Chapter 3 – EVALUATION OF ENVIRONMENTAL IMPACTS CAUSED BY ACTIVITIES SIMILAR TO THOSE PROPOSED BY THE PROJECT

3.1. Introduction and Methodology

Because of the difficulty in evaluating the environmental impacts of agricultural projects *in loco,* and the limited time available, the strategy adopted was to prepare a summary report based on a literature review of expert evaluations of relevant environmental impacts.

This literature review drew on the bibliographic resources archived in the libraries of the headquarters of the Brazilian Agriculture and Livestock Research Agency (Embrapa), the Cerrados Research Centre, the University of Brasília and the Cenagri Library of the Ministry of Agriculture. Being based on the resources available at these institutions, this literature review may present a more complete coverage of some agricultural and ranching activities than of others; this should not be understood as conferring higher priority or greater importance on these activities.

Since the purpose of this study is to inform a Plan which is based on the principle of sustainable development, this chapter will begin with a brief reflection on the definition of "sustainability" as applied to agriculture.

3.2. The Sustainability of Agriculture in the Cerrado Region

Cunha (1994) in his book *"An Evaluation of the Sustainability of Agriculture in the Cerrados"* comments that the various concepts put forward by other authors all express a desire for making economic growth compatible with environmental conservation and that these two factors are intrinsic to the conditions which should ideally feature in sustainable development, namely:

- *an increase in the quality of life, by which is meant an increase in agricultural production accompanied by a simultaneous and comparable increase in demand. Economic stagnation is not an option;*
- *greater control of biological processes by means of agricultural techniques. Nutrient cycles within the agricultural sector should be closed;*
- *a more efficient use of the natural resources of agriculture and an increase in overall productive efficiency (efficiency is here taken to refer to the use of all factors of production);*
- *increased production without increased marginal costs; and*
- *increased welfare for one generation without compromising the welfare of any other generation.*

Cunha goes on to develop this issue in relation to the Brazilian cerrado, identifying four important aspects which are closely interrelated and which enable a better understanding in the evaluation of agricultural sustainability in this ecosystem: *technical efficiency, economic sustainability, social stability* and *ecological coherence*.

The author states that the technical dimension requires an analysis of the patterns of physical yields from the land, in which maintenance of productivity levels would be an indicator of sustainability; analysis of the potential for productivity increases in search of sustainable production; an evaluation of the potential for technology to repair damages; and an evaluation of the capacity of research institutions to respond to the challenges of sustainability in an ongoing and continuous way. In this context, the debate focuses on the ability of technology to ward off the spectre of declining yields.

Cunha's work affirms that the choice of technology is directly linked to economic viability of the technology and of the resource allocations required of the user of the technology in question. On the other hand, the application of techniques which offer the potential to sustain or increase physical yields is also crucial for economic sustainability since otherwise enterprises would depend on external assistance (for example, subsidies) for their survival. It is clear, therefore, that to be sustainable, agriculture must be competitive.

The relevance of social stability is highlighted in the context of agricultural frontiers (which is how the cerrados are perceived) since in this context speculative profits are possible and this hampers the efficient workings of markets and militates against any long-term investment. Cunha (1994) points out a number of fundamental points that need to be borne in mind here:

- *the population need to have a long-term perspective;*
- *lack of certainty regarding land ownership and poverty levels of the farmers concerned puts the sustainability of growth at risk;*
- *the population should demonstrate a minimum level of commitment to project success, envisaging in strong and concrete ways their permanence in the region.*

The author recommends that, in order to obtain a more complete contextual understanding which captures intra-regional differentiations, the region in question should be subdivided into sub-regions.

Ecological coherence becomes a requirement once the intensity of exploitation begins to threaten the support capacity of the environment. Population growth in these regions and the transition to a more intensive pattern of cultivation without any long-term fallow periods has resulted in soil degradation and falling productivity. The author reminds us that the cerrado region is very heterogeneous with some stable and resistant ecosystems and others which are very fragile. The type of exploitation and the cultivation tecniques utilised bring very different results; for example, extractive activities and cultivated forests cause less impact than temporary cropping regimes that are highly mechanised.

It is worth noting here that the cerrado contains both deep and well drained soils such as the latosols and podzolic soils and very fragile soils such as quartzose sands, litholic soils and hydromorphic laterites. They generally have a low cation exchange capacity (CAC) high acidity, moderate levels of organic matter content and textures which range from clayey to sandy (Shiki, 1997). The also have a low water retention capacity and a high infiltration capacity (Goedert et alii, 1980). The *veredas* (marshes, springs and other seasonally waterlogged areas) and *covoais*[1] constitute an immense network regulating and storing the region's water resources. Hence the importance of establishing soil suitability profiles and Ecological Economic Zoning, as these two instruments help decision-making in the short-term to achieve better long-term results.

It is also worth noting certain features of current agricultural practice on the cerrados under what are often referred to as 'family' or 'popular' agricultural systems. These systems utilise land that was originally wooded, and which is also known as *"terras de cultura"* (cultivation lands), for temporary crops, and the farmers generally have few financial resources, little formal education and use little or no inputs. The main crops grown are rice, maize, cotton, maioc and sugar cane. Pastures for extensive cattle ranching account for most of the land area. Extractivism is also practised on the higher plateaus (*chapadas*) for fuelwood, fruit and various species of medicinal plants with these latter being much used by individuals known as 'herb doctors' (*raizeiros*) in a tradition that is well-established in this ecosystem (Péret, 1997).

In these agricultural systems, rice often serves as a transition crop and is used in the formation of pastures. It can also be substituted by maize and beans which are cultivated together with the maize being used as feed for livestock, either pigs or dairy cattle. *Manioc production is concentrated in lands with low fertility and cotton production tends to be characterised by industrial style plantations* (Péret, 1997).

Citing Ruttan (1981), Cunha states that the "natural agriculture," despite causing less environmental impact, is nonetheless *incapable of meeting the growing demand for agricultural products at prices that are compatible with the purchasing power of the majority of the population.*

Among the "collateral effects" of "polluting agriculture" Cunha cites:

- *loss of soil productivity through erosion, salinisation, compaction and destructurisation;*
- *soil loss resulting in sedimentation of hydrographic basins and the reservoirs of hydroelectric plants;*
- *water pollution with fertilisers and pesticides;*
- *increased resistance among insect pests, weeds and pathogens;*
- *loss of natural habitats of plant and animal species threatening their survival;*
- *destruction of genetic material (germplasma) of incalculable economic value.*

Government policies, according to Cunha, are also associated with ecological incoherence. He states that *with the application of subsidies, the Government encourages the overuse of polluting products (agrochemicals), finances the development of activities in unsuitable areas, and regulates economic activity in a way that creates disincentives for environmental conservation.*

Having analysed all these various aspects of the sustainability of agriculture in the cerrado region, Cunha presents a retrospective view which shows the agricultural boom which has occurred in the cerrado ecosystem, pointing out that the region now has more cattle than anywhere else in the country. He also points to the success recorded with crops

[1] Depressions with diameters ranging from 0,5 to 1,5 metres which fill with water during the rainy season (Shiki,1997)

such as maize, soya beans and other cereals, with plantations of permanent crops such as coffee and rubber, with vegetable and salad crops, fruit growing and seed production. He concludes that this agricultural expansion will continue and states that the most critical point with regard to its sustainability is whether future technological advances can compensate for the deterioration in productive capacity.

3.2.1. Production Systems in the Cerrado Region

(a) Grain Production

Cunha makes a specific study of the three crops in this categroy which he considers most important: soya beans, maize and rice. His descriptions of the types of producer involved and the principal impacts arising from the cultivation of these three crops are noted below.

The producers studied are members of a category that is technically and economically efficient. They operate on the frontiers of production, making intensive use of mechanisation with equipment that is optimised in terms of efficiency of use, and as farmers they have much in common with businessmen.

In the context of the conditions that prevailed at the time, particularly those relating to production costs, Cunha makes some important observations:

- soya bean cultivation has established a definite presence in the cerrado region but profit margins are low and leave no room for inefficient producers;
- producers achieving yields of less that 2 tonnes per ha should abandon soya bean production and sell off their equipment unless soya bean prices rise above US$ 12,00/sack;
- the existing insurance system is inadequate and this means there will be instability in the event of a poor harvest;
- there is reasonable scope to adapt existing equipment used for soya bean production (assuming sophisticated technologies and specialised equipment with a high fixed cost) for use in the production of other crops, and this diminishes the risk of having to leave this equipment idle when soya bean markets are in crisis;
- in a crisis situation, various other costs are also reduced and fixed capital is not irretrievably compromised.

Since sustainability presupposes the adoption of practices to maximise the protection afforded the resource base, Cunha examined the prevention of soil compaction through the use of a moldboard plough (*arado de aiveca*) every four years, direct drilling (*plantio direto*) and the integrated control of pests and disease.

The method proposed for the prevention of compaction features deep ploughing using a moldboard plough which results in improved root growth and reduced surface run-off which in turn reduces erosion. This practice results in an increase of 4,5% over traditional methods and the author states that the cost/benefit ratio of the technique is favourable. The question is whether the producer can afford the extra costs (estimated at five times more than a normal ploughing operation) of this investment in the short-term in order to obtain sustainable yields in the longer term.

Direct drilling, in contrast, provides better results with regard to erosion control by reducing the need for ploughing. Cunha's research found that the costs of soil preparation could amount to 47% of total costs for soya bean production. The great advantage of direct drilling is in soil conservation since it results in less compaction, less exposure of bare soil, incereases in soil organic matter content and it can also result in increased productivity and it is well-suited to regions where it is possible to drill throughout the year (Cunha,1994). The negative aspects of this technique are: the increased use of herbicides (which may increase production costs so much that the crop ceases to be economically viable, and which are strong pollutants); the requirement for considerable organisation and competence on the part of the farmer and the provision of constant and efficient technical assitance.

Integrated pest control is, Cinha suggests, most effective in small-scale plantations, and has substantial positive effects on the environment. There is need for more research into its use on a larger scale.

Cunha (1994) questions why such conservationist technologies are not more widely adopted even though discourse is now based on the sustainable development of agriculture and ranching activities. By way of explanation, he points out that *"given the availability of land and incentives for opening up new land-holdings (in the form of speculative profits), it may be more productive for the producer to move on to another area than to invest in soil conservation on previously cultivated areas."*

With regard to maize production, research found that, as with soya bean production, the agricultural systems were modern businesses, with an area of 550 ha to enable the full utilisation of harvesting machinery and with typical yields of 5000kg.

The low levels of manpower required shows the modern cultivation technologies used in the cerrado region. Deep ploughing gives better results in maize production than it does for soya beans. However, maize as a crop has a number of features which result in it being cultivated on a smaller area than soya beans:

- *in order to meet domestic consumption need, economic policies have tended to restrict exports in an unpredictable way. Fluctuations in maize prices and consequently the levels of risk associated with the crop have traditionally been greater;*
- *maize is more demanding in terms of cultivation practices, requiring more human capital (workers and administrators);*
- *credit insurance systems provide little incentive for the establishment of risky crops; and the economic risk increases in line with the requirements for the intensive use of modern inputs.*

In addition to these factors, the National Maize and Sorghum Research Centre (CNPMS) indicates that, since maize production costs are high, the resulting produce needs to be consumed in the locality so as to avoid transport costs; the cost of hybrid maize seed is relatively high and there is a need for research to develop improved national varieties with good productivity and a much lower cost to enable their use by small-scale farmers; and finally there is a need to diversify and select varieties in order to reduce risks, linking productivity with disease resistance.

There are a number of different systems of rice cultivation: dry rice, dry rice for pasture formation, irrigated rice and high technology rice for the cerrado region (Cunha, 1994). Dry rice cultivation is particularly common among subsistence farmers and tends to yield up to 1,5 ton/ha, however, with the adoption of new varieties productivity has increased to rival the levels achieved under irrigated regimes, namely 5,5 ton/ha (CNPAF). Traditional dry rice cultivation could not be mechanised since there was no way to cover the additional cost involved. In biological terms, rice is particularly susceptible to unseasonal weather and outbreaks of the fungal disease known as *brunone* can cause massive damage.

With regard to irrigated rice production, the Formoso do Araguaia project provides a good example of the type of problems that may arise (as reported in the Intermediate Report for the *Development Study for the Agricultural and Cattle Ranching Sector in the North Region of Tocantins State*). Recommended cultivation practices have not been observed (mono-use of fertilisers and very large field sizes), water and seeds are wasted, and water management has been inadequate to control weeds and disease.

(b) Beef Production

Traditional cattle ranching systems involving extensive natural pastures can be found in several regions of Brazil. They are characterised by the low intensity of their use of capital and manpower and their requirements for large expanses of land. They make use of hardy animals that are well-adapted to the environmental conditions, and which require large areas to survive. In the dry season, the animals can lose up to 30% of their weight due to the lack of access to alternative sources of nutrition. Generally the statistics are very low, for example: age at slaughter is over 5 years; they require 4-7 ha per head on soils where fertility is good, growth rates are around 5%; income generated by beef production on a 400-ha property with 80 head of cattle is around US$1.200 per year. The inevitable conclusion is that this production system may be perfectly sustainable from an ecological point of view but not from an economic or social perspective. For the system to function, certain preconditions must prevail, for example: the area must be remote from markets, lacking in adequate transport systems, and with no (or no recognised) technology enabling any alternative use of the land. As such, the system is most prevalent in areas with low demographic density, or in other words, in places where there is no pressure on natural resources (Cunha, 1994).

Extensive cattle ranching systems were among the first land use systems to be established in the cerrado region and they normally occur on the estates of large landowners.

The system established in the 1960s consisted basically of rice cultivation for a few years (favoured by cheap and abundant credit which paid for the opening up of the cerrado and by the fact that it could tolerate the relatively high acidity of the soils), followed by the seeding of pastures consisting primarily of *Brachyaria* grasses. One important fact is that initially *with the establishment of these seeded pastures, the stocking levels of the pastures rose from 0,2*

Agricultural Units/ha/year to 1,2 AU/ha/year on average, and productivity rose from 20kg/ha/year to 200kg/ha/year (CIAT, 1995); however the system remained extensive and highly dependent on the natural soil fertility (Shiki, 1997).

In the 1970s, there was a significant push to expand these pastures and, in the 1980s, soya beans overtook rice in terms of land use. Over this 30-year period, the degradation and exhaustion of the soils had become evident, and the appearance of soil slumping and erosion gullies became common (Barcellos, 1996). Even more serious was the option selected to counteract the decline in pasture productivity: new pastures were opened up in place of the gallery forest, marshes, springs and well-watered areas and this affected the hydrological resources of the whole cerrado region leading to the drying up of steams and creeks in the dry season. In some instances, herd productivity fell back to the rates that had been achieved on natural unimproved pastures several decades earlier: 0,2AU/ha/year (Barcellos -1996).

Cunha(1994) questions the idea that the environmental impact of pasture formation is relatively low on account of pasture being a "long-cycle" cultivation system under which the period of soil exposure is relatively short. The land is most prone to erosion at seeding time and this tendency is exacerbated when previous cultivations have been carried out without any concern for soil management and conservation. With this in mind, the author suggests that it is highly unlikely that those who have leased the land and who are necessarily motivated by the prospect of immediate profit, will be prepared to take the trouble to follow the contours of the land or to take any other soil conservation action which might yield benefits in the long-term.

A further risk mentioned by Cunha is overgrazing which he attributes to the lack of rural credit schemes and taxation compatible with the returns on the activity, and the unfavourable price regime.

The degradation of pastures is one of the greatest problems facing cattle ranching in Brazil and it has a direct effect on the sustainability of this productive system (Kichel et al., 1997). The technological solutions that have been suggested, such as the use of the leguminous *Stylosanthes guianensis* species to raise the productivity of graminaceous pastures by means of fertilisation with biological nitrogen, providing forage with a higher protein content and fixing biological nitrogen for the graminaceous species, have not proved successful enough to generate significant changes in the current situation (Shiki, 1997).

Kichel et al. (1997) state that there are two basic ways in which the recuperation and renewal of pastures can be achieved: through the integration of pasture and agriculture, and through direct action on pastures alone. The first of these can be sub-divided into two systems: intercropping of annual crops and pastoral species, and the establishment of annual crops separately from pastures. The intercropping system involves either the simultaneous sowing of seed for the annual crop and pastoral species, or it makes use of the seed stock of pastoral species that is already present in the soil. Following the harvest of the annual crop, the renewed pasture remains.

The current understanding of the benefits of rotating between forage crops and intensive agriculture will be deepened as a result of the actions suggested in the Plan for the Diversification of Agricultural and Catlle Ranching Activities. The plan suggests the planting of an annual crop, be it maize, rice, sorghum or another species for one or more years, then putting the land back into pasture with the same forage species as previously or an improved and more productive one. The main advantages claimed for this system are:

- reestablishment of forage crop biomass and increase in the pasture's stocking capacity;
- a more efficient recovery of soil fertility since the annual crops are more demanding in this respect and will therefore tend to prompt farmers to safeguard and enhance this;
- ease of application of soil conservation practices;
- the recovery of soil fertility in the pastures is achieved at a lower cost because the profits generated by the annual crop offset recovery costs;
- ease of renewal of the pastures since in the intensive agricultural phase, the elimination of weeds by means of herbicide applications is expected and this will reduce the seed stock of unwanted species present in the soil and thereby favour the forage species (mainly *Brachyaria* species) that will be introduced subsequently;
- improved physical, chemical and biological properties of the soil achieved through the crop-pasture rotation, the avoidance of monoculture, the elimination of compacted layers of soil, the incorporation of animal residues (dung), roots and straw of both the annual and the forage crops, thereby encouraging the microbiology of the soil;
- the control of pests, diseases and invasive species by disrupting their natural cycles;
- plant residues that remain in the soil after the harvest of the annual crop will serve to help fertilise the soil for the forage crop;

- more efficient use of machinery, equipment and labour on the farm, with use being extended over a longer period of the year;
- diversification of the productive system, favouring the exploitation of the breeding, rearing and fattening phases and the production of cereals, and reducing the risks associated with weather and market fluctuations; and
- increased productivity for the enterprise as a whole making it sustainable in economic and ecological terms.

The limitations which are identified are:

- pastures which are located in areas where the climate and soil are unsuitable for cereal production;
- internal and external infrastructural deficiencies with regard to cereal production;
- lack of adequate knowledge of technologies for cereal production;
- lack of financial resources so that the rancher is unable to find partners or tenants;
- lack of suitable machinery and equipment; and
- the need to recuperate the pasture in the short-term.

In the specific case of the direct drilling of soya beans, it can be said that this technology is suited for the recuperation and renewal of pastures in the short, medium or long term but it requires pastures which are not completetly degraded, a good straw cover evenly distributed over the soil with no impediments for machinery and the utilisation of soya bean varieties with a rapid or moderately rapid cycle. This system costs less thatn the conventional system and it is much more simple to make put into operation.

This system, known as the *"Barreirão"*, was proposed by the National Research Centre for Agriculture and Cattle Ranching on the Cerrado (CPAC). Shiki (1997) comments that, until the 1990s, the system achieved positive results in various states in the Central Western Region, with the leasing of pastures for maize or soya bean cultivation (on better structured and more workable soils) or for the intensive production of maize or sorghum together with pasture grasses, but that the strategy depends heavily on the markets for these other products and it may become too costly when markets are in crisis.

Cunha partially agrees with this and undertakes a more detailed analysis in which he affirms that the *Barreirão* technique runs up against a number of obstacles such as: *difficulty for the rancher to grow crops; the system implies the loss of one year's pasture when compared to the direct drilling of pasture species; and the fertiliser inputs which are taken up by the rice need to be replaced.* For this reason, the author argues that, to be economically viable the technique has to achieve a higher rate of return on the rice than on the pasture.
Kichel et al.(1997) suggest a less risky activity than the use of agriculture for pasture recovery and renewal. Basically, this "direct recovery" can be effected without soil preparation, with minimum soil preparation or with thorough soil preparation; a further alternative is the intercropping of an annual forage crop such as forage millet or sorghum, with the latter also serving for pasture renewal.

Direct recovery without soil preparation is most suited to well formed pastures which have been appropriately managed so as to be free of invasive species and erosion, with uncompacted soils; soils with textures in the loamy to sandy range are the most suitable types. Direct recovery with minimum soil preparation is best suited to compacted soils and/or badly formed pastures which may or may not have nutrient deficiencies. Direct recovery or direct renewal with thorough soil preparation is most appropriate where: soil erosion is occurring; there is a high incidence of invasive species; a mixture of forage species with different palatability and growing habits; a large number of termite infestations; thin pasture or pastures with bare patches; highly acid soils, deficient in nutrients, or compacted; or when the existing forage species is going to be substituted for another. In this latter case, the task is inevitably more onerous.

Intensive cattle ranching with confinement of animals is usually most effective when cattle are bought at times of abundant supply for sale during the dry season, thereby yielding profits from production and speculation. This system is advantageous for the following reasons: *it reduces price oscillations between slaughtering time and the rest of the year, it avoids weight loss among the herd during the dry season, it lowers the age at slaughter, and it contributes to a reduction in seasonal unemployment during the dry season* (Cunha, 1994). The system is characterised by its intensive use of capital and labour, it requires careful administration and its highest costs are in animal feed. For this reason, when it is practised in conjunction with other cultivations, for example sugar cane which yields bagasse that can be used as animal feed, it becomes less costly.

In spite of the numerous negative experiences with this system and its possible impacts, the authors reviewed argue that there is strong potential for the development of this activity in the cerrado region and conclude that:

- extensive beef cattle ranching systems on older lands show falling productivity, implying that they lack resilience which is one of the properties required for sustainability (Cunha, 1994);
- the effectiveness of the techno-economic alternatives proposed for the 30 million ha of land which has been to some degree degraded, is not sufficient to deliver results with the swiftness required;
- techniques are available which would enable the expansion of activity (forage cultivations, the addition of urea to mineral salt and improved pasture management); the only thing missing is the financial resources needed to disseminate these techniques (Cunha, 1994);
- the intensification of ranching systems is proposed, *whether by the association of ranching and cultivations in succession and rotation (CIAT – CPAC), or by genetic improvements under a confined or semi-confined management regime with feed being supplemented by forage crops and protein concentrates* (Shiki, 1997);
- a positive effect of the intensification of cattle ranching from the socio-economic point of view would be its tendency *to exert a downward pressure on land prices, if it was accompanied by price stability, a reduction in agricultural subsidies and attractiveness for financial markets* (Shiki,1997);
- intensification *signifies a change in ranching systems and this could be a solution for productivity, but it may also generate other entropies* (Cunha, 1994).

(c) Milk Production

The small-holder famers of the cerrado region have a stronger representation in this segment which tends to be concentrated near urban centres. They use cattle of mixed breeding (zebu and Dutch crosses), productivity is low and rates of return are equivalent ot those achieved by beef cattle on natural (unimproved) pastures (Cunha,1994).

Under a confined or semi-confined regime, milk production has good potential but for this it requires the intensive use of human capital, good breeding stock, physical infrastructure and effective transportation systems (Cunha, 1994).

There is also the potential to raise other animals, such as buffalo and sheep, to produce milk and other derivatives. Buffalo milk has a number of advantages, since in addition to giving higher yields (around 8 - 10 litres/day in the rainy season and 6 litres/day in the dry season); buffalo consume plants which cows will not eat; while they do need shade they do not require water holes for bathing; they are more resistant to disease; their reproductive capacity is around 90% - 95% while that of cows is around 60% - 75% (Pacific Consultants International). The principal obstacle to the spread of buffalo farming is consumer acceptance of buffalo meat which is only marketed in a few regions.

3.3. The Sustainability of Agriculture in the Amazon region

Certain critical areas have emerged in the Amazon region and their emergence is undoubtedly linked to the unsustainability of the activities conducted therein. With regard to the agricultural, ranching or extractivist activities realised within it, the sustainability of the Amazon region requires concommitant ecological, agronomic, economic and social sustainability since these must be balanced in time; for failure in one will compromise the others and thence jeopardise the sustainability of the whole context (Flores et alii, 1991; Serrão & Homma, 1991, cited in Kitamura,1997). The examples below illustrate this reality.

In the case of the autonomous rubber-tappers of Acre, sustainability is high in agronomic and ecological terms but low in social and economic terms (Homma, 1989; cited in Kitamura,1997). Where, in certain areas, the forest has been replaced by pastures for livestock, economic and agronomic sustainability is satisfactory but the other categories of sustainability leave much to be desired. Even flood plain agriculture (*agricultura em várzea*) in the Amazon region, which has good results in agronomic and ecological terms, is unable to maintain satisfactory levels of economic and social sustainability (Serrão e Homma, 1991; cited in Kitamura,1997). It can be stated that no agricultural production system in the region fulfils the four premisses of sustainability in the Amazon (Kitamura,1997).

Extending his analysis further, Kitamura (1997) argues that there is a need to maintain and enhance the plant-base extractivist systems (excluding timber) in the Amazon region on account of their strategic importance in terms of forest preservation. However, he recognises the economic vulnerability of these systems and the need to seek out alternative income sources and ways to add more value to extractivist activities and he makes reference to the possibility of compensating these communities for the environmental benefits that they generate for humanity as one way of improving their economic and social conditions.

Currently, more emphasis is given to integrated forest management as holding real potential for the sustainable non-timber use of the forest. This is a possible strategy for certain localities which have the appropriate natural resources and native populations with traditional experience of this sort of activity.

In contrast, timber extraction activities continue to present the same negative characteristics as they have for years. They are extremely predatory, there is an absence of regulatory mechanisms in the timber market, waste is a continuing feature which results from the incomplete utilisation of the forest's timber potential and the fact that two-thirds of the timber yield is lost in the sawmills.

According to Kitamura (1997), the sustainable development of the Amazon region must begin from an initial premiss which recognises its rich biological diversity is associated with different plant, animal and human populations that have, over time, adapted to create a wide range of economic and socio-cultural diversity. The perspective of the Amazon environment that should be adopted "*is not one of an immense natural global reserve, closed off and protected, nor of an immense anthropogenic desert, but a vision of real opportunities for policies which reconcile environmental conservation with the local populations' needs for the development*" (Kitamura, 1997).

The author establishes attention to the basic needs of local populations as a key concept for addressing the environmental problems of the region, with particular emphasis being given to ensuring food security. Then, economic growth must guarantee a convergence of benefits for the poorer sections of the population. Thus, the management of the natural resources of the Amazon region will only be sustainable when regional development policies ensure concrete results for private investment and when these also bring benefits to the less favoured elements of society.

The author goes on to state that the sustainable development of this ecosystem requires community participation in the planning process and in the implementation of social and/or environmental programmes and projects. It is therefore necessary to comprehend *the culture, the ways of life and, most importantly, the specific ways in which the native populations manage their natural resources* (Kitamura, 1997).

Other factors need to be analysed in order to understand the environmental problems which have arisen to date in the Amazon region. The first of these relates to government policies for the region, which have been marked by the promotion of economic and social goals that lack any interconnection, and which have been delivered through inflexible structures and by organisations having little or none of the flexibility required to interact effectively with the socio-cultural diversity of the region. In recent decades, there has been a tendency to give special attention to large-scale businesses and landowners with a view to export markets, and engagement with other segments of the population has been sidelined.

A second factor to consider relates to the strategies adopted in areas around the Amazon region which have, as a general rule, given rise to migratory movements occurring over the past several decades in which displaced populations from neighbouring regions move into the Amazon region. Such migratory movements are also provoked by environmental policies and development schemes which encourage the speculative occupation of the region's natural resources with fiscal incentives, subsidised credit and regressive taxation policies (Kitamura, 1997). As has been made clear by the example of Rondônia State, attempts to manage such immigration streams are faced with a series of problems and a range of negative results can arise. There is a need to minimise migratory pressures on the region and also to control access to its natural resources.

A number of authors have hailed agroforestry systems as being those best suited for the humid Brazilian tropics. Serrão and Homma (1991) point to high levels of sustainability in the following aspects:

- agronomically: reduced risk of diseases and pest attacks; improved nutrient cycles and consequently a better utilisation of nutrients;
- economically: the producer has a range of income sources;
- socially: diversification of production, greater opportunity for direct and indirect emplyment; increased specialisation of the workforce; and
- ecologically: high levels of biomass accumulation, improved hydrological conditions, enhanced soil conservation, more favourable environmental conditions for both micro and macro flora and fauna.

Agriculture remains a priority in the economy of the Amazon region. While there can be no unique model of a production system, an understanding of the specificities of each group of producers and of how they relate to their environment can only enhance the search for lower impact systems which are more sustainable in the long term.

3.3.1. Silviculture in the Amazon region

Silviculture in the Amazon region has a recent history, with reforestation only just beginning, but nonetheless the process of deforestation proceeds virtually unchecked. Its main characteristic is the exploitation of native forests in which there is a low concentration of commercial species. It should be noted that traditional production systems result in a significant area deforested, with small-holders felling and burning new areas (Yared, 1990).

The main limiting factor in the establishment of large-scale silviculture enterprises is the lack of available seeds and saplings (Yared, 1990). Hundreds of native species have been tested but for the majority, detailed information on seed production, sapling growth, planting techniques and plantation management is lacking.

According to Santana (1994), between 1981 and 1988, the area deforested in the Legal Amazon region was 2.053 thousand ha whereas the reforested area existing in Brazil in 1984 was 5.901 thousand ha. Despite the fact that sustainable forest management is a legal requirement for timber companies, they have proved highly resistant to the implementation of management practices pointing to the high cost of such projects and their need for extensive areas.

Veríssimo et al (1996), working for the Amazonian Institute for Man and the Environment and using case studies from Pará State have shown that forest exploitation can be classified into different types based on: the type of forest and the presence of absence of high value species; transport options for the harvested timber, whether terrestrial or fluvial; market type, whether external or domestic; and access to capital. Their study found that policies geared to promote management and control exploitation were required. They also found that by means of a drastic reduction in waste and in forest damage, it was possible to reduce the cutting cyle from 70 to 100 years (without management) and down to 30 or 40 years (with management).

The best example of silviculture in the region is found on 200 thousand ha of land along the Jari river in the cerrado region of the State of Amapá. This is predominantly comprised of exotic species and output is destined exclusively for cellulose production. Generally speaking, productivity is low, with averages of 20 m^3/ha/year. Some native species are also grown in smaller areas, and these also exhibit low productivity (Yared, 1990).

The Programme of Fiscal Incentives for Afforestation and Reforestation has provided significant stimulus for the growth in the area reforested. In some regions of Brazil, such as the South East, where there is a high concentration of businesses that consume raw materials from forests (cellulose and timber), it has been noted that the socio-economic impact of this programme was minimal in terms of job creation, and contributed to the growing inequality in the distribution of land and wealth, but brought benefits to society as a whole by focusing attention on these consumers of forest products. The producers were benefited by the fiscal incentives (Santana, 1994).

On the other hand, Nascimento, citing Todaro, (1981) finds that: if the forests, whether native of planted, are located in the rural area, many of the jobs created are also in this area. Due to the high transportation costs resulting from the weight and volume of timber products, the processing industries tend to establish themselves close to the resource base and in this way, the author suggests, the forest sector helps to reduce the differences in economic opportunities between urban and rural areas and consequently to reduce rural-urban migration and the related problems of urban unemployment.

The main environmental impacts of intensive reforestation projects based on monocultures are: the utilisation for the most part of fast-growing species (usually *Eucaliptus spp.* and *Pinus spp.*), the elimination of natural vegetation formations, reduced biodiversity and temporary denudation of the soil (the Duraflora S.A. team, 1990).

Other issues relate to biological and economic variability to which reforestation projects may be prone over the long term, with concerns over the emergence of insect pests and diseases on a large scale due to the high degree of uniformity in the system, and also to productivity losses caused by a reduction in available soil nutrients. According to Nascimento (1988), this last factor is due to the fact that the mineral recycling mechanisms of forest plantations are not as efficient as those found in naturally occurring tropical forests.

Taking a wider perspective, it is worth noting the work of Leslie (1987), cited and freely translated by Nascimento (1988), which brings in issues such as interest rates, theoretical considerations and empirical studies and concludes that *"the natural management of tropical forests is probably a better economic and financial proposition than alternative uses or management systems."* In other words, since time is such a strong and characteristic factor in forest management, it becomes incompatible with high interest rates since businesses require faster cash returns.

3.3.2. Agroforestry Systems

In view of the importance of agroforestry systems for the region of Araguaína and Araguatins, reference will be made to a specific work entitled "Evaluation of the Environmental Impacts of Agroforestry Systems" written in 1994 by Elizabeth N. Fernandes, Ronald Bonetti Filho and Elias Silva, which considers three systems whose characteristics are similar to the area under study.

The first system is known as "Taungya", and it consists of a mixture of agricultural crops and tree species with the latter planted fairly close together so that their canopies touch. The principal components of this system are forest species with economic value grown concomitantly in space and sequentially or in rotation over time. The system has proved its adaptability in all regions where it is practised. Production is used for fuelwood, timber and cellulose (MacDiken & Vergara, 1990).

The second system is referred to as "Alley Cropping", and under this system the trees are planted between the rows of the agricultural crops for foliar biomass production. Fast-growing leguminous tree species which produce abundant vegetation are used alongside common agricultural crops grown in strips either amongst the trees or in separate bands. The system is particularly useful for soil improvement, and production from the tree species is used for fuelwood, with their foliar biomass often serving as forage crops. It is well suited for the humid and sub-humid tropics in areas with high demographic density and fragile soils (MacDiken & Vergara, 1990).

The third system is referred to as "silvipastoral" and consists of pastures planted with trees which serve a number of purposes, their timber having high commercial value and their foliage providing both shade and a high-protein source of forage for livestock (MacDiken & Vergara, 1990).

According to Fernandes et alii, the positive impacts on the physical environment are similar under all three systems, namely:

- improved soil structure due to improved root distribution and the development of the soil microbiota;
- reduced soil erosion due to the protection offered by the trees and the consequent inhibition of surface run-off and increased infiltration of rain water into the soil;
- reduced soil nutrient loss due to the reduced surface run-off and improved uptake of nutrients;
- improved physical and chemical soil properties as a result of the fall of leaves and twigs from the trees and the incorporation of these into the soil;
- an increase in the rate of nutrient cycling through the system;
- improved local microclimate due to the reduction in microclimatic variation caused by the presence of tree vegetation;
- raising of ground water levels due to the improved percolation and infiltration processes, with a consequent regularisation in the flow rates of local watercourses.

The Taungya system also has other positive impacts on the physical environment, namely:

- potential application on marginal lands thereby assisting in the recuperation of their abiotic resources;
- improved water quality due to a reduction in the amount of solid particles washed off the land by rain water;
- reduced sedimentation of watercourses due to reductions in the erosive process. This is also a feature of the Alley Cropping system.

The Alley Cropping system contributes to the improvement in soil fertility due to the fixation of nutrients (nitrogen, primarily) by the plant species used.

In terms of negative effects on the physical environment, the three systems may cause:

- an accelerated nutrient loss from the soil due to the greater exploitation of products and the increased nutrient cycling in the deeper layers of the soil; and
- a deterioration in the chemical quality of local water resources due to the use of biocides.

The silvipastoral system also results in increased soil compaction due to trampling by the cattle and this has implications in terms of erosion dynamics. The other two systems also have implications for erosion dynamics as a result of soil disturbance during the management of the agricultural crops.

In terms of the biotic environment, the positive impacts of the three systems are:

- improved utilisation of the factors of production by the system components due to the increased soil cover;

- increased productivity of cropland and pastures as a result of the improvements in land quality;
- increased wildlife diversity due to the greater range of food, shelter and refuge on offer.

The silvipastoral system also offers increased herd productivity due to the improved local microclimate and the supply of additional forage from the trees (leaves and fruit).

The Taungya system offers:

- the potential to link up forest fragments, thereby facilitating genetic flow between plant and animal species;
- an increased capacity for supporting wildlife due to the increase in area under plant cover; and
- a reduced incidence of weeds due to the shading and more extensive soil coverage. This is also a feature of the Alley Cropping system.

The three systems have the following negative impacts on the abiotic environment:

- potential reduction in terrestrial fauna and icthyofauna due to the contamination of the food chain by the inappropriate use of biocides;
- potential reduciton in the productivity of certain crops due to allelopathy and interspecific competition;
- increased interspecific competition for light, water and nutrients.

The silvipastoral system has other negative aspects such as:

- potential for the dissemination and germination of seeds due to the grazing activities of the cattle;
- increased damage and mortality among the trees due to the grazing and trampling of the cattle;
- possible reduction in the productivity of pastures due to excessive shading; and
- possible increase in diseases among the herd due to the excessive local humidity.

The Taungya system has other additional negative impacts, namely:

- possible damage to the forest component due to mechanised cultivation practices;
- possible increase in pests and diseases due to the creation of an environment that favours their development.

With regard to the human environment, the three systems present the following positive impacts:

- diversification of production resulting in yields comprising a range of products;
- greater economic returns due to productivity increases;
- potential to apply the systems so as to regenerate degraded areas;
- minimisation of visual impact due to the increased vegetation cover.

For the Taungya and Alley Cropping systems,the following positive impacts can be added:

- improved distribution of labour throughout the year due to the variety of crops involved;
- retention of the rural workforce due to the improved distribution of labour throughout the year and the increased income;
- potential for employing all available labour (men, women and young people);
- improved nutrition for the producers due to the greater diversity of products;
- minimisation of production losses;
- reduced costs with weeds and pests due to the potential for natural control.

The Alley Cropping and silvipastoral systems have a further positive aspect in the fact that they require only a little initial capital to enable sapling production and distribution among the producers. Under the Alley Cropping system, there is also a reduction in nitrogen fertiliser costs and for the silvipastoral system there are increased economic returns due to the improved productivity of both plants and animals, assuming both plant and animal species with a high commercial value have been selected.

Negative impacts which the three systems have on the human environment are:

- increased initial costs for fertiliser due to the greater nutrient demand;
- public health problems due to water contamination resulting from the inappropriate use of biocides.

TheTaungya and Alley Cropping systems also have the disadvantage of being more labour intensive on account of the difficulty in using machinery among the trees. The Taungya system also requires significant initial capital due to the costs of the tree species. And the silvipastoral system may result in increased medication and veterinary costs on account of the potential increase in disease under this system.

In their conclusions, the authors state that agroforestry systems should not be applied indiscriminately even though they are technically, ecologically, socially and economically viable. All systems have both positive and negative impacts and these need to be analysed in context prior to the adoption of a particular system.

Macedo and Camargo (1994), citing Montagnini (1992), identify as positive impacts those related to socio-economic aspects where: the trees constitute "standing capital" (insurance); the risks of monoculture are avoided (seasonality of price, climate, pests and diseases); the elimination of cultural practice is enabled; no drastic changes are caused in the traditional system; it has little effect on the demand for labour; there is room for greater flexibility with regard to the distribution of labour; in general there is less need for interventions to protect the health of the crops (lower cost); and there is a more efficient use of inputs.

These same authors identify a number of limitations: the management of agroforestry systems is more complex; some systems require more labour; it may take longer to recover the initial investment; there is a lack of specialist knowledge for the establishment and management of such systems; agroforestry systems are not well known in the policy making arena.

Some research results show that in Paragominas (Pará State), the *Schyzolobium amazonicum* species (the 'paricá') is considered a promising species for silvipastoral systems. In Itacoatiara (Amazonas State), an alternative for pasture recuperation is the association of a pioneering chestnut tree with the pasture species *Brachiaria humidicola*, which has yielded good results (Macedo and Natal, 1992, citing Veiga and Serrão, 1990).

Couto (1990), citing a number of authors, points to a number of viable examples of agroforestry systems. In Santarém (Pará State), Brienza Júnior (1983) tested different native species such as crabwood ('andiroba'), cordia ('freijó'), mahogany ('mogno') and laurel ('louro') planted in association with maize, manioc and bananas with a view to increasing farmer incomes. In order to reduce the maintenance costs of oilpalm ('dendê') plantations, Wernigerode et alii. (1983) introduced plantations of maize and 'caupi' in the Capitão Poço region of Pará State. On the Tapajós plateau in Pará State, Brienza Júnior et al. (1985) introduced 'caupi' with forest species such as cordia ('freijó'), mulberry ('tatajuba') and jacaranda ('pará-pará), and found that the association had no negative effects on production or on the survival of the species and led to an increase in both diameter and height of the trees.

3.4. Environmental Impacts of Specific Projects

3.4.1. Projects similar to those proposed in the Plan for Environmental Conservation

(a) Agroforestry Systems (AFSs)

- **The Reca Project**

Installed in 1989 on the border between Acre and Rondônia, in Nova Califórnia, with farmers who came from several regions of the country, the Associated Compact Economic Reforestation Project (Reflorestamento Econômico Consorciado e Adensado - Reca) was part of a settlement established by Incra.

At the outset, planting coffee and cacao amongst rubber tree plantations yielded negative economic results. Noting that the use of certain practices such as the use of machinery, deforestation and burning were not suited to the fragile setting where the fertile layer of the soil was very shallow, the farmers began to organise themselves in the search for solutions which fitted in with the local reality.

Thus they opted to plant regional crops in associated and closely spaced arrangements in an attempt to integrate with the environment of the Amazon forest. They basically used species such as peachpalm ('pupunha'), 'cupuaçu' (a fruit tree similar to cacao) and Brazil nut trees ('castanha-do-brasil') laid out in different ways and grown in conjunction with annual crops such as rice, beans, maize and manioc. Production was intended for sale in regional, national and international markets.

With the support of the church group Pastoral da Terra and by the Federal University of Acre, the farmers drew up a development project and received international funding for the establishment and start-up costs of the Reca Project and subsequently they also received funding from other sources. In 1995, the Project area covered 650 ha and involved 274 families.

Characteristics which were in large part responsible for the success of this Project are: the organisation of the farmers into a communal workforce and the high degree of participation with everyone banding together to undertake the agricultural tasks required; the undertaking of research to find the best production techniques and the best native fruit trees to incorporate into the system; and the fact that the commercialisation of their output also featured the processing of some products (to yield 'cupuaçu' pulp and heart-of-palm from the peachpalm).

It should be noted that the commercialisation of output is a real challenge for this Project since the markets have certain standards which they follow. However, results in terms of production and commercialisation have generally been positive and income levels among the producers have risen as has their quality of life.

➢ **The Nipo-Brazilian Farmers Project in Tomé-Açu (Pará State)**

This Project involves farmers of Japanese descent (herein referred to as Nipo-Brazilians) who have over the past decades lived through an evolutionary process featuring: the development of certain crops; growth in the market for specific products; outbreaks of pests and diseases; a constant search for alternative solutions; positive attitudes with regard to risks; and above all strong farmer organisations (Homma et alii, 1994). The cultivation of the black pepper crop ('pimenta-do-reino') is the axis around which the changes have revolved.

Citing Flohrschutz et al. (1983) and Nascimento and Homma (1984), Homma et al. (1994) state that the evolution of the black pepper economy in the Tomé-Açu area of Paraá State can be seen as occurring in six phases:

- Cultivation of black pepper began in 1933 and in the post-war years it experienced significant growth. At this time it was grown as a monoculture, planted exclusively by Japanese immigrants and their descendants, and achieving high prices on the international market;
- In the Bragantina area, in the 1960s, there was an expansion and democratisation of black pepper cultivation. The appearance, in 1957, of the *Fusarium sp,* reduced the useful life of the crop and made constant renewal of the pepper crop necessary;
- Over the period 1970-78, pepper farmers began to diversify their activities, introducing other crops such as papaya ('mamão Hawaí'), melon, passion fruit, cacao, oilpalm ('dendê'), taking advantage of subsidised rural credit for the purchase of the necessary agricultural inputs. The area of black pepper cultivation expanded despite the growth of *Fusarium sp*;
- Over the period 1978-82, even though Brazil became the world's largest exporter of black pepper, national and international conditions had a negative impact on activity causing a reduction in agricultural credit, an increase in input prices and a fall in pepper prices;
- Between 1982 and 1987, the sector was hard hit by inflation rates and began to stagnate, especially the medium and large scale producers. Production levels and quantities exported fell;
- From 1987 onwards, small-scale farmers began to grow black pepper using family labour and few external inputs but achieving competitive prices. Despite the crisis, production and exports of black pepper reach record levels.

Enormous variation can be seen over the period 1974-1993 in the choice of crops made by the the Nipo-Brazilian farmers of Tomé-Açu, who were associated in the Cooperative for Mixed Farming in Tomé-Açu (CAMTA). Black pepper, for example, accounted for 99,17% of the value of the cooperative's production in 1974, falling to just 21,63% in 1992. Cacao varied even more accounting for just 0,47% in 1974, rising to 13,89% in 1982 and moving to 5,59% in 1990. Production of crops such as 'cupuaçu', 'acerola' (a native fruit) and passion fruit expanded noticeably. The growing of these crops was enabled by the establishment of a pulp processing factory in 1991. The advent of this agro-industrial process led to a 38% increase in passion fruit production, 60% increase in acerola production and a 28% increase in cupuaçu production and allowed the farmers to command prices which were, in relative terms, roughly four times what they had commanded previously for unprocessed fruit (Homma et al., 1994).

Depending on the prices of black pepper and alternative crops, there are constant transformations in the local agroforestry systems (AFSs). There is no single AFS in this Project, but rather a whole set of AFSs. An agroforestry system is seen as being any property on which perennial crops, such as fruit trees and black pepper, are grown. The conclusions which Homma et al. (1994) draw show the uncertainty surrounding the future of this community and it is possible to set out some of the more significant findings noted over the duration of this Project:

- The average income of cooperative farmers belonging to CAMTA over the period 1951-1994 was roughly $1/5^{th}$ of what it was in the golden days of black pepper cultivation;
- There has been a gradual reduction in the number of farmers who are members of CAMTA; the number of members in 1994 was less than half of the maximum membership recorded by the cooperative;

- Some family members have left to work in Japan and these resources coming from outside agriculture and outside the country have been invested in ranching, in buying new land, or in unaccustomed activities and the consequences of these developments are still uncertain;
- The lack of definition of the concept of agroforestry systems (some members understand it as being the growing of a range perennial plants which give shade or which favour shaded places) limits the technological alternatives and the markets that are available;
- The study shows that accumulation is related to the economic factors of production, that the mobility of the producers is low and that forest systems cannot be considered as being the only choice for the Amazon region;
- The authors' suggestion with regard to future policy choices is to recommend economic alternatives with technology, efficiency and management capacity.

Croce and Natal (1992) citing Yared et al.(1988) reckon that the agroforestry system in Tomé-Açu has been a success. After 5-8 years, once the pepper bush has died, it is subsituted by cacao which takes advantage of the shade cast by the forest species. Cordia trees ('freijó') used in the system have shown timber growth rates of 6-9m³/ha/year.

3.4.2. Projects featuring Diversification in Agricultural and Ranching Activities

(a) Family Agriculture in the Cerrados of the Monte Carmelo Region – Minas Gerais State

Based on a study done by José Fernandes Filho and David Francis (1997) into questions relating to the sustainability of family agriculture in a region which has experienced an intensive process of transformation of its technical base (near Iraí de Minas, Prodecer I), it is possible to see which family farmers have been incorporated into or excluded from the modernisation process and its impacts.

Using a definition of family agriculture which takes into account labour use and decision-making with regard to production, consumption, stocks, marketing, investments and other related matters, the study examines a number of parameters with regard to the sustainability of the agriculture in question:

- *Efficiency is needed in the application of capital and in the use of land*, consequently none of the various production systems currently in existence can be said to be efficient;
- *In developed countries, the criteria used to evaluate socio-economic projects are giving more and more emphasis to the number of jobs that will be created.* Perhaps it is of interest to guarantee that one or more of the children can remain on the property;
- The authors suggest that, to increase the productivity of the land or of capital, the use of labour should be increased. They also comment that research shows that sustainable agriculture is necessarily associated with reduced income.

In order to sharpen their analysis of economic, social and environmental sustainability, the authors classify the units of family production as traditional or modern depending on their use of technological innovations.

Traditional family agriculture, which is normally located on slopes, can be further divided into two groups: those whose focus is subsistence and those whose focus is the market.

The chief characteristic of traditional subsistence-oriented family agriculture is that the bulk of its production is consumed on the farm, by the humans and their livestock; the main crops are rice, maize, beans, and manioc, a few livestock and some milk production. The properties are small in total area and are normally quite badly degraded. This degradation is due to the fact that the soils have been cultivated without the adoption of more efficient practices in order to replace their natural fertility. The use of fallow is the most common practice among these rural producers, though the reduction in area no longer allows its use for the length of time required for it to be really effective.

Without an ideal amount of land, with degraded soils, with production on a non-industrial basis and without the use of modern inputs due to the lack of monetary income, the results of this type of farming system are very low in terms of labour productivity and production per hectare cultivated. Thus, it is almost always the case that the occupants find part-time work on medium and large-sized farms harvesting the beans and the coffee. In the region studied, this temporary work caused no problems since it occurred during the dry season, at a time when activity levels on the workers own properties were low.

For instance, it was noted that during the harvest of 1995, the wages earned during the coffee harvest were around 5 - 7 minimum salaries (*salários mínimos* – one minimum salary being worth around US$80 in February 2000) and for the

following harvest they fell to 2,5 - 4 minimum salaries. This was due to the coffee growers making increased use of mechanisation at harvest time in order to reduce production costs coupled with an increase in labour supply on account of workers arriving from other regions.

There is virtually no selling of surplus cereal production from the traditional subsistence-focused family farmer. The lack of economic sustainability of these units causes serious social and environmental problems, including: very poor living conditions for the families concerned; the need to seek income in temporary work which hinders the children's schooling; and the impoverishment of many who sell part or all of their land and move off to the cities, reinforcing the social problems found there.

The lack of environmental sustainability is due to the continued attempts at food production using technologies that are completely unsuited for the type of land (fragile and on an incline). This, in turn, leads to a continuous degradation of the land which ultimately makes the production of even the small quantities of food that once were possible, impossible (Fernandes Filho and Francis,1997).

The main activity of market-oriented family agriculture is the sale of unprocessed milk to the cooperatives and agro-industries that operate in the region. Other industrial units process the milk and sell the resulting products. The basic difference between subsistence-oriented and market-oriented family agriculture is that the purpose of the latter is to produce a product for sale. The market-oriented systems are also located in small properties which are degraded and which have steep inclines which makes diversification into other crops difficult. The resources generated by the sale of their products is reinvested (especially in the case of the proceeds from cheese sales which are particularly important for this group) in dairy farming activities, specifically in the purchase of cereals to use as animal feed, the planting of forage crops and the production of silage for the dry season.

These farmers tend to use inputs such as fertilisers and soil conservation practices such as contour farming. It should be noted that productivity is still low due to the fact that the pastures are degraded and the feed and silage are only given to the herd during the dry season. A further contributing factor is the quality of the herd which tends to be comprised mainly of cattle with mixed pedigree.

Production is around 4 litres/day and this is insufficient to generate resources to invest in improving production conditions. However, even without support of agricultural extension services or credits at affordable cost, some producers are adopting new techniques such as an increase in the use of silage, and the use of artificial insemination. These improvements in production techniques have been reflected in the productivity of the herd. However, in the current reality, these farming units have problems in terms of their social, economic and environmental sustainability.

The modernised family farming in the region consists of three types of producer: land owners who produce cereals; tenant farmers and/or land owners and coffee growers.

Family coffee growing enterprises were established and strengthened by families coming from São Paulo and Paraná States, where they had already worked in the coffee production business. These are small, old, rural properties which, with the incentives and official credit facilities available had been guaranteed high profitability. In the 1980s, with the fall in coffee prices, the incentives became scarce and pests and diseases intensified, production costs increased and economic sustainability vanished. Many farmers had to sell part or all of their land in order to pay off their debts.

The credit available for the sector was drastically reduced and, since it required investment in irrigation and other practices to maintain a stable level of production, economic sustainability was hard to achieve. While irrigation favours economic sustainability, it can cause enormous damage in environmental terms since the management of water resources in the region is very inefficient and the central pivot system is very much the 'champion of waste' in this respect. A further potential problem which the authors note is the pollution of watercourses and ground water with the insecticides that are used, particularly the systemic ones.

The family farmers who grow cereals were attracted to the region by the success of the PRODECER I project in Iraí de Minas, which is described below. Most of them came from the south of the country where they had small holdings but on their arrival at the outset of the programme they took advantage of the cheap land prices and favourable credit lines available as well as other forms of government assistance and were thus able to secure good profits from their subsequent activities.

With the increase in the cost of credit and inputs, the increased incidence of pests and diseases, and falls in the price of soya beans and maize, a decline in this type of production system began, reflecting the indebtedness of the farmers and

consequently of the cooperative. Allied to these problems are those of an environmental type such as the lack of water for irrigation, the emergence of new diseases and pests, erosion and soil compaction. In the absence of economic and environmental sustainability, social problems began to get more serious and affected, albeit to a lesser degree, the other production units described previously.

Tenant farmers who focused on cereal production are also experiencing the lack of sustainability of the rest of the region. The high rents charged on the land tend not to allow the accumulation of resources for land purchase – which is the main objective of those who farm in this way. What's more, most of the land owners rent out their degraded pastures in the hope that the tenants will improve them and this implies a high cost in soil preparation and cereal production. The tenancy period – generally around 3 years – means that any soil improvements achieved will not benefit the tenants and for this reason they tend not to adopt soil conservation practices. *"The conclusion which can be drawn is that, with the contract periods being always close to the legal minimum, and with costs being always close to the legal maximum, it is improbable that land leasing arrangements will spread."* (Fernandes Filho et al.,1997).

Resources to cover costs were in part provided by the cooperative based in Iraí, since the banks demanded guarantees. However, due to the deteriorating situation described above, the cooperative ceased to support tenant farmers in 1995. The consequences of this were: a significant reduction in production by those who had less capital; the tenant farmers left the cooperative; the cooperative's grain sales fell by 50%; and there were many debts. The situation is precarious in economic, social and environmental terms.

The sustainability of the various types of producer in the Monte Carmelo region is compromised in economic, social and environmental terms. The types of producer which have least sustainability are the tenant farmers and the subsistence farmers. The impacts are similar but in different proportions.

(b) The Silvânia Project – Goiás State

The Silvânia Project is a partnership between the Brazilian Agricultural and Ranching Research Agency – Research Centre for Agriculture and Ranching on the Cerrados, the Centre for International Cooperation in Agronomic Research for Development – Department of Agro-alimentary and Rural Systems (CIRAD – SAR), the Technical Assistance and Rural Extension Agency of Goiás (Emater-GO), the Agricultural and Ranching Research Agency of Goiás (Emgopa) and the Municipal Council of Silvânia.

Silvânia is a municipality in the State of Goiás. It lies 90km from the State capital and 200km from Brasília. In 1997 the population numbered 19.800 inhabitants, with 68% of these living in rural areas. From 1970 to 1985 the number of properties almost doubled, however land ownership is concentrated in the hands of large estate owners, 48,3% of all properties are larger that 500ha and only 4,8% are smaller than 50ha. However family agriculture represents 70% of the properties in the municipality (Gastal, 1995).
The Project envisaged a strong technological and management content, and included components such as association-building, rural credit schemes and others. The methodology adopted was one of participatory action for diagnosis and intervention. Analusis of the regional context showed that many farmers were in a situation of "technological immobilisation," since even though a large range of technologies had been generated, these were not being adopted due to problems in the adoption, transference or in the nature of the technologies themselves (Gastal, 1995).

"The general objective was to obtain, though the combined efforts of government agencies, the private sector, and civil organisations, an increase in agricultural and ranching production and productivity in both physical and economic terms, with repercussions on the real earnings of the farmers involved". The Project was experimental in character and was expected to last 4 years, from 1987 to 1990 (Gastal, 1995).

The Project was conceived of as having two stages: the first being the diagnosis of natural and socio-economic resources in order to assess their characteristics in the farming year of 1987/1988; and the second stage being intervention in production systems.

The aim of the first stage was to get to know and to analyse the units of production (agricultural properties) which operated as a component of the region or municipality. In a systemic way, the research studied agricultural operations as a suite of components examining their relations with the environment, and the physical, social, technical and economic aspects to as to be able to extract the real problems and thereby fix objectives in a way that took in the whole agricultural and ranching process in its totality. In this first phase, the project was entitled "Research into Integrated Production Systems in a Municipality in the Agro-Environment of the Cerrados".

The diagnosis took 15% of the rural properties as a sample and classified them into 12 different types according to their production system. From this sample, 35 farms were chosen in order to investigate and describe the dynamic behind their production systems. The objective here was to identify, measure, understand and analyse the factors which impeded the adoption, by most of the farmers, of available technologies which were both agronomically and economically viable.

The main result of this first stage was that agricultural development could be limited by factors external to the property, and as a consequence there was a perception that engagement with groups of producers was needed in order to analyse and intervene in their production systems. An important feature of this work was that the research and the agricultural extension service worked together throughout the whole process of discussion, in order to seek out more carefully considered and informed options with regard to the methodologies adopted.

Beginning in 1989 a new phase began, one which has been described as a *"break from the more restricted perspective of the research, which was focused basically on the agricultural production process within the property, to a wider vision of research into methodologies in support of development considering both the production systems and their external environment"* (Gastal, 1995). The project becomes known as "Establishment of the Research and Development Focus on Technology Transfer in the Municipality of Silvânia". Thus the process had moved on to a rapid diagnosis in which knowledge was gathered, and to the dynamic analysis and interpretation of how rural space, with all its agro-ecological and socio-economic components, is structured.

The diagnosis served as a tool to initiate a process of dialogue in which, once the research team had analysed its results, encounters with the community would enable an initial vision of the current reality. In other words, it would provide the community with the means to evaluate their problems and possible solutions to them. In this way, it was possible to check people's interpretations and to achieve a collective view of the community's problems.

Other important aspects of the process were:

- The diagnosis encompassed three levels: the community, its production systems and its natural resources;
- The diagnosis did not confuse speed with superficiality;
- In the context of research/development, the aims of rural development are: *to better administer the community's productive activities, organise its spaces and professionalise its agriculture* (RUF, 1989);
- The research team were able to see how social relations were conducted and what the differences of perception between the various groups were;
- Essentially the natural resource diagnosis comprised of the identification of the rural areas involved and of the ways in which this space was utilised;
- The work was based on the premiss of providing support for the organisation of rural groups into representative entities. In this way, the work encouraged not just the adoption of technologies, but the action of the community's citizens in the search for better development or credit policies, and for better social, health and education policies among others;
- The individual was free to choose which of the various activities that were prioritised and developed he would adopt. This led to the formation of various interest groups. The idea was that these groups would achieve cohesion as a result of the need of their component individuals to solve similar problems;
- In order to obtain greater efficiency in the productive process, the farmers were divided into management groups which were supported with information and alternative solutions, thus increasing their professionalism in the management of their agricultural activities and their production systems and making better use of the natural resources available to them;
- Evaluation was constant and formative with the establishment of feedback mechanisms.

As a result of this participative process, constantly and effectively supported, a number of associations began to emerge from 1989 onwards in the municipality and in the State, most having the objective of collectively acquiring equipment. Of the five communities that were involved, four formed into associations. With the establishment of this new dynamic began what Gastal calls the third phase, in which research and extension activities focused not only on actions related to technology transfer, but also on those needed for local rural development.

In 1992, the Project's target population expanded to include small and medium scale farmers and in 1993 the Project began to be known as "Use of the Research/Development Focus for the Development of Small-scale Agriculture in the Silvânia Region" aiming to *"promote rural development through the creation of a methodological framwework for intervention in the rural arena, favouring the use of technological and social innovations by small and medium scale farmers."* (Gastal, 1995).

The associative process grew strongly with 14 associations forming and the creation of a Central Association Office in the municipality in 1992. The process promoted changes in the layout of the network of reference farms, and in the support given to farmers' organisations and also resulted in the diversification of research themes. The network of reference farms was modified from 35 farms to 9 identified types of farming system and there are now 28 farms in all represented by the 14 associations.

Support for these associations is, according to Gastal (1995), directed at: drawing up suitable statutes; mobilising finance; programming communal activities such as collective purchases and sales, and communal harvesting; administering assets such as equipment and processing plant; and providing guidance on individual and collective credit schemes.

The new research themes adopted for the period to 1997 were:

- Sociological characteristics of small farmer organisations in Silvânia;
- Georeferenced data bank;
- Agro-ecological zoning as a tool for the rationalisation of small scale agriculture;
- Analysis of the marketing channels in Silvânia; and
- Process of analysis for building demand for support for small scale rural producers.

Among the positive results listed by Gastal (1995) the following can be highlighted:

- Technical, economic and social validation of technologies and records of the evolution of production systems;
- Elaboration of various tools to support technology transfer, such as: georeferenced data bank for technical interventions and planning purposes, sociological studies of the dynamics of associations and characterisation of the marketing chain for an agricultural product;
- Progressive establishment of associations of small and medium scale farmers (numbering 30 associations in 1997) and the Central Assocation Office and resulting achievements;
- Better local infrastructure, such as school transport in the rural area, achieved through farmer participation;
- As a result of the organisation process, many farmers have made viable the use of new technologies by means of the purchase of capital goods and inputs through the association. The mobilisation of the farmers in these associations to gain access to the Central Western Fund (FCO) resulted in the approval of 3 projects in 1990. In 1993/1994 19 projects were approved. The value of these 22 projects exceeded US$ 3.650.000,00, and enabled the associations to acquire: 19 tractors, 12.000 tonnes of lime, 2.300 dairy cattle, 150 mills, 4 pickups, 18 artificial insemination kits, as well as the construction of community centres and agro-industrial plant.

The Central Association Office has recorded a number of achievements, such as:

- Obtaining R$ 1.800.000,00 from Pronaf in 1997 for the acquisition of dairy stock, lime, agricultural equipment, pasture formation, and the renovation and construction of processing plant;
- Establishment in 1997 of a milk committee which negotiates milk prices with dairy industries and has achieved good results;
- Establishment of a technical team employing an agronomist, a vet and two agricultural technicians;
- Administrative support for the associations and monitoring of their debts in conjunction with financing agencies;
- Purchase of inputs for the establishment of 26 community plots in the associations, comprising 350 ha of maize and 300 ha of rice; and
- Coordination of collective purchases of fertilisers, rice and maize seed, soya meal and mineral mixtures, achieveing savings of around 20% on market prices.

With regard to income, Santos et al. (1998) state that diversity functions as a typs of 'insurance' against risk. Their research shows that 40% of the farmers sell rice and the other 60% use other means to cover medium term expenses. Maize and rice are sold in the same proportion and have the same relative importance, that is, similar numbers of properties produce them and the monetary value of the crops is similar. A high percentage of the farms sell processed agricultural products, dairy products and small animals, but sales of unprocessed milk and cattle (unwanted steers and cows) predominate. Some also work as intermediaries, known as "*gambireiros*" buying cattle before the start of the rainy season and selling in the dry season.

External sources of farm income most commonly come in the form of pensions and (to a lesser extent) the salaries of family members who work off the property in low-paid jobs. It is recorded that 40% of the establishments sell their labour. Income flows are not constant throughout the year. For monthly income and some reserves, they tend to sell

small animals and manioc. Income earned from all activities is low, with the most commonly commercialised products being milk and cattle, as is shown in the following table.

Table 49. Income-generating activities on the reference farms showing income resulting from each activity

ANNUAL INCOME (US$)	ACTIVITIES
Up to 500,00	Beans
Up to 2.000,00	Maize; rice; sale of labour; off-farm wages; processed agricultural products; small animals; other agricultural products
Up to 3.000,00	Dairy products and manioc
Up to 19.500,00	Unprocessed milk and cattle

Source: Santos et al (1998)

(c) Intensification of Milk Production in the Municipality of Silvânia (Goiás State)

Intensification emerged in response to the reduction in farm area, usually as a result of the division of land as a result of inheritances, ease of access to credit (FCO and Pronaf) and technical assistance (Affoholder-Figué and Bainville, 1998).

Forage systems during the dry season, which are characteristic of the cerrado region, have for many years been the main ecological limiting factor on the development of milk production in the region. As a result of interviews and analysis of the data available on the reference farms mentioned earlier, and in the agricultural and ranching census (carried out in 1996 by the Central Association Office of Small and Medium Scale Producers for the drafting of the municipal development plan – Pronaf), Affoholder-Figué and Bainville (1998) have found a strong and rapid increases in milk productivity in the municipality.

The interviews carried out as part of the research done by these authors enable the identification of five main forage systems, namely:

- Untreated system;
- System with limited management in the dry season, with cane ('cana') and/or napier and concentrate for cows that have calved;
- System with management with cane ('cana') in the dry season, with pasture rotation in wet and dry seasons, cane and/or napier and concentrate for cows that have calved;
- System with management in the dry season with silage and concentrate for cows that have calved and pedigree cattle without calves; and
- System with continuous management providing, in the rainy season, pasture rotation or silage and concentrate for cows that have calved, and in the dry season, silage and concentrate for cows that have calved, and cane and napier plus concentrate for cattle without calves.

The first system showed an average productivity of 2,8 litres/cow/day and the last system 10,6 litres/cow/day. The process of intensification in Silvânia was facilitated by improvements in herd nutrition during the dry season: in 1992, 65% of the farms sampled had no special management regimes for the dry season. In 1995, the distribution was more uniform, with 10% following the first system, 30% in the second and third systems, 20% in the system with management in the dry season with silage and 10% in the last system identified. It was also noted that productivity during the dry season on farms which adopted specific management regimes for the period reached levels similar to those achieved during the rainy season. For the continuous management system, yields during the dry season sometimes exceeded those achieved during the rainy season.

The authors found that specialisation could be risky, since an analysis of the quotas (*cotas*) –established by the dairy industries to regulate milk deliveries over the year (calculated on the basis of the farmer's average daily production during the dry season) – showed that the price paid for milk produced in excess of the quota (known as 'extra-quota' milk) was 20% less than that paid for quota milk.

Other findings relate to the increase in the amount of resources (land, capital and labour) devoted to the dairy herds at the expense of other activities had given rise to specialisation in production systems. The conclusion reached was that the proportion of the farms' Gross Total Product which was made up of milk sales increased with herd productivity, with the result that other traditional sources of income such as the sale of rice, manioc, pigs, etc., diminished in importance.

Alongside the growing specialisation in milk production, the authors noted a decline in the farmers' production of processed milk products (cheese, butter, cream, fudge and other products) and they concluded that this represented an increase in the level of risk faced by these farmers. Specialisation led to greater investments in a smaller numbers of activities, and a greater dependence on milk prices. Evaluating the sensitivity to price fluctuations of the more intensive systems compared to more extensive systems, the authors found that the intensive systems were more risk sensitive.

The "Milk Committee" was established as a result of the perception among the region's milk producers of the need to negotiate with the sectors upstream and downstream of the productive sector, and the need for support to safeguard the continued existence of farms which had specialised in milk production at the cost of taking on more debts.

3.4.3. Intensive Agricultural and Ranching Projects

- **Prodecer I – Iraí de Minas – Minas Gerais State**

This Project was launched in 1980, and is part of the Nipo-Brazilian Cooperation Programme for the Development of the Cerrados – Prodecer I, along with other projects in Paracatu and Coromandel. As a programme for the colonisation of the cerrados, it also *"represented international interests as a strategy for the supply of agricultural commodities through the international division of labour, which assumed concrete form in the cultivation of soya beans"* (Shiki, 1997). The intention of the Prodecer programme is to provide incentives for the formation of an agricultural structure based on the creation of business structures, the use of modern inputs, the incorporation of the findings of agricultural research, and export-oriented production (Péret, 1997).

Resources for the project were jointly provided on a 50:50 basis by the Brazilian and Japanese governments. Its structure was tripartite, comprising the State, the international agency Jica and private enterprise.

The project initially consisted of intensive soya bean production, which was latter complemented by maize production in proportions of 1 ha maize to 4 ha soya beans. With increasing intensification, the tractors, harvesters, implements and land areas (initially 200-500 ha) required for this maize-soya bean system were financed for 5 years with 2-years free of scheduled repayments, and start-up costs for the initial harvest were also financed by credit. In the 1980s this resulted in a process of resource accumulation in land, machinery and equipment.

Problems resulting from this intensive mechanisation gave rise to the adoption of direct drilling, following the example of this practice in the Southern Region of the country despite the climatic and ecological differences between the two ecosystems. In the micro-region of Iraí de Minas, the spread of this technique was so rapid that by 1995, 80% of the total cultivated are was under minimum cultivation regimes. This success arose not just because of farmers' desire for soil conservation but also because of its economic appeal since direct drilling lowers production costs by reducing tractor use in soil preparation and by making use of equipment which is lighter and cheaper than that used in conventional practice. The farmers, of course, were unable to avoid the costs of dessicant herbicides to deal with arable weeds.

Shiki's analysis (1997) found that the most important technological variable for the intensification of this system was the introduction of the central pivot irrigation system for the production of beans and other vegetables. This enabled the utilisation of the soil during the dry season to achieve two harvests per year (one with a shorter cycle than the other) and consequently, the hiring of agricultural workers on a permanent basis. In this way, *"the total amount of work was increased and there was a more regular distribution over the year."* Under the non-irrigated maize-soya bean system, the work is concentrated at drilling and harvesting time.

Table 50. Economic indicators (in R$) of archetypical soya bean-maize production systems in the region of Iraí de Minas – MG, harvest year 1994-1995

SYSTEM TYPE	FAMILY	EMPLOYER	WITHOUT CENTRAL PIVOT	WITH CENTRAL PIVOT
ha cult.	206	500	421	700
VA	22.616	163.450	120.000	340.000
CI	30.131	190.492	-	-
K	100.614	198.996	150.000	342.400
VA/ha	110,0	327,3	285,0	485,7
VA/K	0,22	0,82	0,80	0,99
CI/ha	146,5	381,4	-	-

Source: Field research coordinated by Shigeo Shiki, 1995.
ha cult. – cultivated area in hectares;
VA – value added, obtained by subtracting the value of production inputs and depreciation of machinery and plant from the value of total gross product;
CI – input costs; K – fixed capital used in production.

A number of observations can be made in relation to the above table. With regard to productivity, the irrigated system almost doubles the aggregate value when compared to the non-irrigated system. Capital intensity is high so to remain competitive, production also needs to be high. The author found that the minimum required size for viability among these production units appeared to be in the 400-500 ha range – a size which enabled the generation of an aggregate value of just under R$ 300,00/ha. With irrigation, capital investments increase substantially (more than double those of non-irrigated systems), as do productive area, and input costs, not to mention the assoicated indirect costs.

Table 51. Average yields (in kg/ha) of archetypical maize and soya bean systems in the region of Iraí de Minas-MG, harvest year 1994/95,

	WITH LITTLE OR NO CROP DISRUPTION		**WITH CROP DISRUPTION**			
Type	**MAIZE**	**SOYA**	**MAIZE**	**(%)**	**SOYA**	**(%)**
Family	5.760	2.550	4.500	22,0	2.126	16,7
Employer	7.080	2.600	4.020	43,0	1.724	33,7
Source of instability or risk			Ocurrence of drought in the critical period and pests (caterpillars) and disease (*Phaeospheria*)		Attacks by nematoid cysts and stem canker	

Source: Field research coordinated by Shigeo Shiki, 1995

The figures given in the above table are the average values of the properties including those with no irrigation. Shiki (1997) found that *"the disruptions which occurred were on average more significant on the larger properties; it would therefore appear that, in addition to the economic risks inherent in the high investments required for these systems, the climatic and biological risks are also more intense."* In other words, once the stability of the system is affected, under the capitalist mode of production, in agriculture in particular, larger investments for the maintenance of returns on capital or profit signify increased risks.

Nematoid cysts spread rapidly through soya bean plantations and the speed of economically viable solutions cannot match this in terms of rapidity or effectiveness. The Embrapa researchers Silva e Souza (1996), cited by Shiki (1997), attribute the appearance of this pest to "disequilibrium in the chemical and biological environment of the soil," on account of the practice of excessively raising base saturation levels to 90%, and they also state that "the most serious contributing factor in its multiplication (...) is continuous monoculture." One of the recommendations of these authors is "the adoption of practices to increase soil organic matter content," pointing towards the search for organic production methods.

Chemical controls are not a viable way of preventing the emergence of stem canker; the recommended solution is the introduction of new more resitant varieties. However, it should be noted that the longer varieties are used, the more chance there is of new diseases and pests emerging, so the constant renewal of genetic material is necessary.

For many crops, chemical control tends to be delivered in increasing doses or to be changed periodically as the pests and diseases acquire resistance to the product's active ingredient. This means that due to the uncertain results achieved from the application of certain agrochemicals and the risks of water, soil and product contamination, a direct increase in the cost of inputs is certain and this may cause further ecological and economic disequilibrium. Shiki (1997) concludes that the sustainabilty of the soya bean-maize system depends on a permanent source of biodiversity, a source which the system itself helps to destroy.

Family farming systems on smaller areas, without land or start-up capital, need leasing and financial arrangements to keep producing and to maintain a structure of high investments in equipment. In the Iraí region, following the unfavourable harvest of 1994/95, a process of diversification began in these systems with the introduction of intensive dairy farming. Despite the use of more specialised breeds (girolanda and Dutch), productivity was low (10 litres/day) because such activities were still being consolidated.

To some degree, at the beginning of the colonisation process, land leasing was encouraged by the owners of large properties since this offered a way to renew their pastures, as discussed previously.

Income from land-holdings, according to Shiki (1997), was 15% in the most productive year (year 3), and was most commonly calculated as being 6 sacks of soya beans per hectare. In the 1980s and 1990s, there was a period of crisis in terms of the profitability of the system which was felt by all farmers and in particular by those wo were leasing their land. Dairy production, and also chicken farming and pig rearing were the alternatives found to ensure the producers' survival. Other solutions, such as the combination of ranching with grain cultivations began to be installed in 1997 and these aimed at achieveing greater diversity and productivity over a longer period.

For Shiki (1997), the agroecology is very promising, featuring practices such as crop rotation, combinations of agriculture, silviculture and pastures, and organic production methods which were in close accordance with the laws of sustainability. However, the tendency is for the strengthening of this model under the pretext of it representing a bio-industrial system.

In terms of social analysis, Rodrigo Péret looks back on how the planning and implementation of the project were undertaken, and points to the negative impacts that this caused. The involvement of government resources and State structures meant that the planning phase lacked transparency for society at large. At no time was guidance given to local populations and these were excluded from the planning and decision-making process. Local farmers were not considered in selecting the benficiaries of the programme, or at most, they were used as a source of manpower. Small scale farmers were also excluded, while producers from the Southern region who had capital, and cooperatives whose *"operational performance was reasonable, and who had a firm financial footing"* were privileged (Campo, s/d).

A further issue raised is that the need for large areas in order to obtain economic sustainability, the use of federal structures and the adoption of a policy which gave land to colonisers from other regions, *"aggravated the land-holding situation, promoting land concentration while ignoring the underlying tensions."* The policy also promoted the export-oriented production of food, without consideration for the basic local diet; it brought in official research and extension agencies at the mercy of *"big companies and large capital interests"* which subsequently appropriated the results. At various times there were problems relating to the registration of employees, descrimination against women, and the use of minors for digging up roots; and in contextual terms, the model *favours the few* (Péret, 1997).

Research by Gomes and Silva for their Masters' dissertations outlined the technological trajectory of intensive agriculture based on the example of the Prodecer I in Iraí de Minas. A summary of the main impacts is given below:

In terms of productivity increases, the intensification of capital applications in the cerrado region was positive, with a consequent increase in income. The region currently accounts for a significant percentage of national soya bean, maize and rice production.
The intensive use of machinery exacerbated social problems since this replaces a large contingent of the labour force. This modernisation process also requires large areas and high volumes of capital and this tends to exclude farmers who do not have access to these requirements.

There was a leap forward in technological terms, supported by government plans which provided insurance against the potential risks involved (total operational costs for the new technology, training shcemes for the work force, new relations with suppliers and new sources of competition, for example) and by the fact that the techniques of the Green Revolution were no longer new and there were farmers who were already accustomed to such practices.

Problems arising from the adopotion of this technological model caused changes in produciton processes:

- Soil compaction led to the introduction of direct drilling. This new technique led to a reduction in the economic costs of machinery and fuel and an increase in the costs associated with the purchase and use of herbicides. Apart from this, the machinery equipment is lighter and cheaper. It is evident that the economic gains are what drove the establishment of such cultivation systems rather than any consideration of its effects on the environment.
- With regard to irrigation which has been increasingly used in recent years to increase productivity, the multiple use of resources is questionable and reference can be made to the wastage of water depending on the type of irrigation adopted.

➢ **Prodecer III – Pedro Afonso – Tocantins State**

It is worth raising a few initial considerations before proceeding with an analysis of this programme. Due to the lack of bibliographic references which evaluate the positive and negative consequences of the installation of the Agricultural Colonisation Project in Pedro Afonso, we have instead focused our investigation on the points raised in the Environmental Impact Statement (Rima) prepare for this programme, and this is the only reference document used for this item.

The Pilot Project for Prodecer III, established in Pedro Afonso, Tocantins State, was intended to implement a guided system of collective settlement, to develop new technologies appropriate to local conditions, to select perennial crops resistant to the dry season, to introduce irrigation as a means of reducing the risks of drought, and to respect the environmental legislation by assigning 50% of the area to a Legal Reserve (Environmental Impact Statement - Rima – for the Agricultural Colonisation Project in Pedro Afonso, 1996).

The principal institutions involved in the cooperation and in the organisational structure of the Project were the Japanese International Cooperation Agency (Jica); the Brazilian government, in the form of the Federal Government and that of the State of Tocantins; the Agricultural Promotion Company (Campo); the Mixed Agricultural and Ranching Cooperative of São João (Cooperativa Agropecuária Mista de São João Ltda – Coopersan) and the Water Use Cooperative (Cooperativa de Aproveitamento Hídrico).

The area targeted covered a total of 39.429,55 ha, with 19.721,20 ha being allocated for crops, infrastructure and settlements for the colonisers, and 19.708,35 ha allocated for the Legal Reserve. The number of families involved at the outset was 40, a number which was deemed capable of viably establishing and maintaining the cooperative.

The Project's planning envisaged the establishment of annual and perennial crops, ranching and aviculture systems, crop rotation, irrigation primarily through central pivot systems, the establishment of terrestrial infrastructure comprising electricity distribution networks, water reservoirs, communications, education and health systems, plus agro-industrial plant and equipment needed for the efficient running of the enterprise. The Legal Reserve was to be established on common land and among the agricultural areas so as to observe the prevailing legislation and enable the conservation of local biodiversity.

The main commercial products envisaged were soya beans, soya seed, rice seed, processed rice, grain maize, beans and cashews.

The Resource Generation Plan provided for financing over the first five years in accordance with the terms of Prodecer with regard to the items covered and financial limits and subsequently the use of resources available under the National System for Rural Credit (SNCR). It was forecast that the project would begin to turn a profit in year 4. The superavit at the end of 20 years was estimated to be around US$ 9.902.900.

The positive impacts of the project arising from the intensive production systems and agro-industries were categorised into those relating to physical, biological and socio-economic aspects:

- Influence on the property market with increased demand for agricultural land and consequent increase in land prices;
- Generation and diversification of jobs, altering the structure of the labour market;
- Increased economic activity, in commercial terms and in the service sector;
- The realisation of the aspirations and expectations of the local population;
- Improved organisation in rural and urban areas with the establishment of new access routes and buildings;
- Improved water treatment and distribution systems in the rural area;
- Increased per capita income in the municipality;
- Increased demand for residences in the town;
- Improved local educational systems with the establishment of a school with trained teachers to be managed by the cooperative;
- Optimisation of the use and occupation of rural lands through the actions of the colony's cooperative members;
- Improved conditions for leisure and culture with an increase in social relations;
- Improved municipal administrative structure with the effective presence of Coopersan and an increase in the tax revenues collected;
- Improved physical conditions in the soil for planting;
- Improved nutrient availability in the soil;

- Intensification of the marketing and sale of fertilisers, lime and fuel amongst other inputs;
- Contributions to a reduction in temperature on a microclimatic level due to irrigation; and
- Improved cash flow due to the continuity of production during the dry season on account of the project's irrigation systems.

The potential for the utilisation of a bimodal transport system was considered an advantage which the project offered relative to road transportation. This potential involved a 'hydrovia' running from Pedro Afonso to Imperatriz in Maranhão State, and the railway running from Imperatriz to São Luiz (MA), where the port of Itaqui could be used for export purposes.

The negative impacts identified were:

- Potential health problems arising from the migration of rural workers
- Potential security problems due to the presence of rural workers;
- Pollution of water resources resulting from provisional camps and temporary accommodations;
- Increased hunting pressures and illicit destruction of plant cover;
- Establishment of erosive processes in consequence of laying bare and disturbing the soil and exposing it to the weather, giving rise to sedimentation in local watercourses;
- Reduction in soil humidity, due to increased evaporation and reduction in its water-holding capacity;
- Reduced soil biological activity as a result of the rapid mineralisation of organic matter and the use of fire;
- Alteration to the natural fertility of the soil due to the elimination of organic matter as a result of the removal of scrub and the clearing of land;
- Interference in the natural recharging of aquifers on account of a reduction in infiltration rates and increased evaporation;
- Water pollution with chemical and bacteriological alterations which affect its quality, as well as an increase in turbidity;
- Generation of dust, noise and gas;
- Increases in temperature at a microclimatic level due to the removal of plant cover;
- Partial destruction of the cerrado ecosystem, with the elimination of plant and animal species provoking the disappearance of certain habitats and the flight of native wildlife;
- Loss of areas with extractivist value;
- Physical alteration of the soil for the establishment of infrastructure;
- Alteration in river water quality, due to contamination by sanitary effluents and an increase in the domestic use of water;
- Irrational use of the resouces of the native vegetation;
- Compaction of the superficial soil layers during soil preparation;
- Chemical and biological alterations to soil and water (eutrophication and contamination) through the application of agrcultural defences;
- Risk of agrochemicals poisoning fauna;
- Risk of human intoxication by agrochemicals and dust;
- Risk of accidents with machinery;
- Potential for surface run-off from irrigation, increased turbulence and leaching;
- Loss of soil structure due to irrigation;
- Reduced flow in rivers and consequent loss of water availability for public supplies; and
- Increase in conditions favouring the development of insect predators.

With regard to the agro-industries:

- Chemical and/or bacteriological alterations to water;
- Water and soil pollution by agrochemical residues;
- Emission of gases and dust; and
- Increased water use affecting supplies for the human population.

With regard to transport:

- Emission of gases, noise and dust;
- Overloading of transport networks; and
- Death of animals and flight of wildlife and other animals.

Among the more preeminent issues, a reading of the Environmental Impact Statement allows the identification of some of these:

- The soils possess qualities with respect to infiltration and drainage which are naturally balanced in the local environmental context, and any disturbance to this balance may give rise to loss of superficial layers with modifications in the relief and negative interference in the recharging of aquifers;
- Although they are well drained and with good physical properties, the soils require the adoption of well planned management to avoid erosion arising from their compaction and the disaggregation of their layers;
- Variation in microclimate will occur cyclically with an elevation in local temperature following the removal of the naturally occurring plant cover of the soil and also at harvest;
- As only 53% of the minimum flow rate of the Lajeado creek is expected, no influence on water availability for public supplies and other ends is foreseen;
- The worst impact foreseen on water resources relates to erosion at various levels, and contamination by agrochemicals, soil correctives and fertilisers which may lead to toxic substances, heavy metals and excess nutrients being carried into watercourses with serious effects on water quality for human consumption and for the ecosystem;
- The avifauna and the mastofauna are of wide geographic distribution, but with the clearance of 20.000 ha these will suffer significant impacts if the measures proposed are not implemented;
- Since the region has a low demographic and economic density, and the predominant productive activities are traditional systems and practices, a transformation with profound effects in terms of productivity, a more efficient use of natural resources and in terms of the dynamics of productive activities is expected.

The main significance of this project, according to the Environmental Impact Statement, is its role in promoting and supporting agricultural development, stimulating and consolidating properties which have already initiated intensive agricultural systems, and introducing up-to-date techniques in the fields of conservation and commercialisation and new forms of organisation for the producers.

In the agricultural units of the project and its area of influence, the amount of direct employment created is not expected to be greater than in other examples of the Prodecer programme.

It should be recognised that these impacts are forecasts and unfortunately it was not possible to undertake any analysis of the current situation through this literature review since no relevant material was available in the libraries listed at the beginning of this chapter.

3.5. General Comments

- Only through long-term monitoring of the environmental impact of the various combinations and processes of agricultural production can a reliable picture of the relationship man/nature in the context of the cerrado region be formed (Cunha, 1994).
- An important point raised by Ab'Saber (1994) in his talk entitled "Assessments and Reports on Environmental Impact – the Environmental Impacts of Agrarian Activities" relates to impact forecasting and what he refers to as "the notion of the current state of affairs" *(noção de conjuntura)*. In other words, *notions of the factors which cause impacts on facts in the natural and social systems which exist at present"*. It therefore represents a retrospective of the past making itself present or not in the current reality. In addition, he speaks of the need to evaluate what changes in agrarian systems in a larger and more complete dimension, where there is an understanding of the new factor or factors that are being introduced, their volume, and their destiny during and after the passage of the system in question. There is a need to understand the total space: the way it is structured, what remains of nature, and the interconnections between its different components.
- Ab'Saber (1994) argues that a basic question in the tropical context is the fact that the idea has arisen that to obtain agricultural space it is necessary to suppress the forests. He points also to the limiting factors, the fragility of the ecosystems that make up tropical forests and the disagreements as to agricultural management which arise for cultural and socio-economic reasons. And, even though he considers it difficult to make any conclusive evaluation, he concludes by pointing to the very high ecological costs and the irreducible social benefits arising from the production of food and of raw materials for agro-industry.
- The great paradox of the intensive high-investment system in agriculture is that *"by intensifying production through changes in the productive process, introducing discrete elements of the process of industrial production into agriculture, there is a tendency to produce homogeneous ecosystems which are increasingly simplified. These changes in their turn increase productivity and, in consequence, allow an increase in relative worth, but they also generate disturbances in the agrosystem which are propitious for the emergence of opportunist species, whether*

they be plants that become weeds, or insects that occur normally which become pests, or even bacteria, viruses or fungi which are also normally present but which can become recurrent diseases of economic importance" (Shiki, 1997).

- Analysing the social dimension of agricultural development in the cerrado region, Cunha (1994) argues that the growth of agriculture in this ecosystem adapts itself to a perfect relationship between *"cheap land which is overutilised, and expensive labour which is saved."* Thus, the author concludes, *"by substituting its work force with capital, the country transferred its social problems to the towns. It remains to be seen whether the riches and the indirect jobs generated by agricultural development, which benefit urban centres, will be sufficient to compensate the towns for the extra burden which the country has transferred to them."*
- *"Research in the Amazon region should be directed at the generation and transfer of technologies and scientific knowledge which ensure the growth of agriculture and the exploitation of agroforestry on a sustainable basis. It becomes necessary to avoid that new areas be deforested and that, in the areas that have been incorporated into the productive process, high levels of productivity of both land and labour be achieved."*
- Rodrigues (1997), in a thesis entitled "Profitability of Agroforestry and Ranching Systems for the Amazon Region – A Case Study," concludes that the new technologies, recmmended and implemented in agriculture and ranching activities take into account the physical suitability of the soil and generate positive effects for the environment, especially when compared to conventional systems. However, a number of problems related to economic sustainability persist in relation to difficulties with the commercialisation of agroforestry products, which restrict the scope of this objective. According to this author, access to credit is providing the incentive for the establishment of agroforestry systems by small scale farmers in the region, but that such systems may only yield an annual return of 9% in 20 years, which is very low and which does not enable the farmer to improve his living conditions. Hence the importance of matching credit to the farmer's physical and human capital, so that he can undertake his activities in a sustainable way.
- Rodrigues explains the process of degradation on pastures and cultivated lands through reference to two tendencies. The first of these is the fact that the development policies prioritising the occupation of land which were imposed on the region in the 1960s and 1970s were one of the causes of this process, The other, which is more current, relates to market conditions with the opening of the economy and the lack of a policy which competitively positions rural producers in the new global market (Rodrigues, 1997).
- *"The Real (currency) Plan reduced the prices of agricultural and ranching products and, in a contradictory manner, raised the prices of inputs, posing financial problems for ranchers and rural producers which have not as yet been solved"* (Rodrigues, 1997).
- The adoption of agroforestry systems is currently limited by certain circumstances: the difference between the price of agroforestry products when they leave the rural area and the price paid by the consumer; the difference between the price of inputs in commercial centres and the price of these inputs at the farm gate; and the lack of market incentives (Rodrigues, 1997).
- To mitigate these factors and to open up existing potential, Rodrigues (1997) suggests biological research to reduce the lack of awareness of the region's potential, socio-economic research to assist the consolidation of alternative development systems which provide greater economic and social benefits for the farmers, investments in the improvement of human resources in the rural arena, and a more holistic conception of the agricultural and ranching system as one which begins at the farm and ends at the consumer.
- Some experts may argue that the length of time required for the Silvânia Project to achieve the extent of rural development that it did is a negative factor. However, as environmental education suggests, the correct understanding would be that, for the process of transformation of any context, one needs understanding, awareness of the questions that need to be addressed for its improvement, new behaviours expressing a commitment to a series of new values, the skills to know what and how to change, and the participation of the social groups involved. And, of necessity, a period extending over the medium to long term is required to perceive and effect such transformations.

From the results obtained over the years, the dependence of the intensive system on constant support from public resources and the lack of an adequate structure to face crises in product prices and other things, can be noted. It is clear that several issues are involved in the wearing down of this structure over the years and, considering the environmental aspects alone, the lack of immediate and precise responses to problems such as the emergence of new pests and diseases, accelerated erosion processes, the harming of water resources, and the contamination of the environment by agrochemicals, soil correctives, or fertilisers can be identified as being an exacerbating factor in this process. There is a need for these responses to be closely linked to the new cost/benefit reality of production, with emphasis on the prices that products achieve in the market, the lack of credit at affordable cost, and the increased but necessary costs of maintaining the proposed production system.