITORIAS (Antes/Depois)

Açúde	…../…..	Barreiro	…../…..	Barragem	…../…..
Cacimba	…../…..	Cisterna	…../…..	Poço	…../…..
Curral	…../…..	Depósito	…../…..	Silo	…../…..

Unidades de transformação (casas de farinha, queijaria, outras) …../…..

Material de transporte e tratamento de leite …../….. Galpão …../…..

Desmatamento …../….. Cerca arame farpado …../…..

Outros tipos de cerca …../….. Outras benfeitorias …../…..

Esclarecimentos:……………………………………………………………………..

5. INSUMOS - USO E COMPRA (Antes/depois)

	Antes	Depois
Esterco	……..	……..
Sementes comuns (não só de batata)	……..	……..
Sementes selecionadas	……..	……..
Mudas/estacas	……..	……..
Defensivos	……..	……..
Forragem	……..	……..
Sal comum/mist.mineral/far.de osso	……..	……..
Vacinas/medicamentos/semem	……..	……..

Qual o insumo mais importante? ……………………………………………..

Condições de pagamento do principal insumo comprado:

1. A vista 2. A prazo 3. Depois da colheita e venda do produto
4. Crédito rural 5. Outro (especifique) ………………….

Quem lhe indicou o uso deste insumo?

1. EMATER 2. IPA 3. Associação
4. Propaganda radio/TV/cartazes 5. Vizinhos 6. Outro ………..

6. FINANÇAS (Antes/Depois)

Como é feito o movimento financeiro da U.P?

1. De cabeça   2. Livro caixa   3. Talão de cheques   4. Outro

Colocou dinheiro na poupança em 1989 após a colheita da batata?

1. Sim   2. Não

Em caso afirmativo, saber se a quantidade na poupança modificou-se após o cultivo da batatinha (média anual)   1. Diminuiu muito   2. Diminuiu   3. Igual

4. Aumentou   5. Aumentou muito ....

Explique ....

Crédito: fontes e uso   Antes/Depois

Uso de crédito rural   1. Sim 2. Não   ...../.....

Comentários ....

Qual a principal fonte de crédito?

1.Banco   2. Cooperativa   3.Parente/vizinho/amigo

4.Patrão   5. Outro ....   (...../.....)

Especifique ....

Há quantos anos usa crédito bancário?   .... anos

Uso de crédito   1. Sim   2. Não   (Antes/depois)

1. Investimento (melhoria da propriedade)   ..../........
2. Custeio (culturas/pecuária/comercialização)   ..../........
3. Consumo familiar   ..../........

PARTE IV- INFORMAÇÕES SÓCIO-ECONÔMICAS

A- Família   (Antes/Depois)

Número de filhos vivos ....   Homens ....   Mulheres ....

Curso de capacitação profissional do proprietário:

1. Ligado a agropecuária   2. Ao setor industrial   3. Ao setor comercial
4. Ao setor saúde   5. Serviços burocráticos   6. Artesanato
7. Não sabe o tipo   8. Outros   ..../........

Especifique ....

Quem informou: 1. EMATER 2. IPA 3. Associação
4. Vizinhos 5. Radio 6. Outro

Alguma ligação com a batatinha: 1. Sim 2. Não

Especifique ....

Curso de capacitação profissional na familia (colocar o status familiar e o curso de acordo com o código acima): ....

....

B- Condições de moradia/vida

1. Casa própria 2. Alugada 3. Empregada 4. Outra

Local onde mora: 1. Na propriedade 2. Na cidade 3. Outros

Número de anos na propriedade: .... anos

Tem outra casa: 1. Sim 2. Não

B-1. Saneamento

I.Características da casa (Antes/Depois)

Número de comodos ..../........

Piso: 1. Chão batido 2.Tijolo 3. Cimento 4.Taco,mosaico ..../........

Parede: 1. Palha,taipa 2. Adobe 3. Madeira 4. Tijolo ..../........

Cobertura: 1. Palha 2.Zinco 3. Telha 4. Laje,cimento ..../........

Reboco: 1. Sem 2. Parte da casa 3. Toda casa......./........

II. Água

Origem:1. Córrego,rio 2. Barreiro, poço, descoberto
3. Cisterna, pçco descoberto 4. Encanada (COMPESA) ..../........

Tratamento (domiciliar) da água de beber: 1. Depositada em jarras/potes
2. Coada 3. Fervida 4. Filtrada ..../........

III. Destino dos dejetos (Possui banheiro em casa?)

1. Mato 2. Fossa 3. Esgoto ..../........

IV. Fonte de energia

Tem luz elétrica: 1. Sim 2. Não ..../.......

Em caso negativo: 1. Vela 2. Lamparina (querosene)

3. Lampião (gás) 4. Bateria 5. Gerador ..../........

B2- Bens domésticos 1. Sim 2. Não (Antes/Depois)

TV P/B e TV-Cor	....../......	Conj. Som	....../......
Gravador	....../......	Geladeira	....../......
Fogão	....../......	Filtro	....../......
Liquidificador	....../......	Batedeira	....../......
Bicicleta	....../......	Moto	....../......
Carro de passeio	....../......		

B-3- Participação em organizações formais/informais

É membro/participa: 1. Associação 2. Sindicato

3. Cooperativa 4. Outro ....../......

É membro/participa 1. Centro comunitário 2. Associação de moradores

3. Clube social/esportivo 4. Partido político 5. Outro ....../......

PARTE V- AVALIAÇÃO DO IMPACTO DAS MUDANÇAS RELACIONADAS COM A INTRODUÇÃO DA BATATA

O senhor tem vontade de aumentar a área plantada com batata?

1. Sim 2. Não Por que? ....

O senhor recomendaria a batatinha para um amigo seu (que ainda não a cultivasse)?

1. Sim 2. Não

Em caso afirmativo quais os principais argumentos que usaria para motivá-lo a plantar a batatinha? ....

Em caso negativo, por que não? ....

Fez alguma mudança importante na maneira como maneja sua lavoura depois que começou a plantar a batatinha? 1. Sim 2. Não

Em caso afirmativo, citar as mais importantes (2 ou 3) ....

....

Se não estivesse plantando a batatinha o senhor teria feito as modificações mencionadas?

1. Sim 2. Não Por que? ....

....

O que aconteceu com sua receita de produção? (total/anual/bruta) depois que começou a cultivar a batatinha? 1. Caiu muito 2. Caiu 3. Continua igual 4. Aumentou 5. Aumentou muito

O que aconteceu com seus custos de produção? (definir tempo, custos, unidade de medição (em relação ao que gastava)) ....

....

....

Qual a importancia da renda obtida com a batatinha no ano de 1989 em relação a renda total da propriedade: 1. Pouco importante 2. Médio 3. Muito importante

A batatinha da lucro? ....

Quais os 2 ou 3 maiores benefícios para sua lavoura que o senhor associa a batatinha?

....

....

A tecnologia da batatinha ajudou a resolver algum dos problemas tecnológicos mencionados anteriormente? 1. Sim 2. Não

Cite o problema e explique ....

Sua vida (e de sua família) mudou depois que o senhor começou a cultivar a batata? Como? O que causou esta mudança? ....

....

....

PARTE VI - COMPLEMENTO

A- Comercialização

Onde o senhor vendeu a maior parte da sua produção de batata em 89?

1. Associação 2. Feira (direto) 3. Feirante 4. Armazem 5. Outro

O que o Sr. acha da idéia da associação comprar a sua produção, estocar no frigorifico e depois vender caro dando-lhe o lucro de volta?

i) ....

ii) 1. Boa idéia 2. Indiferente 3. Má idéia

[Uma das grandes vantagens da batatinha é que quando voce a colher é só por no saco e vender. O dinheiro entra no bolso na hora (isso não acontece com a mandioca, nem com o milho, feijão, etc)].

O que o Sr. fez com o dinheiro da batatinha em 89?

1. Poupança 2. Gado 3. Eletrodomésticos 4. Vestuário

5. Patrimônio (casa ou fazenda) 6. Outro

E nesse ano de 1990? ....

O que o Sr. acha da idéia do Sr. ou um familiar seu vender a batatinha diretamente na feira? ....

B - Envolvidos

Quem tem lhe ajudado mais? 1. Ninguém 2. Prorural 3. IPA

4. EMATER 5.Outro Especifique ....

Como? ....

C- CULTURA/INDIVIDUALISMO

O Sr participa das reuniões da associação - APROBACA (primeira 2a-feira do mes)

1. Sim 2. Não

O que o Sr. acha dessas reuniões? ....

....

O Sr tem facilidade de conseguir emprestado:

1. Arado 2. Pulverizador 3. Pé de galinha 4. Sulcador

5. Transporte para cidade 6. Trator 7. Forrageira 8. Motor

É possível alugar?

1. Arado 2. Pulverizador 3. Pé de galinha 4. Sulcador

5. Transporte para cidade 6. Trator 7. Forrageira 8. Motor

D- NIVEL TECNOLÓGICO

Teve problemas de doenças no seu plantio de batata nos últimos dois anos?

1. Sim 2. Não

Em caso afirmativo, especifique: ....

....

O que foi feito a respeito (tratamento) ....

....

Planta em sulco? 1. Sim 2. Não

Por que? ....

Sabe o que é pé de galinha? 1. Sim 2. Não

Qual o tipo que usa? ....

O que o Sr. pensa a respeito do crescimento do número de produtores de batatinha?

i) ....

ii) 1. Bom 2. Indiferente 3. Ruim

Para finalizar: O que o Sr. acha que pode ser feito para melhorar a sua produção de batatinha? ....

....