SIXTH FRAMEWORK PROGRAMME

FP6-2004-INCO-DEV-3

PRIORITY A.2.3.: Managing Arid and Semi-arid Ecosystems

Second Periodic Activity Report (01.01.2008 – 31.12.2008)
March 2009

ANNEX 4-2-1: Report on Best Practices & Failures from Asia and Latin America

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COMPETE

Competence Platform on Energy Crop and Agroforestry Systems for Arid and Semi-arid Ecosystems - Africa

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Competence Platform on Energy Crop and Agroforestry Systems for Arid and Semi-Arid Ecosystems – Africa (COMPETE)

Work Package 4: South-South and North South Cooperation

Best Practices & Failures from Asia & Latin America

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1.0 INTRODUCTION

The objective of the Competence Platform on Energy Crop and Agroforestry Systems-Africa (COMPETE) is to stimulate sustainable bioenergy implementation in Africa. COMPTE will establish a platform for policy dialogue and capacity building in the major multi and bi-lateral funding organizations and key stakeholders throughout the bioenergy provision and supply chains. COMPETE will deliver a matrix of multi-disciplinary and cross-sectoral work-packages, each led by globally recognized scientists and implementers. The project activities are coordinated under seven focused Work-Packages. The Work Package 4 (WP 4) focuses on South- South and North South Cooperation – Africa, Latin America, Asia and Europe. WII, SEI and EUBIA are entrusted to work on WP 4. The objective of this work-package is to link the project activities in Africa with ongoing successful research and demonstration efforts in the field of energy crops and agroforestry systems in Latin America and Asia. The partners of WP 4 have documented and submitted country reports (**Task 4.2)** on improved energy crop and agro-forestry systems in Asia and Latin America, earlier. The present report describes the Best practices- Successes and failures from Asia and Latin-America **(Task 4.3)**.

This task includes a literature review for documenting best practices, successes and failures on improved agriculture and agro-forestry system in Asia and Latin America. The work is performed by linking current and past projects and involving all the WP consortium partners .The areas emphasized under this task are:

- Innovative land use patterns and their impacts
- Agricultural practices that has led to improvements in yield and / or quality
- Sustainable forest management practices
- Efficient water management systems employed in agriculture, including traditional water harvesting practices and use of waste water
- Lessons learnt from failures
- Policy measures and management strategies being adopted for sustainable use of renewable natural resources
- National policy and strategies addressing the implementation of improved energy crops and agro-forestry systems, legal and institutional frameworks for poverty eradication
- Trade issues and financing mechanisms
- Climate change issues including vulnerability and adaptation strategies

The following sections present the best practices from Brazil, China, India, Mexico and Thailand.

2.0 BRAZIL

This section includes a literature review for documenting best practices on improved agricultural and agro-forestry systems in Brazil. This review includes best practices in land use, water management, policy measures for sustainable use of renewable natural resources, financing mechanisms and climate change issues and their risks in agriculture.

Agriculture has played a key role in the development of human civilization - it is widely believed that the domestication of plants and animals allowed humans to settle and give up their previous hunter-gatherer lifestyle during the Neolithic Revolution. Until the Industrial Revolution, the vast majority of the human population labored in agriculture. Development of agricultural techniques has steadily increased agricultural productivity, and the widespread diffusion of these techniques during a time period is often called an agricultural revolution. A remarkable shift in agricultural practices has occurred over the past century in response to new technologies

In Brazil, the productive area grows each year. In 2006, 249 million hectares of crops and pastures were explored (IBGE, 2007b), 44% of the area possible to used by agriculture (Figure 1).

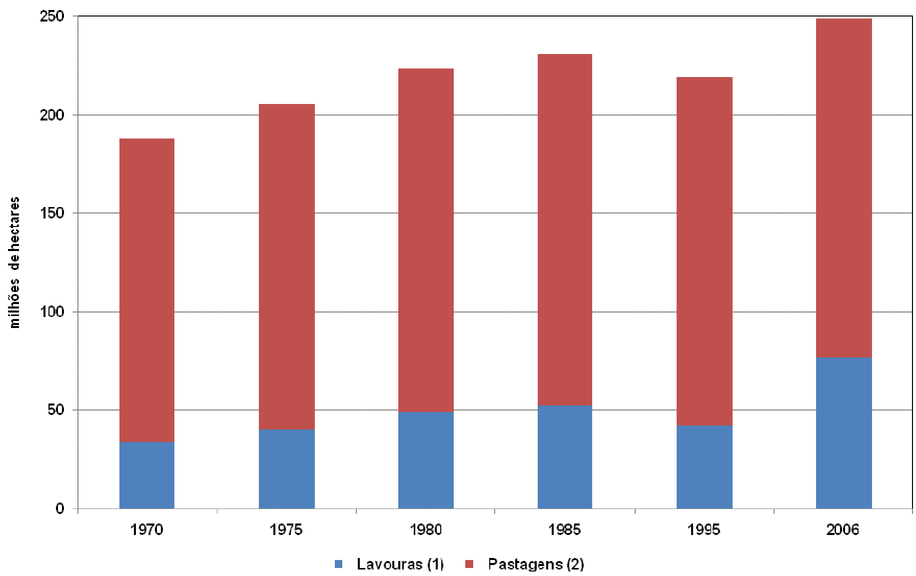


Figure 1: ***Agriculture and cattle raising areas in Brazil, in million of hectares***

Source: IBGE (2007b)

Notes: (1) Permanent and temporary crops. (2) Natural and grown pastures

2.1 Land Use

Although Brazil explores less than a half of its area possible to hold agriculture, 84.5% of non-forest areas are used by agriculture or cattle raising. In order for this land extension not to suffer problems related to soil management, such as erosion, compaction, and increase in soil salinity, it is fundamental that agricultural practices and specific measures in soil preparation are adopted.

2.1.1 Agricultural Practices

The following agricultural practices1 were identified in Brazil by IBGE (2007b) in agricultural and cattle raising establishments:

- *Crop Leveling* – crops are done obeying the natural curves of the land, so that the plants work as natural barriers that contain or decrease the speed of rainwater, avoiding the water runoff and the formation of erosion
- *Use of terraces* – technique used in hilly cultivated areas, with the goal of protecting crops of higher value, such as fruit trees, grapevines, among others.
- *Crop rotation* – altering crop of grasses, vegetables and others, having possible periods of rest
- *Use of crops for reform and/or renovation and/or recovery of pastures* – use of pasture areas with temporary crops with the finality of recovering its fertility
- *Rest of soil* – technique of letting the land used for cropping rest, for undetermined time, so it can recover its fertility.
- *Agricultural burning* – practice of burning vegetable mass for cleaning pastures, cleaning soils or to facilitate sugarcane harvest.
- *Protection and/or conservation of slopes* – practice that consists in using trees or bushes to preserve hills with high slopes, which are subject to erosion.

Besides agricultural practices, for appropriate soil management, some measures in soil preparation are fundamental.

2.1.2 Soil Preparation

To enable the use of land for crops production, it is necessary to prepare soil, which consists in a set of operations carried out with the goal of creating favorable conditions for sowing, development and production of crops, for unlimited time.

In Brazil, three are the main soil preparation forms:

1 This was the first time this subject was inquired in 2007 Agricultural and Cattle Census by IBGE. The preliminary results do not make the participation of this agriculture practices public.

- *Conventional Crop production* (harrowing plus plowing) or deep harrowing – the soil is prepared through harrowing followed by plowing, with harrowing crates or heavy crates.
- *Minimum tillage (only plowing)* – soil preparation is characterized by less utilization of implements. Basically, crates are used and eventually, the scarifier plow which revolves soil, enhancing its draining and physical condition.
- *No-tillage on Straw* – crops are done in furrows opened in soil covered with straw, with no need of plowing or harrowing of land surface, maintaining the rest of previous crops in the soil. According to the Brazilian Federation of No-Tillage on Straw (Federação Brasileira de Plantio Direto na Palha, 2008), the zero tillage system evolved from around 180 hectares in 1972/73 to 25.5 million hectares in 2005/06, considering summer and winter crops and safrinha[2]. It is the second country in the use of this soil preparation technique in the world, behind United States.

As a measure of soil conservation, minimum cropping and direct crop[3] have been each time more used in crops soil preparation in Brazil (Graph 2), one third of crops use direct crop in soil preparation. (Brazilian Federation of No-Tillage on Straw, FEDERAÇÃO BRASILEIRA DE PLANTIO DIRETO NA PALHA, 2008).

In opposition to conventional agriculture, where the soil suffers intense movement, no tillage system is based in the non-preparation of soil and in the permanent cover of soil with crops rotation. The soil is manipulated at the moment of sowing, when it is open a furrow where the seeds and fertilizers are put. The most important control that happens in this crop system is the one of weeds, through integrated management of plagues, diseases in general and infesting plants.

2 safrinha – is the crop between two harvest. In Brazil, this period is between January and March.

3 The same as they did with agriculture practices, IBGE researched for the first time the types of soil preparation in agriculture and cattle ranching establishments, however the information was not divulged in preliminary results

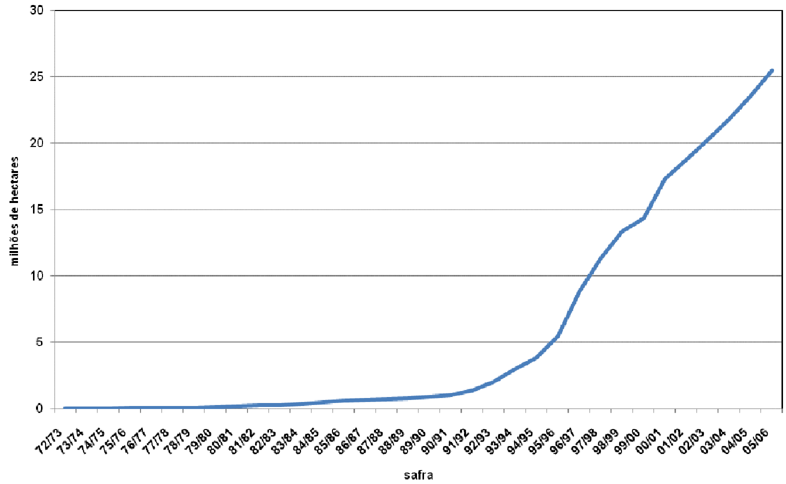


Figure 2: ***No tillage cropping area in Brazil***

Source: FEDERAÇÃO BRASILEIRA DE PLANTIO DIRETO NA PALHA, 2008

No tillage system brings several benefits that will decrease the costs of production and environment impact, such as higher retention of water in the soil, less soil compaction, less erosion, less nutrients loss, economy of fuel (diesel) and less number of operations, including harrowing and plowing. That also contributes to a decrease in the use of tractors, and, consequently, less soil wear. No-tillage was used by the first time in Rolandia, north of the State of Paraná, by the farmer Herbert Bartz in 1972. The innovative idea showed a new path to agronomy, it is considered conservative and its technology is well developed for grains such as wheat, corn, soybean, bean and cotton. There are, however, agro ecology circumstances that limit the use of this system, such as: impossibility of draining, reduced range of friability, clayey soil texture and very high rates of organic matter decomposition (Table 1).

Table 1: ***No tillage advantages and disadvantages***

Advantages	Disadvantages
Reduces soil erosion	Transition from conventional to no tillage system is not easy
Preserves water	Necessary equipments are expensive
Enhances soil quality	High dependence on herbicides
Reduces costs of fuel and labor force	The predominance of weeds, diseases and other pests result in unpredictable changes
Reduces lakes and streams pollution due to sediments and fertilizers	In the beginning, may require more nitrogen fertilizer
Carbon sequestration	Possible delay in germination and reduced production

Source: HUGGINS; REGANOLD, 2008

2.2 Water Management

The practice of irrigation has been fundamental to assure the supply of agricultural products. The future demand in food production is critically dependent on irrigated agriculture. Among the benefits of irrigation, one may highlight: enhancement of finance performance of agricultural business and of the life quality of rural communities, possibility of expansion of agricultural frontier and decrease in the risk involved in agricultural activity. Irrigated agriculture also favors the expansion of work opportunities in the country.

The water demand (withdraw) in Brazil is 1.592 m^3/s, with around 53% of this total (841 m^3/s) being consumed and not returning to river basins (ANA, 2007). Around 26% of withdrawal will flow to urban supply, against 46% to irrigation and 18% to industry. Only 3% are directed to rural supply (Graph 3).

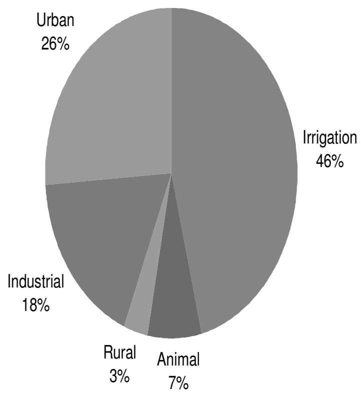


Figure 3: ***Water withdrawal by sector in Brazil, 2000***

Source: ANA, 2007

2.2.1 Irrigated lands and irrigation methods

In 2002, the irrigated area in Brazil was 3,3 million hectares, from which 1,6 million hectares with pressure irrigation and 1,7 million of hectares with surface irrigation, which represents 5.5 percent of the cultivated area, table 2 (CHRISTOFIDIS, 2008). It was considered as irrigation the practice of applying water, not rainwater, directly in the soil surface, cultivated with crops or pastures, in determined quantities and timing intervals, with the purpose of providing water to plants, in appropriate conditions for their growth and production. The irrigation methods are:

- Flooding – consists in the leveling of the terrain for flooding or inundation of cropping area;

- Surface irrigation (Furrow) – consists in the leading and distribution of water through furrows or irrigation canals, located between the rows of planted crops;
- Sprinkler irrigation (centre-pivot) – method in which the area is irrigated by a mobile system, built by a bar with sprinklers, which moves around a fixed point;
- Spray/Sprinkler irrigation (other methods) – fixed and mobile sprinklers, except centre-pivot;
- Localized/Micro irrigation (drip irrigation, micro-spray, etc.) – leading water through pipes, and its distribution is done drop by drop.

Table 2: ***Irrigated area in Brazil, per irrigation method, in hectares [ha]***

Irrigation Method	Area [ha]	%
Flooding	1.107.370	33,8
Furrows	592.297	18,1
Sprinkler (central pivot)	713.649	21,8
Spray irrigation (other methods)	614.811	18,8
Localized irrigation (drip irrigation, micro-spray, etc.)	246.087	7,5
Total	**3.274.214**	**100,0**

Source: CHRISTOFIDIS, 2008

With the current knowledge of soil and water resources, the irrigation potential of Brazil is estimated at 29.5 million ha, table 3. This includes only areas where irrigation can be developed and excludes the areas of high ecological value in the northern region (Amazonas and Tocantins basin). In the savanna areas (cerrados) of the centre-west region, the potential for irrigation has expanded substantially in recent years, following recent advances in soil management and irrigation techniques applicable in that region.

Irrigation techniques differ within Brazil (Graph 4). In the south, southeast and centre-west, rice paddies, as well as some vegetable and orchard crops, are irrigated by simple flooding or using furrow irrigation. Over 990,000 ha of paddy rice are grown with basin irrigation in Rio Grande do Sul. Water is diverted from numerous small streams and conveyed to the farm-gates through earth canals. At least 1.7 million ha in Brazil are estimated to be under traditional systems of this sort. They are used where water availability is ample. This technology, together with proper land preparation and some mechanization, yields a good return. Modern irrigation technologies, which have a higher water-use efficiency and require less labor, are preferred by large farmers in the *cerrados*, for crops such as wheat, soybean, maize, and cotton, and by the producers of vegetables and fruits near the metropolitan areas in the northeast.

Table 3: ***Irrigation potential in Brazil by regions, in thousand hectares***

Region	Lowlands "várzeas*" [1000 ha]	Highlands [1000 ha]	Total [1000 ha]	%
North	9.298	5.300	14.598	49,4
Northeast	104	1.200	1.304	4,4
Southeast	1.029	3.200	4.229	14,3
South	2.207	2.300	4.507	15,2
Centre-West	2.326	2.600	4.926	16,7
Total	**14.964**	**14.600**	**29.564**	**100**

Source: CHRISTOFIDIS, 2008

Note: * *várzeas* are seasonally-flooded or flood-prone lowlands.

These technologies, which are increasingly used in private and public irrigation schemes, range from mobile sprinkler lines to state-of-the-art modern centre-pivot and other self-propelled irrigation equipment. In the northeast there is a strong increase in the use of micro-irrigation equipment, due to the water scarcity in the area. In recent years, the area with surface irrigation has decreased and that with sprinkler irrigation for grain production and micro-irrigation for fruit and vegetables has increased. Total efficiency of water use is estimated, on average, at 40-65 percent for surface, 60-85 percent for sprinkler and 78-97 percent for micro-irrigation methods (FAO, 2008).

Little information is available in drainage, salinity and water logging in Brazil. The surface with drainage equipment is around 1.28 million ha, mostly in the areas with irrigation equipment. Within the framework of the Provarzeas program in the 1980s, around 400,000 ha were drained.

The natural saline areas in Brazil are quantified on average at 86 million ha, located especially in the driest areas with average precipitation below 1,000 mm/y. The area salinized by irrigation is estimated at 15,000 ha, mostly in the northeast (FAO, 2008).

The extension of the areas with natural water logging, called "varzeas", is 13.35 million ha. Up to now, water logging problems caused by irrigation practices have only been recorded in the Nupeba project for an area of 170 ha. Codevasf is in the process of designing and implementing a drainage system to prevent water logging (FAO, 2008).

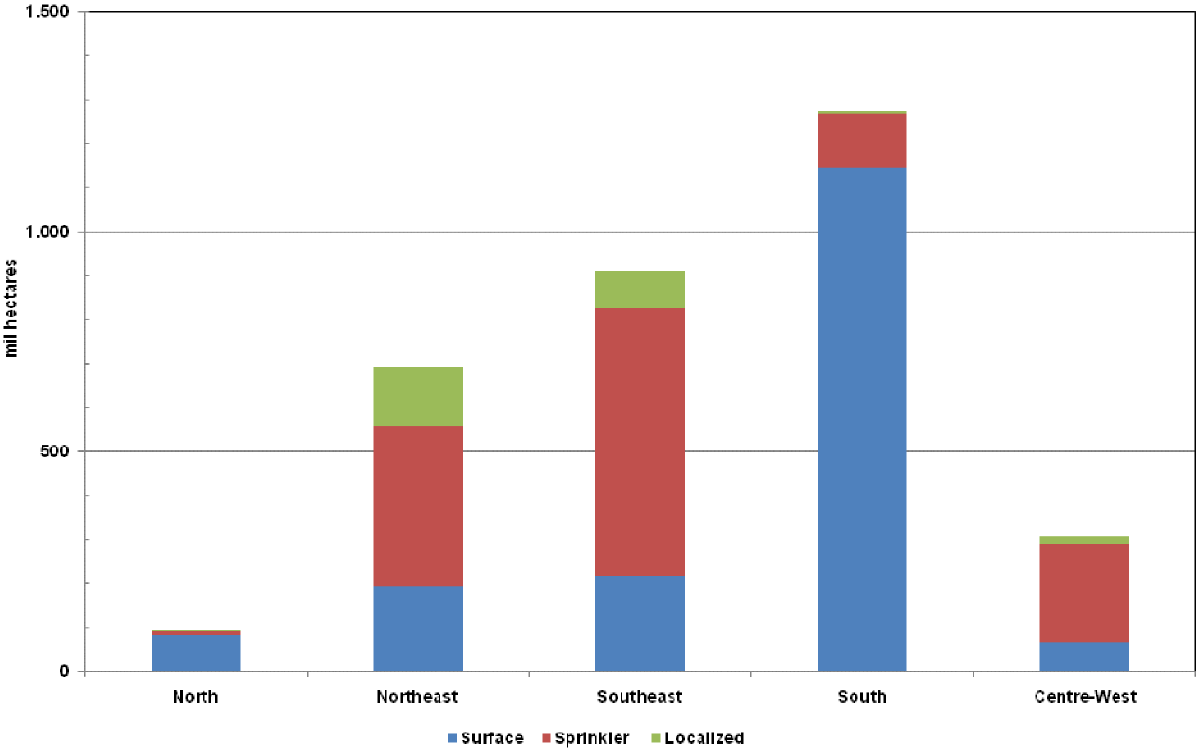


Figure 4: ***Irrigated area by irrigation techniques for regions of Brazil in 2002***

Source: CHRISTOFIDIS, 2008

2.2.2 Water harvesting practices

Brazil is one of the few large dimension countries in the world to register rain in all its territorial extension. In the semi-arid, although there is variation in precipitation, it rains an average of 700 billions cubic meters of water per year (ASA, 2008).

Programs of water harvesting are common in areas with water supply restriction, such as the Brazilian semi-arid. In the northeast area, two programs were identified, carried out by civil society, which aim to enhance the live quality in the semi-arid and allow water supply for human consumption and for food production (ASA, 2008).

➲ *1 Million Cisterns Program (Programa 1 Milhão de Cisternas - P1MC)*

The One Million Cisterns Program for human consumption was an initiative of the NGO Articulation for the Semi-Arid (Articulação do Semi-Árido - ASA) in July, 2003 and aims to benefit around 5 million people in the entire semi-arid region, with potable water, for drinking and cooking. Each cistern is capable of storing 16 thousand liters of water, collected from rain, through pipes installed in the roofs. The most of the 226.800 cisterns already built in this program, up to August 2008, are made with pre-molded slabs.

The cistern is built by masons of the target localities and by the own families, who carry out general services of excavation, acquirement and supply of sand and water. Masons are paid and the contribution of families in the building of cisterns is considered to be a counterpart in the process. If the water of the cistern is used in an appropriate way – for drinking, cooking and brushing teeth – it can last for approximately 8 months.

➲ *Program One Land and Two Waters (Programa Uma Terra e Duas Águas - P1+2)*

The goal of P1+2 is to go beyond rainwater collection for human consumption, moving towards the sustainable use of land and appropriate management of water resources for food production (animal and vegetal), promoting food security and income generation.

The number "1" means sufficient land to develop productive processes aiming food and nutritional security. Number "2" corresponds to two ways of water utilization – potable water for families and water for cattle raising and agriculture production, in a way that farmer's families and people influenced by them live with dignity.

In January 2007, P1+2 started its demonstrative phase, in which aims a bigger interaction among productive and sustainable land management experiences and water resources. In a participatory way, the idea is to trigger a process of mapping, exchanging, systematizing and implementing experiences.

The proposed activities for demonstrative phase of P1+2 will target 96 communities from 10 States (AL, BA, CE, MA, MG, PB, PE, PI, RN, SE), where there will be built 144 rainwater collection technologies for food production. These technologies will benefit 818 families.

There are several relevant experiences of rainwater collection developed in the Brazilian semi-arid, in its majority carried out by family farmers, which can be multiplied. For the demonstrative phase of P1+2, four water storage technologies are being used:

- *Cistern adapted to farming*

  It is formed by a collection area (to collect rainwater which drops from the unevenness of ground or from paved areas such as a sidewalk), by a water tank (which must be bigger than the cistern for human consumption) and an irrigation system (which can be hand-operated or by pumping or drip systems). With the water of a 50 thousand liters cistern (not used for domestic consumption) it is possible to irrigate a "productive garden" [4] of vegetables, water plants or have water for chickens and bees.

- *Underground dams*

  Conserves the rainwater infiltrated in the underground areas, funds of valleys and areas where rainwater flows through a dam dug deep until the impervious layer of soil. It has a great impact over the stability of the productive system, increasing the resistance in drought periods, when the dam area looks a green island in the middle of the dry vegetation. It assures the autonomy in relation to food, allows raising a higher number of animals and decreases the dependence of external inputs.

- *Stone tank*

  Enables the storage of great volumes of water collected in horleys, taking advantage of their natural inclination. In some places it is necessary to build walls enabling the containment or the guiding of water towards the tanks, and consequently, a greater accumulation of water. It is one technical innovation based in the value of family farmers' knowledge in the strategies of water use and management. The stone tank storages water for domestic purposes, for animal feeding and irrigation of a vegetables' "productive garden".

- *Barreiro Trench*

  They are deep and narrow tanks, dug in crystalline underground with one or more compartments and more than three meters deep, with bottom and walls of stone (piçarra), which does not let water to infiltrate. Small kennels are built to direct runoff water to these compartments. It is important to make small rock barriers inside the water diversion to retain sand. Since it is narrow and deep, its evaporation surface is smaller. The *Barreiro Trench* storages water for animals and for irrigation of a 'productive garden" of vegetables.

[4] A "productive garden" corresponds to an area of 10 m^2.

2.2.3 Use of wastewater

With exception of the sugar-ethanol sector, recycled water is not a very widespread practice in Brazil. In sugar-ethanol sector, all wastewater, known as *vinasse*, is used as fertilizer. Although it has high polluting potential, it also has a very high fertilizing value. The application of vinasse in cropping is an adopted practice in all plants, with well known and defined technology. There are numerous tests that have confirmed the positive results in cropping productivity, associated to the economy of mineral fertilizers. The great advantage in employing vinasse is that it may substitute in great part the nutrients of mineral fertilization, and many studies demonstrate the increase in sugarcane productivity, due to its application. Vinasse production varies in function of different processes employed in alcohol production. In a general way, each liter of ethanol produced in a distillery generates among 10 to 15 liters of vinasse. In 2004-2005 cropping, 14,8 million of litters of ethanol were produced, and the vinasse resultant production was 207,2 million dam^3/year (BARROS, 2008).

There are other initiatives of no potable water reuse in the industry sector, in addition to unplanned practices in different sectors, as in the agriculture sector - mainly for irrigation of some vegetables and fodder crops. It is a non institutionalized procedure and it has been developed up to now with no planning or control. Most times, the adoption of the practice is totally unconscious by the user, who uses highly polluted water from streams or rivers that run nearby for vegetables irrigation, not knowing that it may be a very dangerous practice to public health, provoking negative environmental impacts.

In Campos Basin, sugarcane agro-industry producers use water recycling technology, in addition to vinasse, the water resultant from poultry, swine and cattle raising becomes a source that attends the high demand for irrigation in the region, contributing for the economy of fertilizers, since it is rich in nutrients.

The State of São Paulo has specific experiences in the reuse of treated sewage in agriculture. They have practices of reuse in irrigated agriculture of annual crops, as maize and sunflower, hydroponics in flowers and irrigation of pastures for hay production.

Other national experiences can be highlighted in reuse practice, such as the application of sewage, which receives primary treatment in the region of Serido, in Rio Grande do Norte, for irrigation of *capineiras,* in the urban outskirts, with major highlight to the cities of Santa Cruz, Campo Redondo, Caicó, Currais Novos, Goianinha, Eduardo Gomes and Parelhas (BERNARDI, 2003).

There were not identified statistics on activities of water reuse of post-treated sewage for other sectors. This is due to the lack of knowledge on this kind of technology.

Considering that there are activities of water reuse for cropping purposes in certain Brazilian regions, which are carried out in an informal way, without the appropriate environmental and public health safeguards, it is necessary to institutionalize these activities and promote the sector through the creation of a management structure, legislation preparation, information dissemination and the development of technologies which are compatible with our technical, cultural and socio-economic conditions.

Initiatives for fomenting and divulging this technology and investing in ways to establishing political, legal and institutional bases for water reuse were taken with the creation and activities of the Technical Group of Reuse, in the instance of the Technical Chamber of Science and Technology, in the National Council for Water Resources and in the Oversight for Charging and Conservation of the National Agency of Waters (BERNARDI, 2003).

2.3 Policy measures, management strategies, legal & institutional frameworks

The country has developed many policies to use renewable natural resources in a sustainable way and implement improved energy crops and agro-forestry systems, besides programs for poverty eradication. The most important ones are explained in the next paragraphs.

2.3.1 Sustainable use of renewable natural resources

➲ ***Forest Grant Program (Programa Bolsa Floresta)***

Forest Grant is a program of the Amazon State government, which aims to recognize, value and compensate traditional and indigenous populations of the state, for their role of conservation of forests, rivers, lakes and streams (GOVERNO DO ESTADO DO AMAZONAS, 2008).

This benefit is given to the population who do not cause deforestation. Families that deforest an area up to 50% above what is determined for that year by Forest Grant Program, receive a warning and must explain the motive for cutting down the trees. After they are listened, these families continue in the program for another year. If they continue to cut down trees, they are excluded from the program and the financial aid is suspended.

The person who deforests an area bigger than 50% of what is set by Forest Grant Program is excluded in the first year and the benefit is suspended. Families who receive two warnings in a roll of three in alternate years are also excluded. Deforestation is measured annually in the field or through satellite images.

Forest Grant Program does not interfere in productive activities. The inhabitants continue to farm, fish and manage forests, rivers and lakes. Agriculture, extraction, forestry, handicrafts and fishing activities which are ecologically correct are maintained.

As in all protected areas, inhabitants have to follow the rules of the Plans for the Use and Management of Protected Areas. 2102 families who live in 6 protected areas were registered. The money for paying the benefits comes from interest of existing resources of the State Fund for Climatic Change, of the Amazon State government (Fundo Estadual de Mudanças Climáticas) (GOVERNO DO ESTADO DO AMAZONAS, 2008).

➲ ***Program of Social and environmental development of Rural Family Production (Programa de Desenvolvimento Socio-ambiental de Produção Familiar Rural, Proambiente)***

The program of Social and Environmental development of Rural Family Production (Proambiente) gathers concepts of rural production and environment conservation, and it is born in the discussions that happen in rural social movements of Legal Amazon about the need of overcoming the dichotomy among rural production and environment preservation.

The application of rural credit modalities in the region, through the Constitutional Fund of North Funding (Fundo Constitucional de Financiamento do Norte, FNO), during the 90's, did not succeed to overcome certain paradigms towards a proposal of sustainable rural development adapted to the local context, while it has been of great importance for rural family production sector, since it allocated around one billion of reais (roughly 0.5 billion US$) and reached 100 thousand family units production (25% of the total of the region's units) (MMA, 2008b).

One of the great innovations of Proambiente is the remuneration of environment services to compensate the costs of opportunities to qualitative changes in the land use, focusing on production systems identified with the specificities of each biome.

The Program allows the remuneration of environmental services offered to the Brazilian and international society, such as deforestation reduction, atmospheric carbon sequestration, reestablishment of ecosystems hydrological functions, conservation, biodiversity preservation, soil conservation, reduction of landscape inflammability, change of the energy matrix and agrochemicals elimination.

Proambiente Program gathers in the same public policy the following concepts (MMA, 2008b):

- Social Control and Local Participatory Management between Municipal and State Governments and organized Civil Society.
- Territorial Planning, through the formation of Poles (composed by a set of producers associations and cooperatives), based in social, cultural, geographic and natural aspects. The formation of Poles also encourages the collective joining to the Proambiente Program.
- Qualified technical assistance and rural extension, with production and environment preservation concepts internalized by technical staff and beneficiary families.
- Specialized and regionalized rural credit, with the participation of families in the elaboration and application of technical projects offered by operating banks.
- Elaboration of the Pole Sustainable Development Plan, approaching aspects of outside the properties, such as integration, improvement marketing and Sales of the Pole production and infra-structure, with implementation in partnership with the city halls of the territorial base of the Pole.
- Elaboration of the Plans for Production Units Use, approaching the goals of the management and critical points of qualitative conversion of land use, time and space scale of natural resources use and definition of the Production Areas, Permanent Preservation Areas and Legal Reserve.

➲ *Ecological ICMS*

Ecological ICMS is a tributary mechanism which was adopted by several Brazilian states to subsidy and to encourage conservation initiatives. It allows Brazilian cities to receive part of financial resources raised from the Tax collected over Circulation of Goods and Services (Imposto sobre Circulação de Mercadorias e Serviços – ICMS), in recognition to an environment service to society (LOUREIRO, 2008).

Ecological ICMS began in Parana State, in 1991. The cities felt their economies weakened due to the restriction of use caused by the need of preserving water sources of neighbor municipalities and due to the existence of protected areas, while the State Public Power felt the need of modernizing its public policies tools.

Born as a kind of "compensation", Ecologic ICMS evolved, transforming itself along the time into direct and indirect incentive to environment conservation. Due to its cost, legal and constitutional adequacy, Ecologic ICMS operates the principle of protector-beneficiary.

The Program was later developed in the States of Sao Paulo (1993), Minas Gerais (1995), Rondonia (1996), Rio Grande do Sul (1998), Mato Grosso do Sul (2001) and Mato Grosso (2001), and it is in implementation or regulation phase in Pernambuco, Tocantins and Amapá, and is under debate or negotiation in legislative instances in the states of Bahia, Goias, Pará, Santa Catarina, Ceará and Rio de Janeiro.

Ecologic ICMS creates rules for the portion of collected ICMS to which the cities have the right to receive. In the case of Paraná, this composition is funded in two dimensions: one quantitative and another qualitative (LOUREIRO, 2008).

The quantitative dimension takes into account the surface of the protected area in relation to the total area of the city. This relation is corrected by a multiplier that characterizes the level of restriction in the use of the protected area.

The qualitative dimension considers, besides aspects related to the existence of flora and fauna species, necessary inputs available to the protected area, aiming maintenance and enhancement of its management process.

The protected areas considered for the effect of calculation are: Conservation Units, Indigenous Land Areas, Faxinais[5], Permanent Preservation Areas and Legal Forest Reserves.

The most significant results relate to the increase in the surface of protected areas and evolution of the protected areas management quality.

In the State of Parana, for example, there was a raise in 159.77 % of the protected areas surface (Table 4). It is important to highlight the increase in the surface of the *varzea* ecosystem in the Complex of Ilha Grande and in state Private Reserve of Natural Patrimony (Reserva Particular de Patrimonio Natural – RPPNs[6]).

Besides the increase in protected area, the tax collection of municipalities also increased. In the state of Parana, one of the best examples is the municipality of Guaraqueçaba, which tax collection increased 600%.

In the state of Minas Gerais, the municipalities of Betim, Contagem, Ipatinga, Uberlandia and Coimbra had an important increment in its income tax, due to the ICMS after they invested in systems of final garbage disposure (LOUREIRO, 2008).

5 Faxinais are a special type of protected area. It is a rudimental and communitarian agriculture system, keeping the native forest where animals (pork, kid, poultry) are created.

6 RPPN is a private area to protect the biological diversity. It is an owner`s voluntary act without losing its land property.

Table 4: *Evolution of the protected area surface, in the state of Parana, until 1991, and from 1992 until 2001, registered and target of offering credit from Ecologic ICMS to the respective municipalities, in hectares*

Management level	Until 1991	From 1992 to 2001	Evolution (%)
Federal	584,622.98	694,186.26	18.74
State	118,163.59	964,554.92	716.28
Municipal	8,455.50	226,674.89	2,462.60
Indigenous Lands	81,500.74	83,245.44	2,14
Federal RPPN	0,0	1,706.13	-
State RPPN	0,0	33,154.72	-
Faxinais	0,0	18,927.11	-
Permanent Preservation Areas	0,0	17,107.69	-
Legal Reserve	0,0	16,697.73	-
Special Farms	0,0	1,101.56	-
Other connection forests	0,0	3,245.62	-
Total	**794,763.81**	**2,064,594.07**	**159.77**

Source: LOUREIRO, 2008

2.3.2 Improving energy crops and agro-forestry systems

➲ The Proalcool Program

The “Brazilian Alcohol Program” (Proalcool) – to produce ethanol from sugarcane – was established during the 70´s, as a consequence of the oil crises, aiming to reduce oil imports, as well as a solution to the problem of the fluctuating sugar prices in the international market. The program has strong positive environmental, economic and social aspects, and has become the most important biomass energy program in the world.

In Brazil, ethanol is used in one of three ways: (a) as octane enhancer in gasoline in the form of 20 to 26% anhydrous ethanol and gasoline, in a mixture called gasohol; or (b) in neat-ethanol engines in the form of hydrated ethanol and (c) in any combination of (a) and (b) in cars with engines designed to run with gasoline and ethanol (flex fuel cars). The decision to use sugarcane to produce ethanol in addition to sugar was a political and economic one that involved government investments. Such decision was taken in Brazil in 1975, when the Federal Government decided to encourage the production of alcohol to replace gasoline, with the idea of reducing petroleum imports, which were putting great constraints in the external trade balance (MOREIRA; GOLDEMBERG, 1999).

Ethanol consumption has been growing overall by its addition to gasoline as a carburant. The increase in the production and use of ethanol as a fuel was made possible by three governmental actions during the launching of the ethanol program: (a) the decision that the state-owned oil company, Petrobras, must purchase a guaranteed amount of ethanol; (b) the provision of economic incentives for agro-industrial enterprises willing to produce ethanol, offering loans with low interest rates from 1980 to 1985; (c) steps to make ethanol attractive to consumers, by selling it at the pump for 59% of the price of gasoline. This was possible because the government at that time set gasoline price. Nowadays, there are no subsidies for ethanol production and it is sold in general for 60 to 70 percent of the price of gasoline at the pump station in a free market, due to significant reduction on production costs. These results show the economic competitiveness of ethanol when compared to gasoline. Considering the higher consumption rates for neat-ethanol cars and for flex fuel cars using neat ethanol, ethanol prices at the station could be as much as 80% of gasoline prices.

In fact, policies have led to a significant and successful change in the economy. The Alcohol Program in Brazil was possible because of the high price of gasoline and the special policies established to favor the program. In the period 1975-1989 a total of USD 4.92 thousand million was invested in the program (MOREIRA; GOLDEMBERG, 1999). However, savings with oil imports were much higher, reaching USD 43.5 thousand million (2001 USD) from 1975 to 2000 (GOLDEMBERG; COELHO; LUCON, 2003). The large amounts of ethanol produced allowed a substantial decrease in alcohol production costs. Ethanol price paid to producers fell quickly after 1985, due to technological progress and economics of scale. The progress ratio of the technology has shifted from 92% in the period 1980-1985 to 75% in 1985-2002. The lower the progress ratio, the more prices have dropped. Thus, an efficient technology penetration is the one that have achieved low progress ratios (PRs). In October 2002 US dollars, ethanol progress ratios were 93% (1980-1985) and 71% (1985-2002).

It is well known that the strongest argument against renewables, in general, is their high cost and therefore their lack of competitiveness with conventional fuels – a common characteristic of new products and infant industries. This was indeed the case in the beginning of the commercial use of such renewable sources but, as consumption of renewable energy increases, its cost falls, as demonstrated by the Brazilian ethanol program.

Social considerations are today strong determinants of the Program. Presently, ethanol production generates some one million jobs in Brazil, with a relatively low index of seasonal work. The environmental standpoint is another to mention. All gasoline used in Brazil is blended with anhydrous ethanol. In addition to the alcohol-gasoline (gasohol) vehicles, there is a 1.0 million fleet running with pure hydrated ethanol in the country and 4.1 million of flex fuel cars running with gasoline and ethanol in any mixture in a single tank of fuel (ANFAVEA, 2008). Initially, lead additives were reduced as the amount of alcohol in the gasoline was increased and they were completely eliminated by 1991. Aromatic hydrocarbons were eliminated, sulphur and carbon monoxide significantly reduced. Alcohol hydrocarbons exhaust emissions are less toxic than gasoline's, with lower atmospheric reactivity. Acetaldehydes from alcohol use are less aggressive to human health than aldehydes from gasoline and diesel (CETESB, 2002).

With almost null greenhouse emissions balance, in the 1975-2000 period ethanol has saved gasoline emissions of about 110 million tonnes of Carbon (BRASIL, 2004). In 2000, 9.2 million tonnes of carbon dioxide were avoided due only to the gasoline replacement by ethanol (COELHO; PALETTA; FREITAS, 2000; GOLDEMBERG; COELHO; LUCON, 2003)

2.3.3 Poverty eradication

➲ The Biodiesel Program

Brazil mix 3% of biodiesel to petroleum diesel since 2008, for that, it is necessary a cropping area of 1,5 million ha, which is equal to 1% of 150 million ha cropped and available for agriculture in Brazil. This number does not include the areas occupied by forests and pastures (COMISSÃO EXECUTIVA INTERMINISTERIAL, 2008).

Brazil foresees biodiesel production will be around 1.1 to 1.2 billion of liters in 2008, the first year of obligation to mix biodiesel to petroleum diesel. This puts Brazil as third bigger producer and consumer of this fuel, behind Germany and USA (MDA, 2008c).

Besides the economic and environmental advantages of biodiesel, there is the social aspect, of fundamental importance, overall if we consider the possibility of synergism combining all these potentialities. The rules allow the production from different oil plants and technological routes, enabling the participation of agribusiness in family agriculture.

The cultivation of raw materials and biodiesel industrial production has a great potential of employment generation, especially when we consider the use of family agriculture.

In the semi-arid, the annual liquid income of a family who cultivates 5 ha with castor plant and an average production of 700 to 1,200 kilogram per ha, may vary from R$2.5 thousand to R$ 3.5 thousand. Besides that, the area may be consorted with other cultures as beans and corn.

To encourage this process, Federal Government launched the Social Fuel Stamp (Selo Combustível Social), a set of specific measures aiming the social inclusion of agriculture (COMISSÃO EXECUTIVA INTERMINISTERIAL, 2008). The social responsibility of projects or companies which produce biodiesel allows the access to better conditions of financing from BNDES and other financial institutions, besides giving the right to participate in auctions for biodiesel purchase. The manufacturing companies have the right to some taxes exemption; however they must assure the purchase of a share of raw material in pre-determined prices, offering security to family farmers. Family farmers must participate as partners or quota holders in oil extraction industries or in biodiesel production in a direct way or through production associations or cooperatives.

Family farmers have access to credit lines from PRONAF, through banks that operate with this program, and technical assistance offered by the companies who hold the Social Fuel Stamp. With this, the producer may increase his/her income, without leaving its main activity of food cropping. Farmers maintain their maize and manioc production, and in the *safrinha* they cultivate oil crops. Credit limit and financing conditions must follow the same rules of the PRONAF group he or she belongs to (COMISSÃO EXECUTIVA INTERMINISTERIAL, 2008).

➲ ***Program Light for All (Programa Luz para Todos)***

Federal government began in 2004 the National Program for Universal Access and Use of Electric Energy – Light for All, with the goal of bringing electric power for rural population (MME, 2008).

Majority of families without access to power lives in areas with the lowest Human Development Index. Around 90% of these families receive less than 3 minimum wages (minimum wage is US 150/month) and 80% are in the rural area.

The goal of the Program is to bring power to these communities so they may use it as a vector for social and economic development, contributing to the reduction of poverty and increase in family income. Besides that, the arrival of power facilitates other social programs, such as the access to health and education services, sanitation and water supply.

The connection of power in the houses is free and includes three points of light and two electrical sockets in each house (MME, 2008). Two million of families of the rural area were benefited from this program, from each 130 thousand are agrarian reform settlers (MME, 2008).

➲ *National Program for Education in Agrarian Reform (Programa Nacional de Educação na Reforma Agrária, Pronera)*

The National Program for Education in Agrarian Reform, of the National Institute of Colonization and Agrarian Reform (Instituto Nacional de Colonização e Reforma Agrária, Incra), has the mission of broadening the levels of formal education of settled rural workers (INCRA, 2008b).

Youth and adults from settlements participate in courses of basic education (literacy, primary and middle education), vocational courses, and different college courses and post-graduation. Pronera builds the capacities of educators to work in the schools of agrarian reform settlements, and also local coordinators, to replicate and organize community education activities.

The program supports projects in all levels of education.

- *Education of Youth and Adults (Educação de Jovens e Adultos, EJA):*

The project promotes literacy courses and continuation of formal education in fundamental and middle school. Project comprehends three basic actions:

- Promote literacy courses and educate youth and adults in the fundamental and middle school;
- Build capacities and train educators in fundamental school, so that they may replicate knowledge in agrarian reform settlements;
- Form and educate local coordinators to act as social agents and planners of community education activities.

- *Middle School and Vocational Training:*

The project carries out activities for the formation of teachers in Pedagogy course and education of youth and adults technicians in agrarian reform areas. The goal is to build capacities in the settlements of professionals able to contribute to the enhancement of communities' life quality and promotion of development in agrarian reform settlements.

- *Higher Education:*

The project has the goal of promoting professional formation, through graduation and pos-graduation courses, in several areas of knowledge for the promotion of sustainable development in settlements. They promote the dialog and scientific research among communities and universities, developing appropriate methodologies for the territorial diversities.

Pronera is a partnership of INCRA with social movements and rural workers' unions, public education institutions, community education institutions with no lucrative ends and municipal and state governments (INCRA, 2008b).

➲ ***Program of Rural Libraries "Chest of Letters" (Programa de Bibliotecas Rurais Arca das Letras)***

The Program of Rural Libraries was created to encourage reading and facilitating the access to books in settlements, family farmers' communities and former slaves' communities (*quilombos)*.

The Program of Rural Libraries assures the participation of communities in the formation and implementation of libraries. The inhabitants indicate the place for the installation, the themes of their interest and their Library Agents, who are volunteers in charge for lending the books and for encouraging reading in the community.

The books are selected according to the cultural profile of each community. Later, the collection of books is formed. Each library has 220 titles obtained by donation, covering children literature, literature for youths and adults, didactic books, research and technical books, including issues of rural population interest and their specific realities (MDA, 2008a).

2.3.4 Land use

➲ ***Program for Technical, Social and Environmental Assistance to Agrarian Reform (Programa de Assessoria Técnica, Social e Ambiental à Reforma Agrária, Ates)***

The Program for Technical, Social and Environmental Assistance to Agrarian Reform seeks to ally the traditional knowledge of settlers with technical knowledge. With this union, it is expected that settlements become unities of structured production, competitive and integrated to the dynamics of municipal and regional development, in a socially and environmental just way (INCRA, 2008a).

The services of Ates are a set of techniques and methods of permanent, public and free nature, with emphasis in agroecology, cooperation and popular economy. Coordinated by INCRA, count with public and private partner institutions, entities that represent rural workers as well as non-governmental organizations which work with agrarian reform.

The program works with technical staff specialized in agrarian, social, environmental and economic sciences. The groups work in settlements elaborating development or recovery plans for settlements projects, in rural extension, ongoing capacity building, aiming the formation of competencies and change in attitudes and procedures that enhance life quality and promote sustainable rural development (INCRA, 2008a).

➲ ***National Program for Hydrographic Micro Basins and Soil Conservation in Agriculture (Programa Nacional de Microbacias Hidrográficas e Conservação de Solos na Agricultura)***

The National Program for Hydrographic Micro Basins and Soil Conservation in Agriculture has the goal of promoting rural development in an integrated and sustainable way, having the hydrographic micro basin as the unit for producers' planning and organization, as strategy to promote enhancement in agricultural productivity and use of appropriate technologies, under the environmental, economic and social point of view (MAPA, 2008).

The activities that aim rational use and management of natural resources, mainly soil, water and biodiversity, aim to promote a sustainable agriculture, increase food supply and enhance the levels of work and income in rural areas.

Micro basins are natural geographic units more appropriate for the establishment of use and management plans, monitoring and evaluation of human interference in the environment.

The planning and implementation of works in hydrographic micro basins are carried out starting from the organization of the community towards common goals. The feature of the physical and biotical environment (native vegetation, climate, kinds of soil, topography, actual use of land, available water resources, fauna), allied with social economic aspects (agrarian structure and situation, market, transportation infra-structure, energy, telecommunications, financial agents), allow the establishment of priorities and goals, in short, medium and long term, the division of responsibilities and joint efforts to assure productivity enhancement, environment stability, generation of work and income and well being in rural areas..

The program works in all national territory, respecting the regional and local peculiarities. Organized communities, partnership between public and private institution, agreements of technical cooperation are the basis of the adopted strategy.

As a priority, the following actions are developed (MAPA, 2008):

- Capacity building of technical staff and farmers in Planning of Hydrographic Basins and Water and Soil Preservation;
- Validation and divulgation of appropriate technologies in soil management and conservation;
- Introduction of practices of soil cover;
- Practices of organic agriculture and agro forestry;
- Implementation of gardens;
- Recomposition of gallery forests and protection of fragile areas;
- Practices of preservation and sustainable use of water resources;
- Fix of land secondary roads;
- Lime and gypsum of crops soil;
- Practices of contention and control of *voçorocas*[7];
- Demarcation of level curves and construction of terrace systems;
- Implementation of demonstrative projects of plagues integrated management;
- Production and divulgation of technical/educative material;
- Support and carry out technical events (day-in-field, seminars, work meetings);
- Recuperation of degraded areas;
- Introduction of the No-Tillage System

➲ *State Program for Hydrographic Micro Basins (Programa Estadual de Microbacias Hidrográficas)*

The State Government of Sao Paulo implemented in 2000 the State Program for Hydrographic Micro Basins, which promotes actions to assure the conservation of natural resources, to enhance productivity, increase income, and reduce costs of producers. These actions, besides assuring profit to farmers, generate work and increase tax collection in municipalities, stops social exclusion and rural exodus, preserving the environment (SÃO PAULO, 2008).

The goal of the program is to promote sustainable rural development. In order to do that, besides technical assistance and rural extension to family farmers, the program carries out financial incentive, where the producers pay small amounts, enabling the implementation of practices that promote the conservation of natural resources and acquirement of equipments and services necessary to cattle raising and agriculture activities, which the producers would not be able to get without the program.

In the case of individual practices, the grants vary from 60 to 90% of the total value. The Program gives financial support to:

[7] Geological phenomenon that consists in the formation of great holes of erosion, caused by rain and weather.

- Services of Moto mechanization in the control of ravine and voçorocas,
- Installation of fences to protect springs,
- Installation of biodigestor septic tanks,
- Control of erosion, building of terraces and constructions of retention boxes or basins,
- Acquisition of lime,
- Construction of retention tracks,
- Implementation of systems of pastures division,
- Construction of water storage tanks (abastecedouros)
- Acquisition of agriculture implements, in addition to the donation of seedlings for recuperation of gallery forests and springs preservation.

2.3.5 For water use

At present there is a tendency for developing basins and State water master plans. This is done in order to secure the use of water in the various sectors and reduce future risks in water use. Up to now, fourteen states have advanced their plans for water resources management and river basin management: São Paulo, Minas Gerais, Espirito Santo, Goiás, Mato Grosso do Sul, Mato Grosso, Distrito Federal, Ceará, Rio Grande do Norte, Bahia, Alagoas, Sergipe, Rio Grande do Sul and Santa Catarina. Furthermore, a large number of committees, consortium and associations at water basin level have been created. Various Master Plans at water basin level have been elaborated and others are in the process of preparation (ANA, 2007).

The main trend with the "*New Irrigation Project" (Novo Projeto de Irrigação)* is towards increased private participation and privatization of public schemes. Ministry of Environment initiated a complete study of irrigation, which intends to map the actual sites of the irrigation schemes and select potential areas for irrigation projects without risk of water conflict.

➲ *State Program for Collection and Management of Rainwater (Programa Estadual de Captação e Manejo de Água da Chuva, Pecmac)*

The State Program for Collection and Management of Rainwater (Pecmac) is an initiative of the State Government of Rio Grande do Sul and seeks alternatives for the use of rainwater in projects of collection and storage in cisterns (PÁGINA RURAL, 2008).

Rural workers interested in the construction of reservoirs in their proprieties receive technical assistance to attend their need. With the project, the rural producer may obtain financing for their work. R$ 2 million are available for Pecmac, using resources of PRONAF.

➲ *Program for Night Irrigation (Programa Irrigação Noturna, PIN)*

Program for Night Irrigation is an initiative of the State Government of Paraná and has the goal of facilitating the access of farmers to the irrigation technique, with the reduction of electric power fee used between 9 pm and 6 am. The proposal is to assist more than 15 thousand proprieties and reset irrigation timing for other 15 thousand. The plan is that the Program for Night Irrigation is used in more than 50 thousand hectares and double the agricultural production in the state in the middle term (PARANÁ, 2008).

The program consists in the reduction of 60% to 70% in the electric power fee from low and high voltage, in addition to the supply of up to 200 meters of electric power networks, complementation of up to 500 meters of free power network and the rest with 50% of financing. The costs with installation for power measurement may be divided in up to 24 months, with no interests, besides the easy access to credit for buying and installing irrigation equipments.

The program reduces the energy consumption in peak times, settles the supply of crops, enhances water utilization, and rationalizes the use of pesticides, in addition to that, contributes to the insertion of small farmers in the market in a competitive way and serves as a tool to increase productivity and production.

➲ *Funds for the Agribusiness and for Water Resources (Fundos Setoriais do Agronegócio e de Recursos Hídricos)*

The Funds for Agribusiness and Water Resources, maintained by the National Council for Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico, CNPq/MCT), support researches in themes that prioritize water and soil conservation and increase in water production in family production rural units and have available R$ 10 million (US$ 5 million) in 2008 (CNPQ, 2008).

The project must prioritize themes as reestablishment of ecosystems hydrologic functions; adoption of agriculture techniques that promote the sustainable use and conservation of water; technologies for recovery and protection of springs, gallery forests and permanent preservation areas; conservation and valorization of environmental services; and sewage treatment and proper allocation of waste on farms.

2.3.6 National Action Program for Combat and Mitigation the Effects of Drought *(Programa de Ação Nacional de Combate e Mitigação dos Efeitos de Seca, PAN Brasil)*

National Action Program for Combat and Mitigation the Effects of Drought gives financial and technical support, through partnerships with funding agencies, for the elaboration and implementation of the Plans to Combat Desertification and Drought in the nine northeastern states, in addition to Espirito Santo and Minas Gerais, where are situated the areas most susceptible to drought. (MMA, 2008a).

Brazil is the fifth country in world ranking of populations most affected by soil degradation. The estimative is that 46 million people, the majority living in the northeast semi-arid, already suffer the direct consequences of desertification.

One of the planned tasks in PAN Brasil is to establish strategies for implementing the Convention of the United Nations for Combat to Desertification and Mitigation of Droughts Effects, from which the country is signatory for ten years.

PAN Brasil, which gathers nine ministries, the Codevasf, The Bank of the Northeast of Brazil, the SUDENE, DNOCS, the National Agency for Waters (ANA), Embrapa, and the National Association of Municipal Environmental Institutions (ANAMMA), in addition to the government of eleven states and representatives of civil society, identified localities to implement the projects of drought effects mitigation and combat to desertification. With the projects, the communities and governments may prepare themselves to face long periods of drought, adopting soil protection measures, and water and food storage, among other initiatives to minimize the effect on population (MMA, 2008a).

PAN-Brasil assured resources of around one million reais (US$ 400,000) to support small projects of combat to desertification in 2009. This is the double of what is applied in 2008 in nine of the 11 states with areas susceptible of desertification. They are projects of up to R$ 25 thousands, proposed and carried out by organizations of the civil society (MMA, 2008a).

2.4 Trade issues and financing mechanisms

Agriculture is an economic activity highly dependent on financing, both for investment in infra-structure and, mainly, for production. Modern agriculture depends on machinery, equipments and inputs that are each time more expensive. In industrial production, normally, the period between buying inputs and selling the final product is only a few days or weeks. On the other hand, even in annual crops, the period between production beginning with soil preparation, and finishing with commercialization is never less than four or five months. A great part of rural producers expenses concentrate also in the first steps of the production cycle, increasing the need and dependence of financial resources for its feasibility.

Rural credit was, historically, the main tool for agriculture policies in Brazil. With the government effort for industrialization, agriculture had to assume a role, among others, of resources supplier for the country, through exportation. Government, then, created a broad system of subsidized rural credit, which could facilitate the acquisition of machinery and equipments, in addition to modern inputs that would enable the adoption of new production technologies. At the boom of this policy, in the 70's, there was abundant volume of credit at very low interest rates. Some producers benefitted a lot from this policy, while others never had access to cheap and abundant credit in this period. (SILVA JÚNIOR, 2008).

Starting from the 80's, the volume of available credit decreased and interest rates significantly increased. Serious debts crisis began in the sector, aggravated by the economic instability and several economic plans implemented in the 80's and 90's. The agriculture sector modernized and continued to depend each time more on resources for investments and financing of the production. This dependence was most evident in business agriculture with the debts crisis, but the problem of financing was even more critical in family farming.

The shortage, difficulty or impossibility of access to credit creates conditions highly unfavorable to rural producer while creating opportunities to those other agents to act, offering credit in critical times for agriculture production and obtaining highly advantageous benefits in the payment of the debt, which typically occurs in harvest time. This situation is especially unfavorable for the producer when the crop buyer is also the financer of the production. That is to say, besides the fact of the crop production being seasonal and products being perishable, they must pay off its debt exactly at the time of most unfavorable prices. This situation is very common in business and family farming.

Certainly, political pressure is important in crisis situations and search for renegotiation of debts, once or several times, changes in dollar exchange rates and economy policy significantly affect debt value. However, in the decision of cropping and searching for financing, the rural producer does not count with the appropriate assistance. Obviously, it is not expected that farmers became financial specialists, even more when we know the reality of the field and the difficulties and problems in technical assistance and rural extension. However, there is no other alternative for rural producers than to know and use in an appropriate way the available financing tools.

In addition to direct funding provided by traders, there are other tools:

➲ *Rural Product Ballot (Cédula de Produto Rural, CPR)*

The Rural Product Ballot (CPR) can be understood as a “document” issued by rural producers or cooperatives which allows them to raise funds. The application for loan becomes not personal, that is to say, the producers does not need to obtain resources from his buyer or seller of inputs. He or she uses the CPR through a bank, which liberates the financing resources for the rural producer. The bank sends the document to any economic agent that wants to buy this “paper”. The producers may pay his debt through the delivery of products or financing resources. Since the CPR is regulated by specific policies, this is a safe tool and broadly known. (SILVA JÚNIOR, 2008).

➲ *National Program for Strengthening of Family Farming (Programa Nacional de Fortalecimento da Agricultura Familiar, PRONAF)*

Another tool for financing family farmers is the credit lines of PRONAF. They were created in the mid 90’s and the offered volumes have increased significantly, so far. For the 2007/2008 crops, 12 billions of reais (US$ 6 billions) were allocated in several credit lines, to support the family producer with greater access to technology, even to agrarian reform settlers. (BNDES, 2008).

The goal of PRONAF is to fund agriculture and cattle raising activities and also non-agriculture and cattle-raising activities explored through direct employment of rural workers and their families’ labor, understanding non-agriculture or cattle raising activities the services related to rural tourism, handicrafts, family agribusiness and other services delivery in rural areas, which are compatible with the nature of rural exploitation and with the best employment of family labor (BNDES, 2008).

PRONAF has lines for activities with agro ecology, forest production, agro industries and also for specific groups. There are six different credit lines from PRONAF (BNDES, 2008) described below:

- *Conventional PRONAF*

Funding support to investments for implementation, enlargement or modernization of infra-structure of agriculture and cattle raising production and services, in rural establishments or in rural community areas, according to specific projects.

- *Agro-industry PRONAF*

Funding support to investments, including infra-structure, which aim the improvement, processing and marketing of agriculture and cattle raising production, of forest products and of extrativism, handicrafts products or rural tourism exploitation.

- *Women PRONAF*

Funding support to credit proposals of women farmers, according to technical project or simplified proposal.

- *Agroecology PRONAF*

Funding support to investments in agroecology or organic production systems, including the costs relative to the implementation and maintenance of the business.

- *PRONAF ECO*

Funding support to investments in the implementation, utilization and/or recovery of renewable energy technologies, water storage, small hydro energy exploitations, forestry practices and adoption of conservationists practices and of correction of soil acidity and fertility.

- *More Food PRONAF*

Funding support to investments for production of maize, bean, rice, wheat, cassava, vegetables, fruit and milk.

With all the above credit lines PRONAF has been very useful but some negative aspects can be identified. As in business agriculture, in some regions there is a high rate of unpaid debts among family farmers, to whom PRONAF is not available anymore. With this situation, a cycle starts where the farmer has no more access to credit, because one has unpaid debts and cannot leave this cycle, once one has not conditions of investing or financing his production, due to the lack of credit.

PRONAF presents another problem: the availability of the resource in the bank does not assure that it will arrive to rural family workers. It is not difficult to understand the difficulties of a rural worker family with low level of formal education in their interaction with financing agents. There are, however, several successful experiences with PRONAF, in which the technical assistance is carried out by professionals that have knowledge in the rural credit mechanisms (BNDES, 2008).

➲ ***National Program for Land Credit (Programa Nacional de Crédito Fundiário)***

Land Credit is a program that enables rural workers with no land, owners of small lands and youth rural workers the access to the land through financing for acquisition of rural buildings/lands (MDA, 2008b).

Investments in basic infrastructure (houses, electric power, water supply, roads) are also funded, as well as the settling of the productive unit (technical assistance, initial investment in production) and community projects. There are additional credits for projects that aim the improvement of life in the semi-arid and recovery of

environmental liabilities. It is only possible to finance the acquisition of lands that show no risk of being expropriated for agrarian reform (MDA, 2008b).
The National Program for Land Credit is part of the National Plan for Agrarian Reform. It is the result of the Loan Agreement with the World Bank. The resources for acquisition of buildings and lands come from Federal Government.

The Land Credit is carried out in a non-centralized way, in partnership with state governments and with rural workers unions and family farmers unions and counts with the participation of the Municipal and State Councils for Sustainable Rural Development.

There are three lines of financing (MDA, 2008b):

- *Combat to Rural Poverty*

For the poorest areas and poorest rural workers;

- *Our First Land*

For youths sons of family farmers and students of agriculture technical schools and *Escolas Família Agrícola* (Farmer Family School);

- *Consolidation of Family Agriculture*

For family farmers that want to enlarge their proprieties.

Interests rates may vary between 3 and 6.5% per year, according to financing values, which vary from R$ 5 thousand to R$ 40 thousand (US$ 2.5 to 20 thousands).

In the case of the credit lines *Combat to Rural Poverty* and *Our First Land*, which counts with resources from the World Bank, the funding of investments is not reimbursable (MDA, 2008b).

➲ *Installation Credit*

The granting of Installation Credit allows the initial support to settlers of the National Program for Agrarian Reform in the Settlement Projects created or recognized by the National Institute of Colonization and Agrarian Reform (Instituto Nacional de Colonização e Reforma Agrária, Incra). The benefit must assure the food security of settlers' families, through acquisition of food and farming inputs; construction and rebuilding of houses; water security of projects located in the semi-arid, with construction of small water collection systems, water storage and distribution; and the application in production liabilities (seeds, seedlings, animal matrix, etc.), for income generation (INCRA, 2008c).

Installation Credit has been granted since 1985, and it is an important tool in the implementation of settlement projects. Its values and modalities have been set through the years in order to provide dignified conditions for occupation, production and maintenance of families in rural areas. There are five modalities and correspondent set values (INCRA, 2008c):

- Initial support: R$ 2,4 thousand (US$ 1,200) per family;
- Acquisition of building materials: R$ 5 thousand (US$ 2,500) per family;
- Foment: R$ 2,4 thousand (US$ 1,200) per family;
- Semi-Arid Additional: Up to R$ 1,5 thousand (US$ 1,250) per family;
- Recovery of building materials: Up to R$ 3 thousand (US$ 1,500) per family.

The Installation Credit Program works with a multidisciplinary staff of technicians in INCRA Regional Oversight and Advanced Units. The application of resources is carried out with the participation of settlers associations or representatives, guided by the Technical Assistance, in the choosing and receipt of products, which are paid directly to the supplier: local markets, building material stores and farming inputs stores (INCRA, 2008c).

➲ *Other rural credit lines*

Rural credit is accessible, but it is not an easy credit. The institution that offers rural credit establishes conditions for its liberation, including, sometimes, the need of technical follow up and supervision of the planned activity. The funding institution will also ask for guarantees, such as liens, mortgages, among others. Taxes and fees related to the operation will also be charged, including rural security prize and additional of Agriculture and Cattle Raising Activity Guarantee Program (Proagro). Interest rates vary according to the rural credit line that is been applied. Once the credit is granted, it will be released in a single or in several installments. The payment of the loan can also be done in a single payment or in several payments.

In the case of resources controlled by Government, limits vary between R$ 60 thousand and 400 thousand per producers (US$ 30,000 to 200,000), with interest rates of 8.75% per year, equalized by National Treasure, distributed in different rural credit lines (BANCO CENTRAL DO BRASIL, 2008):

- *Program for Modernization of Farming Tractors Fleet and Associated Implements and Harvesters (Programa de Modernização da Frota de Tratores Agrícolas e Implementos Associados e Colheitadeiras, Moderfrota)*

To facilitate the acquisition of farming tractors and associated implements and equipments for preparation, drying and improvement of coffee, funded as an isolated item or not.

- *Program for incentive of the Use of Soil-Corrective (Programa de Incentivo ao Uso de Corretivos de Solos, Prosolo)*

To encourage the appropriate use of soil-corrective.

- *National Program for Recovery of Degraded Pastures (Programa Nacional de Recuperação de Pastagens Degradadas, Propasto)*

For recovery of degraded areas and pastures.

- *Program for incentive to the Mechanization, Cooling and Bulk Transportation of Milk Production (Programa de Incentivo à Mecanização, ao Resfriamento e ao Transporte Graneleiro da Produção de Leite, Proleite)*

To encourage the enhancement in the quality of milk production.

- *Program for Beekeeping Development (Programa de Desenvolvimento da Apicultura, Prodamel)*

To encourage the development of beekeeping in Brazil.

- *Program of Support to Tree Fruit Production (Programa de Apoio à Fruticultura, Profruta)*

Support the developing of tree fruit production.

- *Program for Development of Small Animals Raising (Programa de Desenvolvimento da Ovinocaprinocultura (Prodecap)*

To enhance the management, feeding and genetic of animals, increasing production and productivity of small animals raising.

- *Program for Development of Cashew Production (Programa de Desenvolvimento da Cajucultura (Procaju)*

For enhancing cashew agribusiness in the Northeast Region.

- *Program for Systematization of Lowlands (Programa de Sistematização de Várzeas, Sisvárzea)*

To increase the production of grains in lowlands, especially maize, in all national territory.

- *Program for Support to the Development of Wine Production (Programa de Apoio ao Desenvolvimento da Vitivinicultura, Prodevinho)*

To modernize wine production in the South Region.

- *Program for Sustainable Development of Flower Plantation (Programa de Desenvolvimento Sustentável de Floricultura, Prodeflor)*

To accelerate the development of Brazilian flower production and quality.

- *Program for Incentive to the Construction and Modernization of Storage Units in Rural Proprieties (Proazem)*

To increase the installed capacity for storage in rural proprieties.

- *Program for Support to the Development of Fish Farming (Programa de Apoio ao Desenvolvimento da Aqüicultura, Aqüicultura)*

To increase the production of fish, shrimp and shellfish in regime of aquaculture.

- *Program of Support to Irrigated Agriculture (Programa de Apoio à Agricultura Irrigada, Proirriga)*

To support the development of irrigated agriculture, in order to assure greater stability in production, overall of vegetables, grains and fruits.

- *Program for the Cooperative Development for Adding Value to Agriculture and Cattle Raising Production (Programa de Desenvolvimento Cooperativo para Agregação de Valor à Produção Agropecuária, Prodecoop)*

To increment the competitiveness of agriculture industry complex of Brazilian Cooperatives, through modernization of production systems and commercialization.

- *Program of Support to the Development of Cocoa Production (Programa de Apoio ao Desenvolvimento da Cacauicultura, Procacau)*

To increase the productivity of cocoa production, through cloning and density.

- *Program of Commercial Planting of Forests (Programa de Plantio Comercial de Florestas, Propflora)*

To implement and maintain forests destined to industry use.

2.5 CLIMATE CHANGE ISSUES

Despite technological advances, such as improved varieties, genetically modified organisms, and irrigation systems, weather is still a key factor in agricultural productivity, as well as soil properties and natural communities. The effect of climate on agriculture is related to variability in local climates rather than in global climate patterns. Consequently, agronomists have to consider individually each local area.

On the other hand, agricultural trade has grown in recent years, and now provides significant amounts of food, on a national level to major importing countries, as well as comfortable income to exporting ones. The international aspect of trade and security in terms of food implies the need to also consider the effects of climate change on a global scale.

The 2001 IPCC Third Assessment Report concluded that the poorest countries would be hardest hit, with reductions in crop yields in most tropical and sub-tropical regions due to decreased water availability, and new or changed insect pest incidence. In Africa and Latin America many rainfed crops are near their maximum temperature tolerance, so that yields are likely to fall sharply for even small climate changes; falls in agricultural productivity of up to 30% over the 21st century are projected (IPCC, 2001).

Climate change induced by increasing greenhouse gases is likely to affect crops differently from region to region. More favorable effects on yield tend to depend to a large extent on realization of the potentially beneficial effects of carbon dioxide on crop growth and increase of efficiency in water use. Decrease in potential yields is likely to be caused by shortening of the growing period ant decrease in water availability.

In the long run, the climatic change could affect agriculture in several ways:

- productivity, in terms of quantity and quality of crops;
- agricultural practices, through changes of water use (irrigation) and agricultural inputs such as herbicides, insecticides and fertilizers;
- environmental effects, in particular in relation of frequency and intensity of soil drainage (leading to nitrogen leaching), soil erosion, reduction of crop diversity;
- rural space, through the loss and gain of cultivated lands, land speculation, land renunciation, and hydraulic amenities;
- adaptation, organisms may become more or less competitive, as well as humans may develop urgency to develop more competitive organisms, such as flood resistant or salt resistant varieties of rice.

They are large uncertainties to uncover, particularly because there is lack of information on many specific local regions, and include the uncertainties on magnitude of climate change, the effects of technological changes on productivity, global food demands, and the numerous possibilities of adaptation.

Most agronomists believe that agricultural production will be mostly affected by the severity and pace of climate change, not so much by gradual trends in climate. If change is gradual, there may be enough time for biota adjustment. Rapid climate change, however, could harm agriculture in many countries, especially those that are already suffering from rather poor soil and climate conditions, because there is less time for optimum natural selection and adaptation (IPCC, 2001).

For Brazil, the prevision is that global warming causes significant changes in Brazilian agriculture map, generating production losses at around R$ 7.4 billion in 2020 and of R$ 14 billion in 2070 (PINTO; ASSAD, 2008). The results are part of the study called “Global Warming and Future Scenarios of Brazilian Agriculture”, which evaluates the impact of the increase in temperature on agriculture in 2020, 2050 and 2070. The research assessed the following crops: cotton, rice, beans, coffee, sugarcane, sunflower, cassava, maize and soybean. The study was done based in the technology of Climatic Risks Zoning, a public policy that guides all structure for farming credit in Brazil, since it informs the risk level of more than 5000 Brazilian cities concerning the most common crops in the country. The study does not include the Amazon since this region does not belong to the Climatic Risks Zoning, tool which based all the projections.

Based on the 2007 Zoning for the crops, cropping scenarios were simulated for Brazil in 2010 (closer representation to current conditions), 2020, 2050 and 2070, having the current perspective of global warming, projected by IPCC (2000). Two IPCC scenarios were adopted: A2, which estimates an increase in temperature of 2℃ to 5.4ºC up to year 2100 – and scenario B2, which foresees an increase in temperature between 1.4℃ and 3.8ºC in 2100. Climatic scenarios were then simulated based in these conditions, for each country municipality in 2020, 2050 and 2070.

The increase in temperature shall promote a growth in evapotranspiration and, consequently, an increase in water deficiency. The dry regions will be even drier. Scenarios indicate a strong impact on Northeast region with the increase in temperatures. Semi-arid shall turn into arid, and the *Agreste* into semi-arid. The poorest areas, all the area correspondent to the northeastern *Agreste*, today responsible for the biggest part of corn regional production, and the region of *cerrado* in northeast – south of Maranhão, south of Piauí and west of Bahia, where soybean crops dominate – will be the most affected. Cassava will be in danger of disappearing from the northeastern semi-arid. In the southeast, climate warming will affect mainly coffee cropping, which will have few conditions of surviving in this area. On the other hand, the south region, that today is the most restricted area for crops adapted to tropical climate, due to the high risk of frosts, shall became appropriate to the cultivation of cassava, coffee, sugarcane, but no longer to soybean. Some areas from the Midwest, which present a high productive potential, must remain a low risk area, becoming, however, each time more dependent on irrigation in the dry season.

Soybean, main crop exported by the country, with a production of around 52 million t/year and production value of R$ 18.4 billion (US$ 20 billions) (IBGE, 2007a), may suffer an economic loss of R$ 4 billion in 2020, result of a reduction of almost 24% in the area proper for cropping in Brazil. The losses may get to R$ 7.6 billion in 2070, due to a decrease of 40% of the area appropriate to cultivation. The region that shall suffer most the impacts is the South region.

Having as a base the Brazilian coffee production, of around 2.5 million tonnes and production value of R$ 9.3 billion (IBGE, 2007a), global warming will bring losses for this crop of at least R$ 882 million in 2020, with a decrease of 9.48% in the area proper for cultivation. In the worst scenario (A2), the decrease in the area of low risk reaches 33% in 2070, which represents a loss of R$ 3 billion. Currently, the state of greatest coffee production in Brazil is Minas Gerais, followed by Espirito Santo, Bahia, Sao Paulo and Paraná. However, with the climatic changes forecast, it is possible that coffee has not many chances of surviving in the Southeast, migrating for the South region.

The forecast for cassava is that the increase in temperature will not be advantageous for the crop throughout the country. In 2020, the northeastern semi-arid shall no longer be a low risk location and other regions would still not be warm enough for the cropping. There will be a loss of 3.1% in cassava production area, with a financial loss of R$ 137 million. In the following decades, the situation will improve for this root, which will find more favorable areas in the South of the country, due to the decrease in the risk of frosts, and in Amazon, for the decrease of water surplus. The increase of the appropriate area starts with 7.29% in 2050, reaching 16.61% in 2070, in scenario B2. In scenario A2, the increase in the area reaches more 13.49% in 2050 and 21.26% in 2070, with earnings between R$ 589 million and R$ 929 million.

With the production of around 11.5 million tonnes (IBGE, 2007a), rice is considered a high risk crop, due to its extreme sensibility to climatic changes. Currently, the greatest production of rice is found in regions with the appropriate level of rain, especially in mid-north of Mato Grosso. In 2020, rice production may have suffered a loss of R$ 417 million and a reduction in its area appropriate for cultivation of almost 10%. In 2070, financial losses shall be around R$ 600 million in the two scenarios.

Brazilian bean crop in 2006/2007 was 3.52 million tonnes (IBGE, 2007a), almost stable in relation to the previous crop. Using this data as a reference, the foreseen loss will be of R$ R$ 155 million, due to a reduction of 4.3% in the area appropriate for cultivation in 2020, and it is possible that the financial loss reaches R$ 473 million, with the decrease in the low risk area of up to 13.3%. This decrease shall be greater in the Northeast area.

Of the different crops, sugarcane shall be the most favorable one until the end of this century. This crop, which counts today with a cultivated area of around 6 million ha, will have a potential area of 17 million ha in 2020, in scenario B2. With this expansion, the value of production, which was almost R$ 17 billion in 2006, may go up to R$ 29 billion in 2020, in scenario B2.

Areas in the south of Brazil, which today have restrictions to sugarcane cropping, may transform themselves in areas of productive potential, in 10 or 20 years. Places of Mid-West, which today represent a high productive potential, shall remain as low risk areas; however they will be each time more dependent on complementary irrigation in the dry season. With the increase in temperature in the following decades, the crop will need more irrigation and the total area must fall to 15 million ha until 2070 in scenario B2, decreasing the profit for R$ 24 billion.

According to scenario A2, sugarcane shall have a potential area of 16 million ha, decreasing for 14 million in 2070. In this scenario, the value of production may rise to R$ 27 billion in 2020, and back to R$ 20 billion in 2070 (PINTO; ASSAD, 2008).

3.0 CHINA

Biomass liquid fuel generally refers to fuel ethanol and bio-diesel which can be used for car driving. At present, in China the main raw materials for fuel ethanol are amylum and saccharide, whereas the main material for bio-diesel is grease from various kinds of animal and plant.

3.1 Making fuel-ethanol from amylum material

3.1.1 The amylum material

The amylum material mainly consists of grist crop (such as corn and wheat etc) and earthnut-tuber amylum material (such as cassava and sweet potato).

The amylum content of corn and wheat is about 60%-70% and it is the main amylum material for producing fuel ethanol in the world (especially in America, China and Europe Union area), approximately 3.2 tons of corn for 1 ton of fuel ethanol. At present, there are four fixed enterprises in China using stale corn to produce fuel ethanol, the overall output is 1.02 million tons per year, For the sake of food security, the related government branches have already decided not to enlarge the scale.

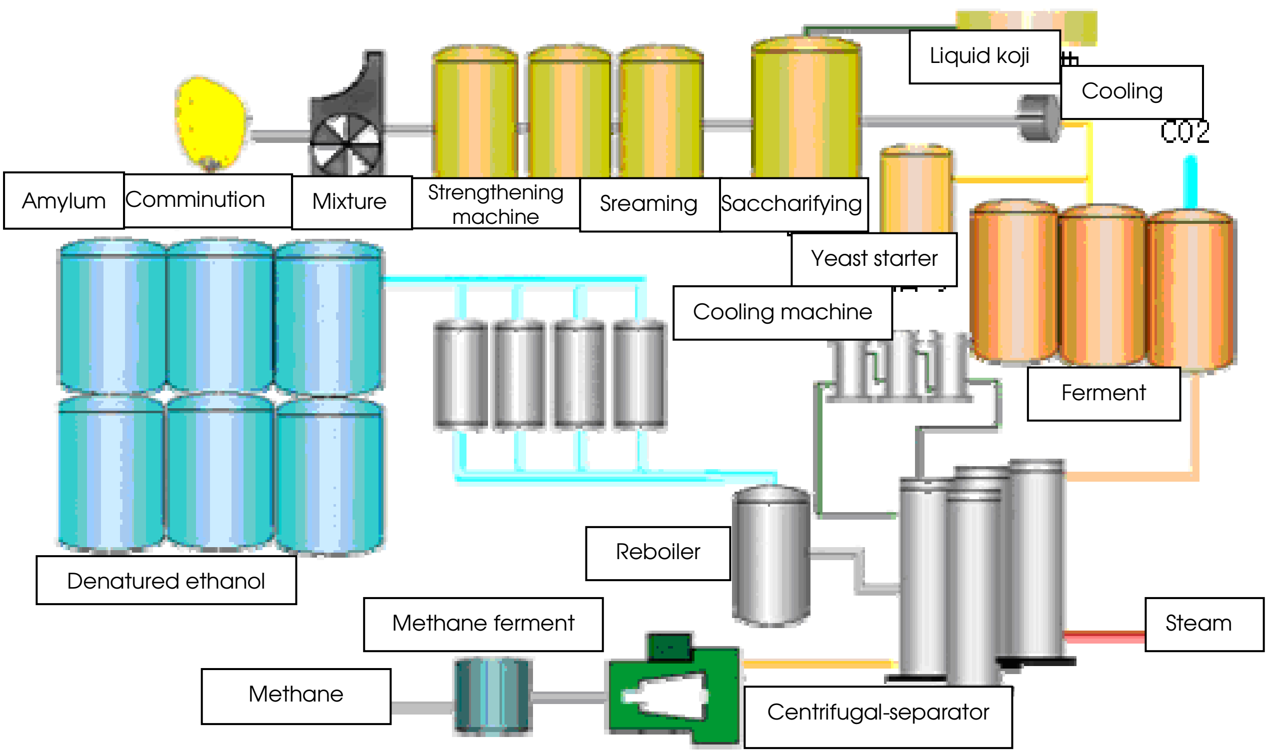
The amylum content of cassava can reach 25%-30% (dry cassava can reach 80%), cassava has a strong adaptability to soil and drought as well as barren conditions etc. The main producing areas in China are located in the north tropic, such as: Guangxi, Guangdong, Yunnan, Hainan and Taiwan etc. The planting area is approximately 420 thousand ha with an output of 4 million tons of earthnut per year. Cassava is mainly used for animal feed and ethanol producing. At present, one ha of cassava can produce 3 tons of ethanol averagely.

The amylum content of sweet potato is about 18%-20%, sweet potato is widely planted in the majority regions of China, and the planting area in 2005 is about 5 million hectares. The total output is approximately 1.07 million tons and the main planting areas are Sichuan, Henan, Shandong and Anhui provinces etc. At present, sweet potato is mainly used as fodder and material for producing amylum, but the general utilization level is relatively low, excess waste phenomena exist in some big producing provinces such as Sichuan etc. At present, 1 hectare of sweet potato can produce 2.5 tons of ethanol averagely.

In addition, some research institutions and enterprises are still grope for using basho, Jerusalem artichoke, etc to produce fuel ethanol.

3.1.2 Technics of making fuel ethanol from amylum material

Making ethanol from amylum material is a traditional and mature technics. In the field of industry, the technics process of it generally comprises the following processes: material pretreatment, saccharifying, fermentation, distillation and purification (refers to the chart below). In the pretreatment period, the material is crushed, braised, so as to intenerate and gelatinize amylum as well as to provide necessary catalyse conditions (such as sufficient contact surface area and moisture) for saccharifying enzyme. In the process of saccharifying, saccharifying enzyme hydrolyzes big molecule of amylum to hydatidiform mole monosaccharides. In the fermentation process, glucose is transformed to ethanol by yeast; In the distillation and purification process, ethanol is extracted from fermentation broth and refine fuel ethanol by using distillation and other extraction methods.



Stem from China petrochemical

The production process of amylum material fuel ethanol

3.1.3 Utilization status of technology of making fuel ethanol from amylum material

The technology of making ethanol from amylum material has a perennial and wide application in the industry of edible and industrial ethanol all over the world.

Before 2001, ethanol industry (the edible and industrial ethanol industries) in China was scattered and the scale was small, there were more than 200 professional ethanol producing enterprises, about 700 liquor-making enterprises had set up ethanol producing workshops. Among them, there was only one enterprise with the output over 200 thousand tons, 9 enterprises with output of 50-100 thousand tons, about more than 100 enterprises with output of myriad tons, others were small enterprises with output of kilotons. The main material contains various kinds of amylum material.

Since 2001, China has started to execute the experimental unit item of using ethanol gasoline for car-driving, four fuel ethanol enterprises have been set up in China focused on digesting stale grain. They were Jilin Fuel Alcohol limited company, Henan Tianguan Group Co, Ltd. BBCA Group, and Hei Longjiang Huarun alcohol Ltd. Except Henan Tianguan Group Co. Ltd using wheat as material, the other three enterprises all use corn as main production raw material, with the total output of 1.02 million tons. These four fuel ethanol experimental unit enterprises invested heavily in producing equipment and they all reached the international level. Besides, there are many other regions and enterprises are planning to use corn, cassava and sweet potato etc as raw material for ethanol producing.

But, in general, most domestic ethanol-producing technics and technology are all relatively low-standard, especially in the aspects of technique equipment, automation, comprehensive utilization, waste residue water treatment and enterprise management. This results in many problems such as general excess production cost of fuel ethanol, excessive investment in energy, low utilization rate of material and poor economic benefit etc.

3.1.4 Technology and economy brief assessment of making ethanol from amylum material

Using amylum material to produce ethanol from edible and industrial material has already realized its commercialization, but the fuel ethanol which uses corn as material is still lacks economic competitiveness compared with gasoline and other oil products, the main reason is the high cost of raw material. The material cost of making fuel ethanol from amylum material accounts for 60%-80% of the total, therefore, through developing high quality and high yield cassava and sweet potato etc, the production cost can be reduced and the economic competition can be enforced.

In order to push the utilization of ethanol fuel made from amylum, in the near future, China will need to provide the producing enterprises with preferential and supportive policies. At present, the four domestic fixed fuel ethanol enterprises that depend on government's allowance keep making profits, the total allowance per year exceeds 20 million. In order to stimulate ethanol-producing enterprises to reduce cost as well as to alleviate national financial burden, the allowance given by state to ethanol producing enterprises was reduced year by year during 2005 to 2008. At the same time, we actively develop high-yield and low cost production raw material such as cassava and sorghum, we also develop and utilize the advanced production technics to reduce energy consumption and to improve the utilization ratio and utilization efficiency of material.

3.2 Making fuel ethanol from glucide material

3.2.1 Glucide material

Glucide material that can be used to produce fuel ethanol mainly consist of sugar cane and sweet grain sorghum.

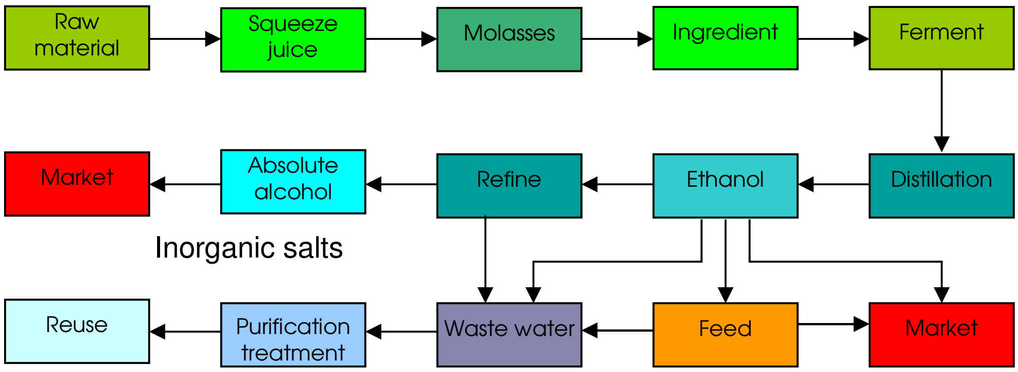
Sugar cane is the glucide crop that is suitable to be planted in tropic and semitropical areas and it's mainly used for producing glucide. In the recent decades, sugar cane was used in Brazil for large-scale fuel ethanol production.

Sometimes molasses was used for fuel ethanol producing. In the recent years, the planting area of sugar cane in China is approximately 1.20 million hectares with an annual output of nearly 90 million tons. These sugar canes were basically used for producing saccharose. At present, the output of sugar cane stems is about 75 tons per hectare that can produce 8 tons of fuel ethanol. China has already cultivated 3 kinds of energy source sugar cane breeds and the output of sugar cane stems reached 121-130 tons per hectare. Thus, in the future each hectare of sugar cane can produce 11-14 tons of fuel ethanol.

Sorgo is one of the varieties of common grain sorghum, and its stem contains a great deal of sugar juice that can be used for fuel ethanol producing. Sorgo is able to bear drought, water logging and salt. It has a strong adaptability to soils. At present, sorgo is planted in Beijing, Tianjin, northeast part of China and Inner Mongolia etc. It is mainly used as dairy cow feed and the material for sugar and wine production. In the recent years, domestic institutions and enterprises began to research on making ethanol from sorgo's stem and made remarkable progresses in fine breeds cultivating and process technology. The series of "pure sweet sorgo" cultivated in China can get the same good harvest when planted in the soil which contains 3-5‰ salt compared with good soil, and each hectare of sorgos can produce 4-6 tons of fuel ethanol.

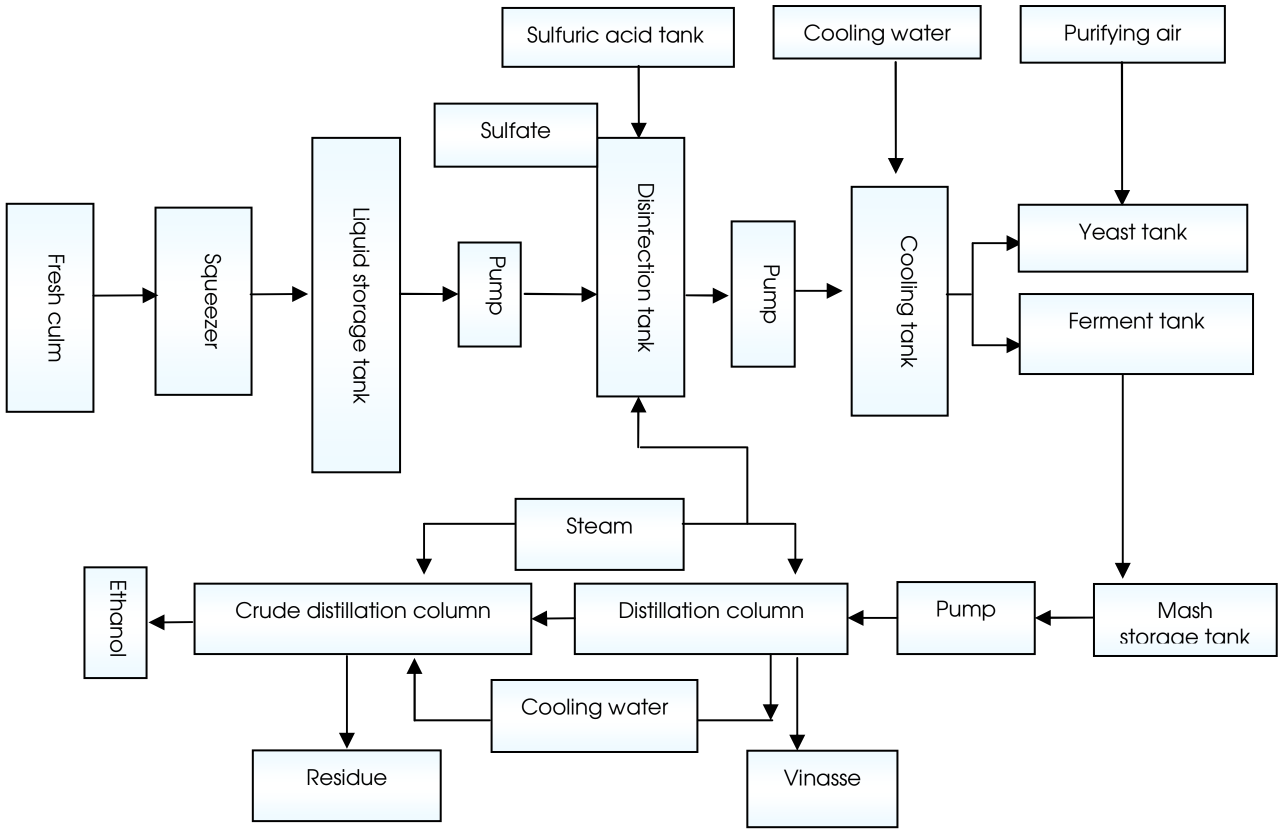
3.2.2 Technics of making fuel ethanol from glucide material

The sugar that glucide material contains is mainly saccharose. It can be hydrolyzed to grape sugar and fruit sugar by microzyme, saccharose can produce ethanol by fermenting grape sugar and fruit sugar in the oxygen-free conditions. Therefore, the technics of making ethanol from glucide material and amylum material are basically the same except the pretreatment methods before fermentation are different and the subsequent processes are basically the same.



General process flow of making fuel ethanol from glucide material

At present, the whole world has developed the technological procedures of making ethanol from sorgos' stem, the main processes consist of Mechanical press, Acidification antisepsis, Cooling, Ferment and Distillation etc, refers to the chart below.



The flow chart of making ethanol from sorgo

Compared with amylum material, the fermentation of glucide material lacks saccharifying procedures and the subsequent processes are basically the same, so the key technology lies in solving the problem of high energy consumption of distillation and rectification. But, there are some differences in the aspect of specific process details. In fact, the fermentation efficiency of amylum material is 5-7% higher than glucide material. In normal conditions, the fermentation efficiency of amylum material can reach 90% while the ferment efficiency of glucide material can only reach 85%.

3.2.3 Utilization status of technology of making fuel ethanol from glucide material

At present, the technology of making fuel ethanol from sugar cane and molasses is very mature and it has got a long commercialized application in Brazil. In China, except the technology of making fuel ethanol from sugar cane, the main focus is on the technological procedures of making fuel ethanol from sorgo's stem. In the early 1980ies, people began to use sorgo's stalk to produce liquor in Henan, Liaoning and Inner Mongolia etc. In the middle of 1980ies, Shenyang Agricultural University worked on how to use the juice of sorgo's stalk to produce ethanol and did some experiments using ethanol as fuel of gas engine and got valuable experience. In

1996, The Ministry of Science and Technology of the People's Republic of China supported to establish "The commercialized demonstration engineering of development and comprehensive utilization of high energy crop sorgos" in Hohhot, Inner Mongolia and has set up a production line based on making ethanol from sorgos' stalk. This has passed the check in December 1996 and created favorable conditions for popularizing the technology of making fuel ethanol from sorgos and its comprehensive utilization. Until 2001, the sorgo breeding has entered the substantive popularization stage while production technology of fuel ethanol entered the demonstration engineering construction stage with an output of 5000 tons per year.

"precocious number 1" sorgo production base

Brut distillation workshop of making fuel ethanol

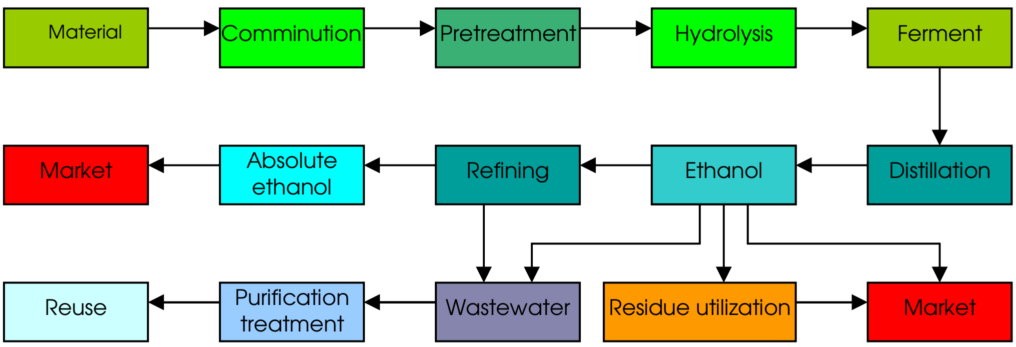
3.2.4 Technology and economy brief assessment of making fuel ethanol from glucide material

In countries such as Brazil, which possess superior natural condition and high productivity of sugar cane, sugar cane fuel ethanol has already completely realized its commercial production application and has the ability to compete with gasoline material. Nowadays, although there is no ethanol production enterprise in China which puts sugar cane ethanol into production, related reckoning shows that its production cost is lower than corn fuel ethanol. But due to the deficiency of saccharose supply and long term import needs, the key development direction of glucide fuel ethanol needs to turn to sorgo fuel ethanol. According to estimations, the production cost of sorgo fuel ethanol is about 4000 RMB per ton. Under the support of certain fiscal levy preferential policies, it is possible to realize its commercial application in the near future.

3.3 MAKING LIQUID FUEL FROM CELLULOSE MATERIAL

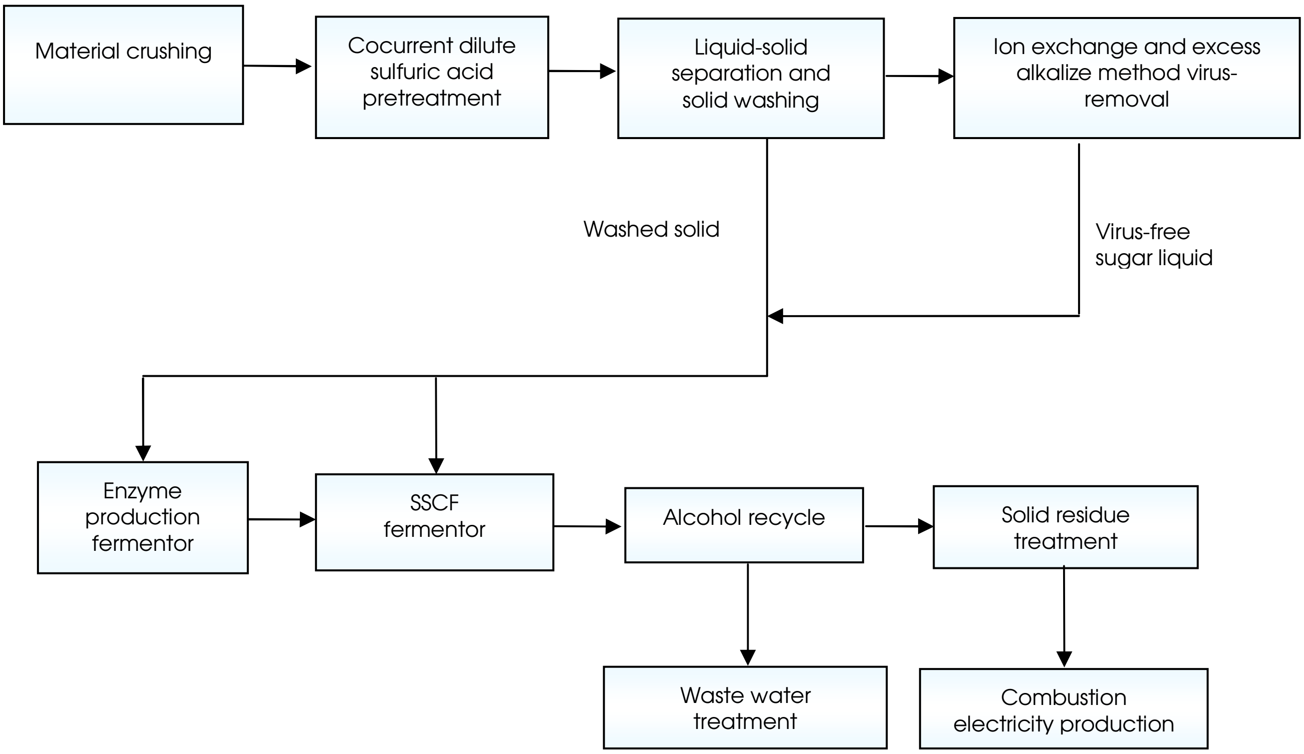
3.3.1 Technics of making liquid fuel from cellulose

The general process flow of making fuel ethanol from cellulose material refers to the chart below. It mainly consists of Pretreatment, Hydrolysis and Fermentation. The difference of the processes of making ethanol from various kinds of cellulose material just lies in the processes of pretreatment and hydrolysis before fermentation. The working procedures are basically the same after fermentation. Pretreatment comprises physical, chemical and biological methods, to diminish the granularity of biomass material and increase the contact surface to enzymes, demolish the crystal structure of cellulose, which is good for highly efficient hydrolysis. The hydrolysis process uses acid hydrolysis or enzyme hydrolysis methods to hydrolyze cellulose material (from pretreatment) to monosaccharide material such as yeast or bacteria that can be used for ethanol producing. The technics of acid hydrolysis is very easy, the material treatment time is short, but the yield of sugar is very low and it can generate byproduct that is difficult to ferment. Enzyme hydrolysis is a bio-chemical reaction that microorganism cellulose enzyme degrades cellulose. Its merits are: the reaction is carried out under normal temperature, low energy consumption, the output of sugar is very high (more than 95%), low pollution, but the process time is long (generally several days), the production cost of enzymes is high while the pretreatment cost of material for hydrolysis is very high.

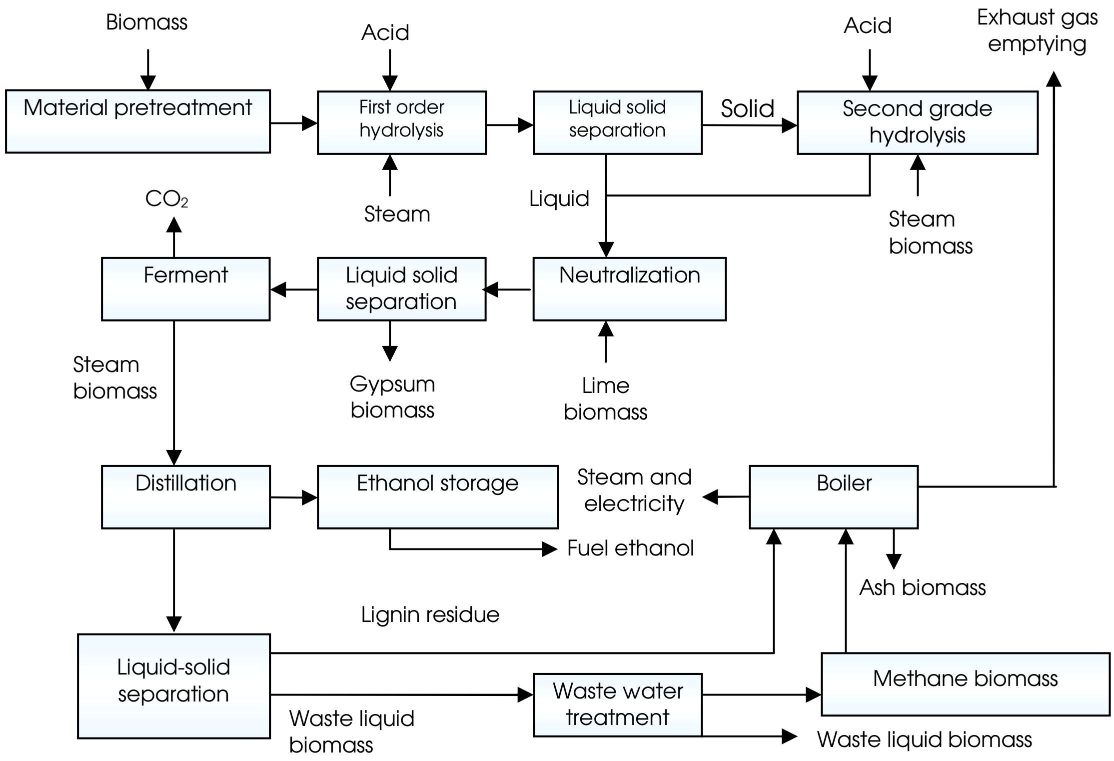


The general technological process of making fuel ethanol from cellulose material

In order to reduce the production cost of ethanol, the technics of saccharifying and fermentation (SSCF) has been developed in the 1970ies. It became a promising technique that uses biomass to make ethanol. The main problem is the matching between hydrolysis and fermentation conditions.



The flow chart of SSCF enzyme hydrolyzing ethanol



The technological process flow chart of second grade dilute acid hydrolysis

3.3.2 Research and development status and prospect of the technology of using the cellulose material to make liquid fuel

At present, cellulose-ethanol production technology is in the Research and Development demonstration stage internationally and has not realized its commercial application. China began its research in the 1950ies through introducing technologies and autonomous exploitation. It has expanded its research focused on making ethanol from woody scrap and cottonseed shell in Heilongjiang Nancha Timber factory. Suzhou grease chemistry factory and Beijing Guanghua Timber factory have acquired several achievements. Since the 1990ies, with the implementation of the national high tech “863” plan and the start-up of engineering of national ethanol gasoline substitute fuel, it has greatly stimulated the Research and Development on plant fiber for cellulose fuel ethanol. Up to now, the national 863 key task “Technology of making ethanol from cellulose waste” is assumed by East China University of Science and Technology. Making fuel ethanol through an organic combining of bio-chemical method as well as heat transformation method and the test scale has already reached 600 tons. The China National Petroleum Corporation has carried out an industrialized demonstration project research demonstration focusing on using corn stalk as raw material to make fuel ethanol in Jilin Fuel Corporation with an annual output of 3000 tons ethanol. Henan Tianguan Group Co. Ltd cooperates with Shandong University and Henan Agriculture University and reached a small breakthrough in the aspect of cellulose material pretreatment and technology development of ethanol transformation. The work ready to be done is the industrial transformation of cellulose enzymes. The BBCA Group works together with domestic related junior college academies and acquires preliminary achievements in raw material pretreatment and the cultivation of cellulose enzyme. Besides that, there are many institutions and units (such as Nanjing University of Technology and Tsinghua University etc) which are actively carrying out this research. But, this technology is not mature yet. There are still many key technical problems to be solved. However, compared with foreign countries, the gap is small and prospects are very good.

3.4 Making biodiesel from oil plants

3.4.1 The introduction of oil plants

➲ ***Cole***

The main producing areas of cole in China are centrally located in the regions along Yangtze River valley such as Sichuan, Hubei, Hunan, Jiangxi, Anhui, Jiangsu, Zhejiang as well as Yunnan and Guizhou which are located in the southwest of China. Among them the planting area and output of cole in Hubei province are all ranking in the first place of China. At present, the planting area of cole in China is about 1.2 million mous The output of rapeseed is approximately 12 million tons annually, with more than 90% used for making edible oil, with an annual output of rapeseed oil of about 4.5 million tons, ranking in the first place of the world. There are some experts proposing to use the glebe of central China and south China as well as southwest China to develop cole planting for energy use in winter seasons. At present, the average output of rapeseed in China is 100 kilograms per mou, with an oil extracting rate of 35%. With the improvement of breeding level and planting technology, it is hopeful to get an output of 150 kilograms per mou with an oil extracting rate of 40%.

➲ ***Ricinus***

The main producing areas of ricinus in China are located in the regions of the east of Inner Mongolia, the north of north China and northeast Among them, the region of Tongliao in Inner Mongolia, Baicheng in Jilin province and Shandong, Shanxi are the main producing areas of ricinus. The average output of ricinus is about 150 kilograms with oil-bearing rates of about 50% in seeds, 65% in seed kernels. Castor oil has a wide application in the field of modern industry and a big potential of market development with many good characteristics such as large viscosity, high specific weight, as well as reduced solidification at low temperatures.

➲ *Jatropha curcas (little kiriko)*

Jatropha curcas is suitable to grow in the dry-hot valley regions. Asia is the Proterozoic and the world distributing center of jatropha curcas. In China, jatropha curcas is mainly distributed in Sichuan and Yunnan provinces. Jatropha curcas grows fast with strong vitality and high yield, the average fruit yield of a 5-year old forest stand jatropha curcas can reach 300-500 kilograms per mou, the average oil-bearing rate of fruit is above 40%. The oil-bearing rate of seeds can be more than 60%.

Fruits of jatropha curcas

Jatropha curcas

➲ *Pistacia chinensis*

Pistacia chinensis is distributed in north China, central China, south China and southwest China. It has a long life-span and full fruit period. For an adult tree, the fruit yield can reach 50-150 kilograms per plant, with peaks at 250 kilograms. The oil-bearing rate of pistacia chinensis seed is 43%; pistacia chinensis is an important woody oil tree species in China.

➲ *Tungoiltree*

Tungoiltree is mainly distributed in Sichuan, Guizhou, Hunan, Yunnan, Guangxi provinces. Sichuan and Guizhou provinces have the largest planting areas and approximately account for 50% of the total area nationally. The full fruit period of tungoiltree is 6-30 years after the seeds are seminated. The yield of a 10-year old tungoiltree can reach 45 kilograms. In the recent years, the yield of tungoiltree in China keeps 80-120 thousand tons and China is the main production country and main export country of tungoiltree in the world. The oil-bearing rate of tungoiltree seed is 33%-71%. Tung oil is not easy to rot and there are no restrictions on the transport and storage conditions of tung oil.

➲ *Wilson dogwood*

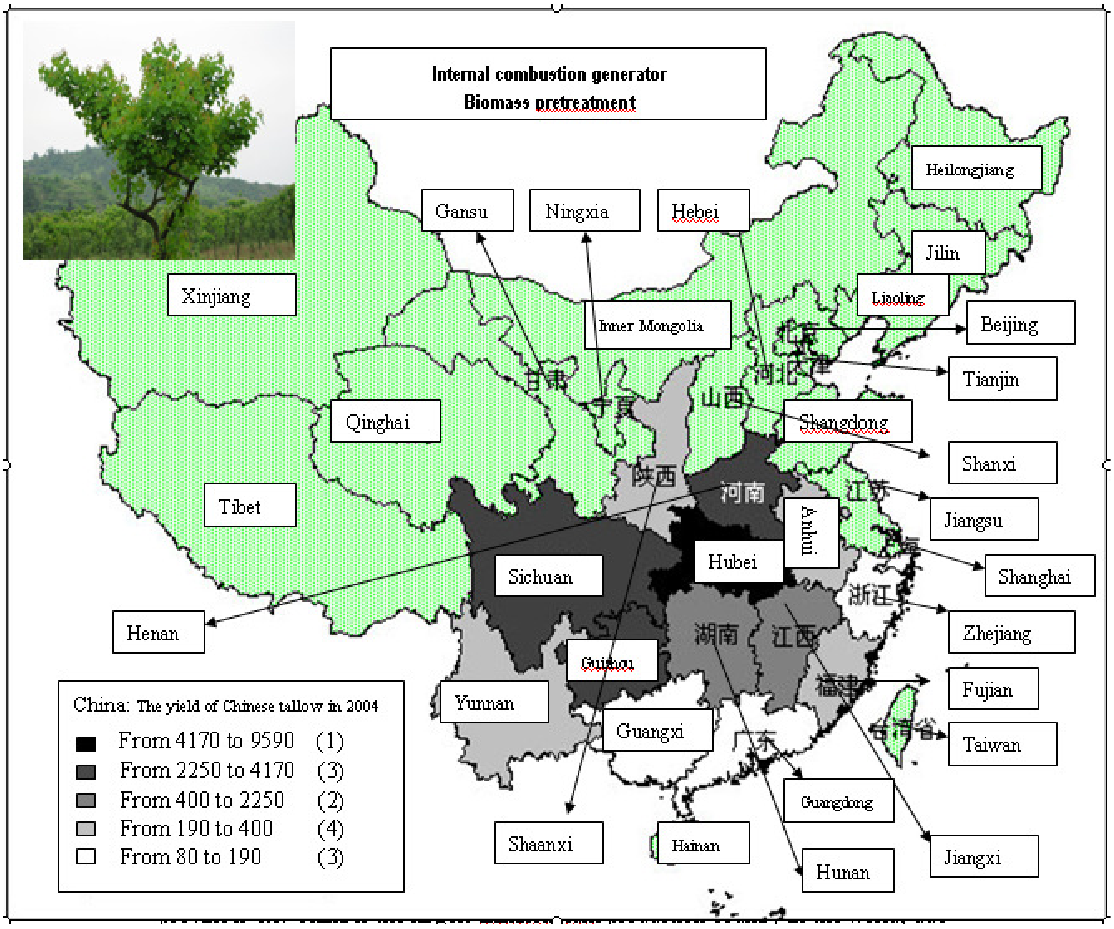
Wilson dogwood is originally planted in China and it is mainly distributed in the south part of Yangtze River valley and the southwest provinces of China, mainly distributed in Hunan, Jiangxi, Hubei. Wilson dogwood is suitable to grow in the limestone mountains. It resists Alkali, drought and barren soils and seedlings begin to fruit after 5-7 years. The oil-bearing rate of fruit is 33%-36%, the yield of fruit can reach more than 45 kilograms per plant in full fruit period.

➲ *Xanthoceras sorbifolia*

Xanthoceras sorbifolia is a special tree species in China, it is mainly distributed in the northwest region of China It has a strong adaptability to drought, barren, and alkali conditions. Xanthoceras sorbifolia bears fruits early, and the fruit-bearing rate of a five-year old orchard can reach 95%. Domestic data shows, "the seed yield of a 10-year old individual plant is about 5 kilograms; for a 30-year old individual plant, the seed yield is 20-35 kilograms, ripening period can last for more than 100 years". The oil-bearing rate of Xanthoceras sorbifolia is 30.4%. For seed kernels, the oil-bearing rate can reach 66.4%. Xanthoceras sorbifolia is an important oil woody tree species in the north part of China. At present, the artificial cultivated area of Xanthoceras sorbifolia is less than 10 thousand mou, and the development potential is huge.

➲ *Chinese tallow (wax subtree, woody oil tree)*

Chinese tallow is originally planted in China and is widely distributed, from the north part like Shandong to the south part like Taiwan, Guangdong and Yunnan provinces. The yield of Chinese tallow in Zhejiang province accounts for 1/3 of the total yield of China and its fruit quality is the best. Chinese tallow begins to bear fruits 3 years after field planting. 6 years later, it enters into its rich-in period, with an output of 350 kilograms per hectare. The seed of Chinese tallow also named white wax fruit, the oil-extracting rate of seed can reach more than 40%.



➲ *Zanthoxylum*

Zanthoxylum is a special season spice of China. The main producing areas are located in Sichuan, Shanxi, Hebei, Shanxi, Henan, Hubei, Guizhou and Gansu provinces. China is the largest Zanthoxylum production country in the world, due to the increasing export quantity of Zanthoxylum in recent years. The planting area of Zanthoxylum rises sharply. As it is investigated that in the main producing areas the average output of dry Zanthoxylum can reach 100 kilograms, with 55 kilograms of by product prickly ash seed. The oil bearing rate of Zanthoxylum can reach 25%-33%. The output of by product Zanthoxylum in China is more than 300 thousand tons annually, and the potential use for biomass energy development is huge.

➲ *Oil-tea camellia*

Oil-tea camellia is a Chinese specialty of woody edible oil tree and it is widely distributed in the regions along the south part of Yangtze River. Hunan, Jiangxi, Guangxi, Zhejiang and Fujian provinces are the main producing areas. The seed kernel of oil-tea camellia is about 45%, and the average tea oil output of oil-tea camellia forest is about 150 kilograms. At present, the oil tea seed is mainly used to extract edible oil.

3.4.2 Technics of making bio diesel oil from woody oil plants

Bio-diesel refers to fatty acid alkyl lipid, which came from transesterification reaction that uses fatty acid and alcohols (mainly alcohols) of animal and plants oil. The key challenges for production technology developments are to reduce the investment and production cost of bio-diesel production equipment, to reduce environmental pollution, and to adapt the process to other raw materials, as follows:

- Solvent's strengthening transesterification technology is adopted. This technology can dispose a wide source of raw oil including plant and animal oil with high acid value through introducing reactionless cosolvent in the transesterification reaction which greatly accelerated the reaction speed.
- The supercritical reaction's strengthening transesterification technology is adopted. Adding pressure and improving the reaction temperature are both important means to strengthen the reaction. With the temperature goes further high, when the temperature of reaction system is close to methanol's critical point, the mass transfer and reaction properties between reactants get obvious aggrandizement. Even if no catalyzer exists, transesterification can also goes smoothly. This technics can be used to process raw material with high acid value. Moreover, the post-treatment is easy and there is reduced waste emission.
- Solid base catalysis technology. Solid base catalyst stands for the important direction of recent research and development. It can solve the problem of the separation between outcomes and catalyze, due to the adoption of solid base catalyst, the waste emission is greatly reduced. But the solid base catalyst is sensitive to both free fatty acid of oil and water, the life span of catalyst is generally short, it's hard to meet industrialization's demand.
- Enzymatic catalysis transesterification technology. Enzyme catalyst is another important transesterification catalyst. Its merits are: transesterifications of triglyceride and free fatty acid proceed at the same time. This can process high acid value material; the concentration of by product glycerol is high and the

catalysis can be used repeatedly. Its shortcomings are: the cost of enzyme catalyst is high, enzyme catalyst is easy to lose its activity, it has a short life-span. The reaction temperature of enzyme catalyst is mild. The direction of research for enzyme catalyst must be reducing the cost of enzyme, improving the conversion rate of transesterification.

3.4.3 Utilization status of technology of making bio-diesel from woody oil plants

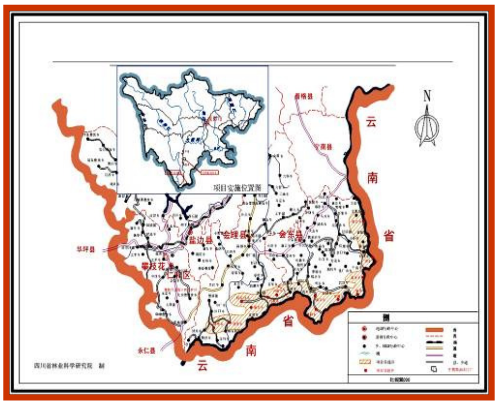
At present, the development and research of making bio-diesel from woody oil plants has already acquired preliminary achievements. The research contents involve: the filtration of oil plant, good varietal selection and cultivation as well as its process technics and equipment. The technology of transforming the seeds of little kiriko and pistacia chinensis as well as Wilson dogwood into bio-diesel is especially mature. Some enterprises have already entered into the field of utilization of bio-diesel.

Hunan Academy of Forestry and Hunan Tianyuan Bio clean Energy Co. Ltd have established a production line with capacity of 20 thousand tons of bio-diesel annually using Wilson dogwood oil and vegetable oil leftover as raw material. The Chinese Academy of Forestry has established an integrated line with capacity of 500 tons of bio-diesel and chemical products. Hainan Zhenghe bio-energy corporation and Sichuan Gubin grease chemical corporation as well as Fujian Excellence Biomass Energy Co, Ltd have already developed technology owned freedom property. The production line of bio-diesel with capacity of more than myriad 10 thousand tons will be built successively. Sichuan University and Sichuan Yangtse River afforestation Bureau as well as Sichuan Academy of Forestry work together and focus on how to transform jatropha curcas to bio-diesel and its comprehensive utilization.

They have developed the technology of using a two-step transesterification method to produce bio-diesel and established Medium Stage Test Workshops with a capacity of 200 tons per year. The B-15 mixed diesel oil they produced has passed 15 thousand kilometers driving test of diesel engine. The B-20 little kiriko bio-diesel complexed by microemulsion composite additive has been used in the diesel oil public automobiles of Chengdu Public Transportation Corporation. The diesel engines run reliably. It has reached the standard of zero-sized diesel oil.

The bio-diesel extracted from little kiriko by Guizhou University has passed the test of German relative corporation's test and it shows that 5-10% little kiriko bio-diesel oil can be added to normal diesel oil for mixed use. Guizhou Zhongshui energy development limited corporation bought solid phase catalytic technology which has its own intelligent property right possessed by Guizhou University. The medium test production line built presently can operate smoothly with capacity of 300 tons of little kiriko bio-diesel per year and its production of bio-diesel has passed the test of Europe Union bio-diesel's standard requirements and its property is super to the zero-sized diesel oil significantly.

The medium test device of physic nut bio diesel with capacity of 200 tons per year



The position schematic diagram of physic nut resource high efficient cultivation and its bio diesel industrialization demonstration project in Sichuan province

3.4.4 Technology of making bio-diesel from oil plants and its economical brief comment

At present, we still lack data for economical analysis and cost estimation of making bio-diesel from woody oil plants. We only have a rough estimation according to the Tanezane yield, price, oil-bearing rate of several kinds of tree species that are suitable to making bio-diesel. The following are the 3 kinds of cost estimation of making bio-diesel from oil tree that have been successfully used for making bio-diesel.

Little kiriko: the oil-bearing rate of little kiriko seeds is 30-60% and the output of seed is 300-500 kilograms per mou. Calculate according to seed output of 300 kilograms per mou with 40% oil-bearing rate, the raw oil processing rate is 95% with seed's price of 1.2-1.5 RMB per kilogram and the income of seed per mou is 360-450 RMB.

We can get 100-110 kilograms raw oil through processing 300 kilograms kiriko. Calculate according to 3 tons of little kiriko for 1 ton of raw oil, the production cost of raw oil is about 4100-5000 RMB per ton. The processing cost through raw oil to diesel oil is 1000-1200 RMB per ton. The production cost of little kiriko bio-diesel oil therefore is estimated at 5100-6200 RMB per ton.

Pistacia chinensis: the oil-bearing rate of pistacia chinensis seed is 35-50% and the seed output is 200-600 kilograms per mou. Calculate according to 300 kilograms seed per mou with 40% oil-bearing rate, the raw oil processing rate is 95%, seed's price is 1.5-1.6 RMB per kilogram with seed income of 450-480 RMB per mou.

We can get 100-110 kilograms raw oil through processing 300 kilograms pistacia chinensis seed. Calculate according to 3 tons of pistacia chinensis seed for 1 ton of raw oil, the production cost of raw oil is 5000-5300 RMB per ton (raw material cost 4500-4800 plus processing cost 500 RMB) with the processing cost from raw oil to diesel oil of 1000-1200 RMB per ton. The production cost of pistacia chinensis is 6000-6500 RMB per ton.

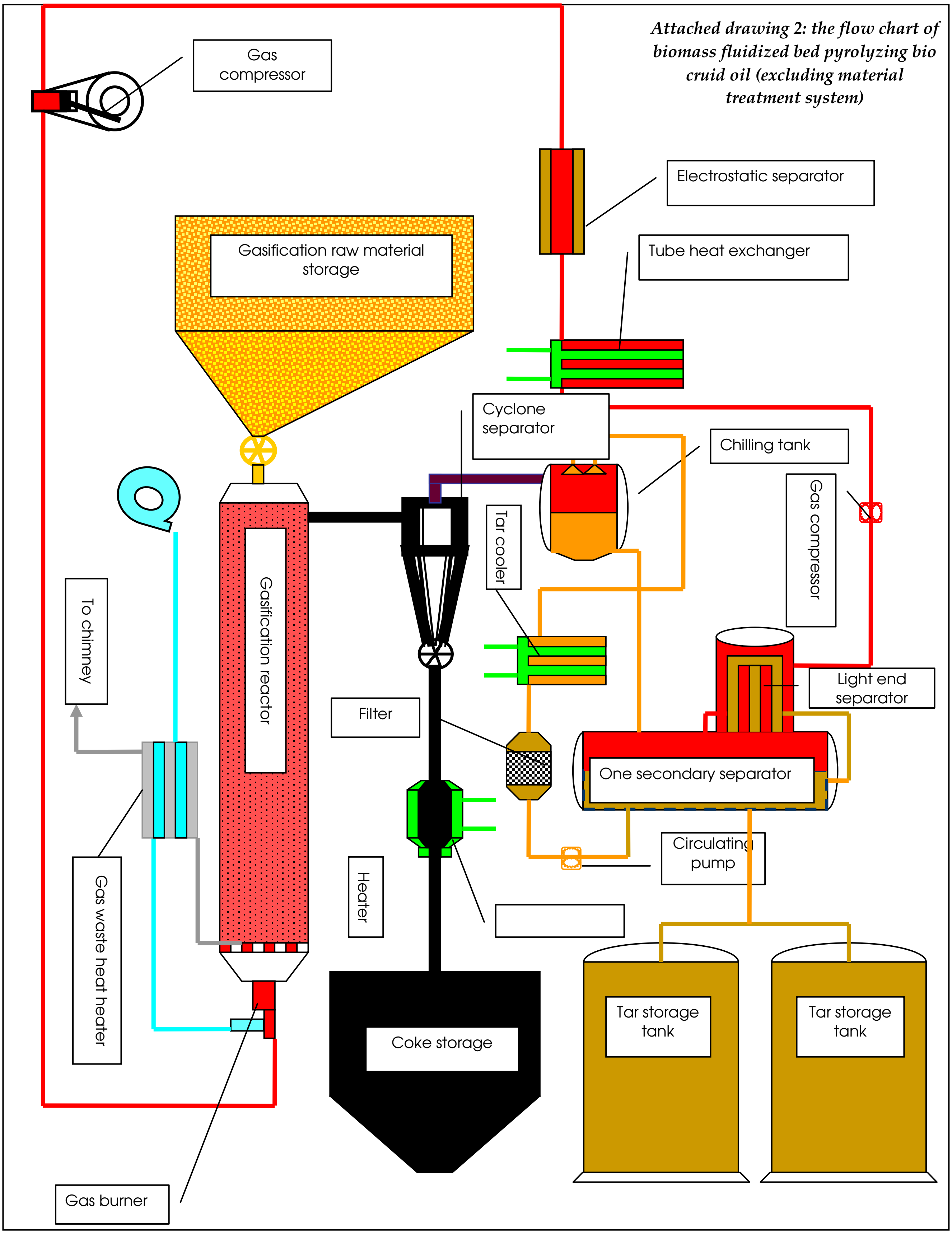
Wilson dogwood: the oil-bearing rate of Wilson dogwood fruit is 30-40% with an output of 200-700 kilograms per mou. Calculated according to 300 kilograms seed per mou with 35% oil-bearing rate, the raw oil processing rate is 95% and the price of seed is 1.2 RMB per kilogram with the income of seed 360 RMB per mou.

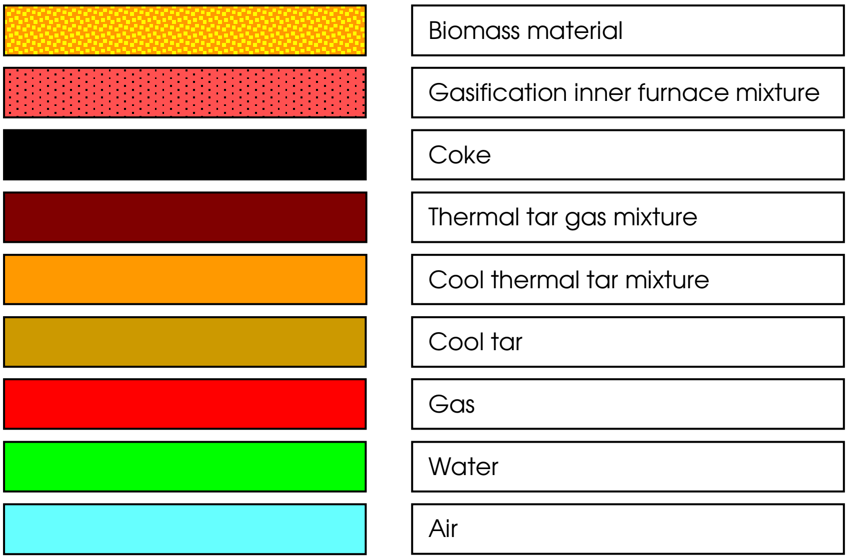
3.5 Making bio-oil from agroforestry surplusage pyrolytic

3.5.1 Technics of making bio-oil from agroforestry surplusage pyrolytic

Crop straw and forestry waste as well as waste from wood processing factories etc biomass material were pyrolyzed rapidly in fluidized bed gasifier. The mixture of wood coke and bio-oil and as well as biomass flammable gas which came from cracking will be separated, wood coke and bio-oil will be sold out as product after recovery while biomass flammable gas will provide heat source to fluidized bed gasifier. The whole process is divided to material treatment, gasification, separation of gas and liquid, reuse of gas, water circulation and automatic control etc subsystems, the process flow refers to chart below.

Attached drawing 2: the flow chart of biomass fluidized bed pyrolyzing bio cruid oil (excluding material treatment system)





3.5.2 Utilization status of making bio-oil from agroforestry surplusage pyrolytic

In the recent years, the Chinese government pays much attention to the development of bio-diesel. In 2004, new and high technology and industry division of Ministry of Science and Technology started up “the fifteenth” national science and technology tackling key problems plan, item of “technical development of bio-diesel”. In 2005, national special agroforestry biomass engineer and replacement fuel development strategy research was started. In May, 2005, national 863 plan the field of biology and modern agriculture technology decided to start up the item of “technology development of biomass energy and its industrialization” in advance.

In China, although the research on wood pyrolytic technology started early, it proceeds slowly, restricted to the stage of test and research. At present, domestic technology of making bio-oil from agroforestry surplusage pyrolytic is only applied in the University of Science and Technology of China with a capacity of 120 kilograms per hour.

3.5.3 Technology and economy brief assessment of making bio-oil from agroforestry surplusage pyrolytic

At present, the commercial device that successfully developed and built by Canadian Damao Corporation has been put into production, with a capacity of 100 tons of bio-material daily. The commercial device with a treatment capacity of 200 tons of bio material is in construction. The fuel heat value of biomass produced by this technology is 4500－6000 kcal/kg. The water-bearing rate is high, thus it can only be used as fuel oil. The PH value of fuel oil can reach 2-3, and it will have a corrosive effect to equipment for direct use. It is acknowledged by test research, when bio fuel oil is mixed with heavy oil with mixing proportion less than 15%, the effects to equipment can be neglected. But it still lacks the support of long-term test data.

According to the economical analysis results of the technology developed by Canadian Damao Corporation, the production cost of fuel oil and the price of heavy oil are almost the same (calculated according to the same heat value), but with the rising of biomass material price, the project economy is at risk. If it can get the support of finance and taxation policy, this technology has intensive market competitiveness.

4.0 INDIA

4.1 Modern agro-forestry systems in India

The production strategy with respect to land-use patterns has not changed and modern plantations have maintained their traditional characteristics at the same time being adapted to commercial applications. Examples include mono-cultural production of crops like teak and Eucalyptus. The modern agro-forestry practices which evolved are not only commercially oriented but aimed to meet specific needs. Modern agro-forestry systems could be adapted for multiple uses such as shade, fodder, fuel-wood, fruits, timber, industrial raw materials like oils and drugs, gums, medicinal plants and most importantly their importance as biofuels.

➲ *Agro-silviculture system*

Under the modern agro-silviculture practices, two types of systems can be identified. In one case farmers grow trees in and around fields where they grow food crops and in the other case, trees are grown in farms where the main product is a commercial crop. The trees are grown in agricultural fields, on farm boundaries or as separate woodlots. These include *Prosopis cineraria, Zizyphus nummularia*; *Eucalyptus globulus, Jatropha curcas,* etc. Among the plantation trees which are grown on farm boundaries, Eucalyptus species are the most prominent and popular. They are grown on field boundaries and terrace risers. The trees are grown primarily for harvesting leaf to extract Eucalyptus oil.

➲ *Plantation crop combinations (commercial crops)*

This includes the following:

- Integrated multi-storey (mixed, dense) mixtures of plantation crops.
- Mixtures of plantation crops in alternate or other regular arrangement.
- Inter-cropping with agricultural crops.
- Shade trees for plantation crops and shade trees scattered. Three practices are identified shade trees may be planted for growing a plantation crop (e.g. tea, coffee), shade may be provided to a plantation crop (e.g. Cacao) by a commercial tree crop (such as coconut or arecanut); shade may be provided by trees in a natural forest to a commercial crop. (e.g. small and large cardamom).

➲ *Silvo-agriculture practices*

Two types of silvo-agriculture practices are identified. In one case farmers grow agricultural crops with commercial trees-the latter component being more dominant and more valuable. In the second type, the forest dwellers, the farmers and the forest departments, use forests to grow crops and to extract NTFPs. Growing of commercial trees is a very important cash cropping practice. These trees are usually widely spaced and planted in rows and lines. Till they grow and cover the entire land, it is possible to raise agricultural crops in the interspaces. As a consequence, raising of agricultural crops with commercial tree crops is a very widely practiced system. Crops are being grown with short-rotation (poplar and Eucalyptus) and long rotation commercial forest tree species, like teak. The practice of growing annual or relatively short duration crops in the interspaces of perennials is referred to as *intercropping*; whereas growing other perennials in the interspaces of perennials is called *mixed cropping* in India. Mixed cropping of arecanut with coconut, citrus, jack fruit, and other perennials is also practiced.

➲ ***Alley cropping (hedge-row intercropping)***

It is a promising agro-forestry technology for the humid and sub-humid tropics, which has been developed during the past decade. It entails growing food crops between hedgerows of planted shrubs and trees, preferably leguminous species. The hedges are pruned periodically during the crop's growth to provide biomass (which, when returned to the soil, enhances its nutrient status and physical properties) and to prevent shading of the growing crops. Alley cropping is, thus, a form of the so-called hedgerow intercropping, and combines the regenerative properties of a bush fallow system with food-crop production. Hedges of *L. leucocephala* and Eucalyptus trees are intercropped with cassava, groundnuts, and vegetables.

4.1.1 Features of modern agro-forestry practices

Short duration non-edible oil crops like castor (Ricinus conmunis), linseed, and mesta are grown as inter-crop, catch crop, alley cropping, border-crop plantations in a cropping system. In marginal lands, castor yields 1.0 to 1.5 tons per hectare with more than 50% oil content. Among the oil bearing trees/shrubs, Pongamia and Jatropha are also grown as multi-storey planting in wastelands. *Pongamia pinnata* is planted in 10 meter alleys and in the same alleys *Jatropha curcas* is planted at 2*2 meter distance. Jatropha and Pongamia can also be grown as block plantations. It has been demonstrated that the interspaced area of Jatropha could be utilized for growing various intercrops and additional income can be generated. Seed production of Jatropha ranges from about 0.4 tons per hectare per year to over 12 t /ha. The experience in India and elsewhere shows that a plant density of 2500 per hectare has been found to be optimal. One hectare of plantation on average soil will yield on an average 2.6 t of oil.

4.1.2 Geographical spread

Poplar based agro-forestry systems with short rotations (6-8 years) are spread over the "Terai" belt of U.P., Punjab and Haryana. Poplar plantations are now being established every year under agro-forestry. Alley cropping is carried out in parts of Southern India. Jatropha cultivations have been carried out in Andhra Pradesh, Punjab, Chattisgarh and Tamil Nadu. Approximately 40 million hectares of land spread out in 23 states and Union Territories in India have been considered as potential areas for Jatropha cultivation. While Jatropha curcas cultivation attempted in Maharashtra and Andhra Pradesh on a commercial scale did not succeed due to poor yields of less than one kg of seed per plant, its use as a bio-fence in tribal areas and as a species for soil conservation in degraded lands of Jhabua area of Madhya Pradesh was significant. Pongamia pinnata is widely prevalent in Andhra Pradesh, Karnataka and Tamil Nadu states.

4.1.3 End-uses of modern agro-forestry practices

These include:

- ***Food:*** Modern cultivation practices besides yielding fruits also yield commercial crops like *Moringa oleifera*, *Mangifera indica, Morchella esculenta (*mushrooms*)* and nuts, etc. for food-processing industries.
- ***Industrial raw materials:*** These include gums (e.g. *Acacia nilotica*), resins (e.g. *Pinus roxbergii*), wood for craft purposes, bamboo, fibre, spices, drugs, oils, medicinal plants, etc.
- ***Fuel, timber, fodder, reclamation of degraded soils and shade:*** The tree species that are commonly used for amelioration of degraded soils include Prosopis juliflora, Acacia nilotica, Parkinsonia aculeata and Eucalyptus tereticornis.
- ***Carbon storage:*** Like all trees, Jatropha removes carbon from the atmosphere, stores it in the woody tissues and assists in the build up of soil carbon. It is thus environment friendly. Additionally carbon is also sequestered in the plant biomass at an estimated rate of 8 t/ha under high density plantations.

4.1.4 Bio-fuel component of modern agro-forestry practices

Among the crops grown under modern energy plantations, oil bearing trees like Jatropha and Pongamia hold the maximum potential for production of bio-diesel. *Jatropha curcas (physic nut)* is a quick maturing perennial shrub species that starts bearing fruits within a year of its planting and the oil can be blended with petroleum diesel, following a process of extraction and trans-esterification. It is also not browsed by cattle and so its plantation can be easily undertaken in the fields and their boundaries, and wastelands.

A Committee on 'Development of Bio-fuels' was constituted in July 2002 under which Jatropha plantation is promoted for production of Biodiesel. 400,000 ha has been phased in 3 years, i.e. 80,000 (2006-07), 160,000 (2007-08), 160,000 (2008-09) promoted by the Government. Plantations would be raised through SDA, Forest, Horticulture and Panchayati Raj. With a view to substituting diesel for biodiesel, the Government of India has launched the National Mission on Biodiesel.

Various initiatives have been taken by the State Governments. In Andhra Pradesh., the Government has proposed plantation targets along with supplying Jatropha seeds to the farmers and encouraging land development through pit digging, bunding, wasteland utilization, etc. Natural Bioenergy Limited (NBL), a joint US-Austrian private venture, has been granted 120,000 ha in the state for Jatropha cultivation (Gonsalves, 2006:30). NBL's first biodiesel plant in Kakinadad, Andhra Pradesh started commercial production in October 2007 (with a capacity of 100,000 tonnes per annum).

➲ ***Bio ethanol from sweet sorghum***

India has made it mandatory to blend petrol with bioethanol. A large volume of ethanol is needed to meet current and future blending requirements. In India molasses (a by-product of sugarcane after the extraction of sugar), the traditional source of raw material for ethanol production, is unlikely to meet the demand in the long run. Molasses-based ethanol distilleries operates only for 180 days a year (during the sugarcane crushing season), i.e. at 50% efficiency due to lack of supply of feed stock.

Sorghum [Sorghum bicolor (L) Moench] is considered to be one of the most important food and fodder crops in arid and semiarid regions of the world. Globally, it occupies about 45 million hectares with Africa and India accounting for about 80% of the global acreage. Although sorghum is best known as a grain crop, sweet sorghum is similar to the grain sorghum, besides possessing sweet juice in the stalk tissue that traditionally has been used as livestock fodder due to its ability to form excellent silage; the stalk juice is fermented and distilled to produce ethanol. Therefore the juice, grain, and bagasse (the fibrous residue that remains after juice extraction) can be used to produce food, fodder, ethanol and electricity. The ability of sweet sorghum to resist draught, saline & alkaline soils and water logging has been proved by its wide prevalence in various regions of the world. The per day productivity of sweet sorghum is higher when compared to sugarcane besides a short growing period of four months and low water requirements of 8000 cubic meter that are about four times lower than that for sugarcane. Other positive aspects of sweet sorghum is its higher profitability (23% higher) than the grain sorghum under rainfed conditions in India.

Sweet sorghum juice is better suited for ethanol production because of its higher content of reducing sugars as compared to other sources including sugarcane juice. These important characteristics along with its suitability of seed propagation, mechanized crop production, and comparable ethanol production capacity vis-à-vis sugarcane molasses and sugarcane juice makes sweet sorghum a viable alternative source for ethanol production.

➲ *Multiple uses of Sweet Sorghum Crop*

In addition to sweet stalks, average grain yield of 2 to 2.5 tons per hectare can be obtained from sweet sorghum for use as food or feed. The bagasse remaining after the extraction of juice has higher biological value than the bagasse from sugarcane when used as cattle feed, as it is rich in micronutrients and minerals which is also as good as stovers in terms of its digestibility.

Sweet sorghum is more accessible to poor farmers because of its low cost of cultivation and its ability to grow in areas that receive a minimum of 700 mm annual rainfall. Secondly, sweet sorghum has a high net energy balance, 3.63 compared to grain sorghum (1.5) and corn (1.53). Even though the ethanol yield per unit weight of feedstock is lower for sweet sorghum compared to sugarcane, the much lower production cost and water requirement for this crop more than compensates for the difference and hence, it still returns a competitive cost advantage in the production of ethanol in India. It produces three valuable products: food, fuel and feed, raising smallholder incomes by about 23% in central India, while probably reducing net greenhouse gas emissions compared to fossil fuels.

➲ *Cultural Practices for Maximizing Stalk and Bioethanol Yields*

▪ Rational for development of improved cultural practices

The major constraints in sweet sorghum production include non-availability of sufficient feedstock during the crushing period for the industry. In order to meet the industry demand for raw materials especially after crushing of sugarcane crop, there is a need to develop and evaluate sweet sorghum cultivars that are photoperiod and temperature insensitive with high stalk and sugar yields. Hence evaluation of sweet sorghum under staggered planting in different seasons is urgently needed to meet the continuous supply of feed stock to the distillery.

▪ Adaptation and growing Condition

Sweet sorghum can be grown under dryland conditions with annual rainfall ranging from 550 to 800 mm. Air temperature suitable for its growth vary between 15 °C and 37 °C. Sorghum being a C4 tropical grass is adapted to latitudes ranging from 400N to 400S of the equator.

- **Integrated Crop Production /Management**

a) **Land Preparation and Manuring:** Two ploughings followed by leveling for good soil tilt. Application of 50% Nitrogen, entire Phosphorus (40 kg P_2O_2) and potassium (40 kg K_2O/ha) plus 10 tons of farmyard manure along with last ploughing.

b) **Planting time and method:** Sweet Sorghum can be grown during rainy, post rainy and summer seasons depending upon the availability of soil moisture/irrigation sources and with suitable temperature regimes.

c) **Rainy Season Crop (June-October):** Sowing should be taken up immediately after the onset of monsoon, preferably from the first week of June to first week of July. Seeds are sown in a furrow opened by the bullock drawn plough or locally available implement.

d) **Post-rainy season crop (October-February):** Planting should be done from last week of September to first week of November. Temperature should be above 15 °C at the time of sowing. The crop should be irrigated to ensure proper germination if there is no rainfall.

e) **Summer Crop:** Planting is done from mid-January to mid-March under supplemental irrigated conditions. Night temperature should be above 15 °C at the time of sowing.

f) **Seed Rate**: 8 kg/ha

g) **Soil type & Depth:** Deep black soil or red loamy soil with a soil depth of ≥1.0 m is suitable. The ideal PH range is 5.0 -8.5.

h) **Spacing:** 50-60 cm row to row distance and 12-15 cm plant to plant distance.

i) **Plant population:** 1.20 lakh plants/ha.

j) **Thinning:** Thinning operation is very essential for uniform stand establishment and growth of plants. First thinning is done at about 15 days after planting (DAP) to retain two seedlings per hill at 15 cm apart. Second thinning is done at about 20-25 DAP to retain single plant per hill.

k) **De-tillering:** The basal tillers that occur from the base of the plant should be removed manually if they occur 20-25 days from planting.

l) **Intercultivation or hoeing:** Intercultivation is done once or twice between 20 to 35 days to prevent lodging, especially after flowering

m) **Fertilizer management:** Application of 50% nitrogen, entire phosphorus (40 kg P_2O_2) and potassium (40 kg K_2O/ha) plus 10 tons of farmyard manure along with last ploughing.

n) **Weed management:** Pre-emergency spray of Atrataf should be applied on the first or second day after sowing or first irrigation. Mechanical irrigation twice up to 35-40 days age of the crop will check the weed growth.

o) **Pest management practices for Sweet Sorghum**

- Early and uniform planting of the crop
- Use of insect resistant varieties such as ICSV 700 and ICSV 93046 minimizes shoot fly and stem borer pests
- Use of intercrops such as pigeon pea and mung bean minimizes the risk of crop failure, and reduces insect damage
- Neem seed kernel extract are also used for pest management

p) **Irrigation/Rain water Management**

Rainy Season: Normally additional irrigation is not required for crops raised under rainfed conditions. In case of late onset of monsoon the crop should be planted and irrigated immediately. Soil moisture should be maintained and excess irrigated water should be drained out to prevent water logging. By and large 2-3 irrigations may be required for rainy season crop depending on the planting type soil type and rainfall distribution at a particular location.

Post-rainy and Summer Season: A total of 4-5 each are required for post rainy and summer crop. Irrigated water should be applied about 50 mm each time.

q) **Harvesting:**

Harvesting should be done at about 35-40 days after flowering of the plants i.e., at physiological maturity of the grain when a black spot appears on the grain at the lower end. Alternatively the brix of standing crop can be measured using a hand Refractometer as is done in a sugarcane crop. The methodology of pre-harvest crop quality survey and assessment as followed for sugarcane is recommended for sweet sorghum also. Harvest the crop if brix reaches 16-18%. A leaf stripper can save the cost of dethrashing in sweet sorghum.

4.1.5 Farmer-industry tie-up to raise trees on farms

As a result of the implementation of the Forest (Conservation) Act, 1980, and following the provisions of the National Forest Policy, 1998, supply of raw material from government forests to wood-based industries has gradually declined. This has forced the industry to look for alternative sources such as imports of timber and pulp, and sourcing timber through the farm forestry sector. Wood-based corporations like ITC Bhadrachalam Paperboards Limited, JK Paper Corporation Limited, and Ballarpur Industries Limited initiated tie-up with farmers by supplying seedlings to these farmers, arranging micro-credit, providing technical back-up and entering into buy back arrangements with farmers.

Because of the farmers defaulting on loans and then selling products at open markets at higher price, most of the formal arrangements have now been abandoned. The companies are now selling high quality clonal seedlings though local nurseries to the farmers and purchasing raw material from open market. Farm forestry/agroforestry is now a viable land use option in many parts of the country for farmers as it helps to diversify their income from agriculture and at the same time reducing the risk of growing only agricultural crops on their farmlands.

A notable aspect of the development in the farm forestry sector has been the investment by the companies, though only few in numbers, in research activities to develop high yielding clones and appropriate silvicultural and agroforestry practices. For instance, the annual productivity of clonal seedlings developed by ITC Badrachalam range from 20-58 m^3 per ha per year, while the productivity of seed-raised eucalyptus plantation is only 4-5 m^3 per ha per year (MoEF undated), (TERI, 2005)

4.2 Sustainable forestry management practices

4.2.1 Joint Forest Management

Joint Forest Management (JFM), introduced in 1990, has been a significant development in the context institutional arrangement to protect and manage forests in India, which were subjected to large scale degradation due to increasing stress from human and livestock populations. A collaborative arrangement between the forest department and local communities is a remarkable example of policy working for both people and forests. The socio-economic incentives and forest development have been instrumental in eliciting people's participation in managing forests, which are owned by the state. The relationship between the Forest Department and the JFMCs are formalized through a Memorandum of Understanding. Till 2005, around 100000 JFMCs have been constituted under the JFM framework in 28 states and Union Territories.

4.2.2 Positive Impacts of JFM

The program has brought a large change in the people's right over forest products like NTFP, timber, and other intermediary products. All NTFPs barring a few nationalized products are available to the people in most of the states. In a study of 1421 JFMCs across six states of the country, it has been reported that 29% of FPCs perceived the overall performance and impact of JFM as good, 49% rated it as moderate and rest 22% could not definitely say or did not perceive any change (Sudha and Ravindranath, 2004). JFM has increased the incomes of the participating communities through employment in forestry and non forestry activities, benefit sharing under JFM, soil and water conservation work and through creation of community assets.

In Harda division of Madhya Pradesh, it is reported that Rs. 4.08 crores were spent for providing irrigation facilities through water harvesting structures and lift irrigation to 145 forest fringe villages. Water harvesting structures alone increased per hectare crop yield from 2 to 5 times (Dubey, 2001). In a few states like West Bengal, where JFM is relatively old, FPCs are earning money through intermediate and final harvest. In South West Bengal, it is estimated that each FPC has earned about Rs. 70,000 on an average after JFM was started. At household level, it has resulted in increase of a cash income of Rs. 1700 per household after every 2 to 3 years.

In the Shivalik region Haryana, the JFM program has provided better access to the fibre grass bhabbar (Eulaliopsis binata). As result of JFM program the grass is given on lease to JFMCs on first priority basis, which before the JFM era was auctioned to contactors. Money so received is kept as community fund and in a few cases, it was observed to be as high as Rs 2-3.

4.2.3 Case study: Joint Forest Management In Shivalik region of Haryana

➲ The problem

The area under the Shivaliks, which was once covered by dense forests with a variety of flora and fauna, reached its worst form of degradation in the early 1970s. Reckless felling of trees, frequent forest fires, and increasing biotic pressure destroyed the vegetation in the area. Large tract of lands was cleared for agriculture. The problem of grazing was so serious that in heavily grazed areas, 4-6 cm of topsoil used to disappear after just one heavy shower. On the other hand, because of the poor economic conditions of the people, forest laws and traditional methods of forest regeneration proved ineffective. Against this background, an intervention has been designed with three criteria, namely ecological viability, economic feasibility, and social desirability (social and political acceptability).

➲ Setting

The program site is located in the Himalayan foothills (Shivaliks) of northern India covering about 3000 square kilometers of north and north-eastern Haryana. The tract is hilly with rugged and undulating topography. The slopes are gentle to very steep. The seasonal torrents, which originate from the hills and get wider as they enter the plains, are a peculiar feature of the drainage system of the area. The area falls under two territorial forest divisions, namely Morni Pinjore and Yamunanagar, on the forest administration map. The economy of the area is primarily dependent on agriculture and livestock. However, agricultural productivity in the area was beholden to the whims of nature in the absence of irrigation. Livestock, the other main source of livelihood, consisted of mainly unproductive stocks because fodder was scarce. The Bhanjdas (the basket-making community) and Banjaras (those who make ropes from a grass locally known as *Bhabbar*) are directly dependent on availability of such NTFP (non-timber forest products) as bamboo and '*bhabbar*.'

➲ Intervention

TERI began a JFM (joint forest management) support program in the Haryana Shivaliks in July 1990 in collaboration with the HFD (Haryana forest department), with financial support from the Ford Foundation. The program envisaged people's participation in the management of forest resources of the state jointly with HFD. TERI has been providing all the necessary backup support in developing and implementing the program. Village-level resource management institutions, popularly known as HRMSs (hill resource management societies), were formed in 55 villages in the two forest divisions, which worked in close collaboration with the local forest department officials.

The other strategies that have been undertaken to elicit people's participation in the management and protection of degraded forests are as follows:

- ***Water harvesting structures***

A series of small check dams in the upper hilly catchment and earthen water-harvesting dams at suitable sites have been constructed for soil conservation and water harvesting. As a result, cultivation that was earlier restricted to wheat and maize has now diversified to include rice, jowar, bajra, groundnut, and vegetables. The productivity of wheat, the staple rabi crop, rose from 0.9 t/ha to 45-50 t/ha in response to irrigation. Similarly, the productivity rose to 5.5 tons for maize and 0.2 tons for rice.

- ***Grass lease***

Plots of forests were leased to HRMS for harvesting of bhabbar and other fodder grasses to contribute to the general economic improvement of the local communities. The internal rate of return worked out to approximately 80% when bhabbar grass was leased out to the community; when sold to the contractor, the rate was as low as 17%.

- ***Bamboo permits***

After the beginning of the JFMP in the area, the monthly quota of bamboos (felling permit of bamboos) was increased from 50 to 100 per family, at Rs 7 per 100 bamboos and the felling season was extended from 6 to 9 months.

- ***The key achievements are summarized below***
  - The maximum average yield of *bhabbar* grass was 850 kilogram/ha under six years of community protection compared to the yield of 300 to 360 kilograms/ ha in the unprotected areas.
  - The total number of trees/ha increased from a minimum of 700 in unprotected forest areas to a maximum of 3960 in case of 10 years of protection.
  - The number of shrubs/ha is maximum in unprotected forest areas 13,885 whereas in areas protected for 10 years, it is as low as 3247.
  - Water-harvesting structures help villagers to increase their earning from farming through diversifying the agricultural activities.
  - Supply of bamboos to *Bhanjda* community at concessional rates provides employment and a source of income.
  - Leasing out of forest areas to HRMS for extraction of bhabbar contributed to the development of village infrastructure and also economic improvement of the local communities, especially *Banjaras*.
  - Leasing out of forest areas to HRMS for extraction of fodder grasses helped the pastoral community to re-stock their livestock with more productive breed.

4.3 Efficient Water Management practices employed in agriculture

Water harvesting is an ancient art practiced in many parts of North America, the Middle East, North Africa, China and India. Different indigenous techniques and systems were developed in different parts of the world, and they are still referred to in the literature by their traditional names.

In India tank irrigation is a long established and many tanks are centuries old. Here the tank is a small water reservoir behind an earthen dam or a pond excavated out of a field to catch and hold run-off. Farmers are responsible for water distribution and management below. The use of tank-based systems in SAT India is quite widespread, but its efficiency is gradually declining due to i) lack of appropriate soil conservation measures in the catchments areas, causing high soil erosion and siltation in the tank, ii) inadequate maintenance, iii) lack of effective water-user organizations, iv) encroachment of farming on to the tank bed, v) poor sluice location vi) temporal shift in seasonal distribution of rainfall and vii) increase in population densities.

4.3.1 Efficient application of Supplemental Irrigation Water

In the SAT (Semi Arid Tropics) region, water is a scarce resource and the amount of water available for supplemental irrigation is generally limited. In such situations, an efficient application of water is very critical as it can contribute significantly to reduce water losses and increasing water use efficiency. The methods used for application of irrigation water can be divided into two types, namely surface irrigation systems (border, basin and furrow) and pressurized irrigation (sprinkler and drip).

4.3.2 Surface Irrigation System

Currently in the SAT about 96% of the areas are irrigated using surface flood irrigation. This system is not very efficient and water losses through seepage and evaporation are very high. In the surface irrigation system the application of irrigation water can be divided in two parts. First: the conveyance of water from its source to the field, and second: application of water in the field.

In most SAT areas the water is carried to cultivated fields by open channels which are usually unlined and therefore a large amount of water is lost. In the absence of proper lining, about 10-35% of water is lost during conveyance from the source to the field due to seepage and evaporation losses. Several lining material e.g. LDPE film, cement-concrete, brick masonry with plaster, slates in cement, oil: cement, soil silt, asphaltic spray, saline sodic soil etc., have been tried to control the seepage loss. Many of these materials reduced the seepage losses by 35-90%.

The efficient application of supplemental water in the field is probably the most important and crucial aspect of the surface irrigation system. The method of irrigation plays a vital role in reducing the water losses and in increasing water use efficiency. The major problem with surface flood irrigation relates to uneven distribution of applied water and associated high seepage and evaporation losses. Considerable research work has been done to improve the performance of surface irrigation on different soils and under various topographic conditions. Improved surfaces, e.g. border strip, narrow ridge and furrow, broadbed and furrow (BBF), wave type bed and furrow, compartmental bunding basin, limited-irrigation dryland system (LID system) and others, were found to be suitable for different SAT region situations.

4.3.3 Surge flow irrigation system

Surge flow irrigation is an efficient surface irrigation method, which enhances the water productivity by improving the efficiency of furrow irrigation. This system applies surges of water intermittently rather then in a continuous stream. These surges alternate between two sets of furrows for a fixed amount of time. The alternate wetting and resting time for each surge slows down the intake rate of the wet furrow and produces a smooth and hydraulically improved surface. Thus the next surge flows more rapidly down the wet furrow until it reaches a dry furrow. Surge irrigation provides more uniform moisture distribution and limits deep percolation losses. Surge flow can also save more than 35% of energy cost compared. This irrigation system also increases fertilizer application efficiency and lowers salt loading by reducing deep percolation .With proper planning and design this method can be extensively used to efficiently irrigate vegetable crops grown on a ridge and furrow land configuration.

4.3.4 Pressurized irrigation systems

The traditional surface irrigation methods (flood, border and furrow), which involve water delivery to plants through gravitation, usually result in substantial water losses and limited uniformity in moisture distribution. The improved pressurized irrigation systems enable controlled supply of water at the root zones of the crops drip method) or sprinkling in the vicinity of the plant (sprinkler method), resulting in a substantial increase in water saving and irrigation efficiency. In this systems, the required quantity of water can be applied more uniformly and precisely at the desired sites as needed by the crop. In drip irrigation, the decreased wetted surface area results in a significant reduction in evaporation losses, which further augments saving of water and soluble nutrients helps in better crop growth, enhanced yield and superior quality of produce.

4.3.5 Sprinkler Irrigation

The sprinkler method of irrigation can be used for the efficient application of supplementary irrigation. Studies have been conducted to evaluate the conventional sprinkler system against the traditional methods of surface irrigation (border, check basin, and furrow irrigation) for various crops. The sprinkler method gave as much yield as a 6 cm application by the surface method, thereby saving about 34% water over 2 years.

Recently more efficient sprinkler system, i.e. low elevation spray application sprinkler (LESA sprinkler) and low energy precision application sprinkler (LEPA Sprinkler), have been found to be extremely useful for the efficient application of irrigation water. The LESA sprinkler irrigation system distribute water directly to the furrow at a very low pressure (6-10 psi) sprinklers positioned 30-45 cm above ground level. The LESA system apply water in stream rather then fine mists, to eliminate wind-drift and to reduce spray evaporation, deep percolation and underwatering.

4.3.6 Drip Irrigation

The area under drip irrigation is fast increasing in India. This is primarily due to its better performance and encouraging government policies. Drip irrigation applies small amounts of water frequently to the soil area surrounding plant roots through flexible tubing with built in or attached emitters. Surface drip irrigation delivers water underground directly to roots. Since water is applied directly to individual plant roots, drip irrigation minimizes or eliminates evaporation, provides a uniform application of water to all plants, and applies chemicals more efficiently. In this irrigation system, a managed amount of water is applied, thereby avoiding deep percolation and run-offs while reducing soil accumulation.

4.3.7 Watershed program in India and evolution of the Concept

The comprehensive Assessment of Water Management in Agriculture highlights the need for urgent action in improving water management and the opportunity in this for “low yield farmers” to raise their yields to 80% just as what “high yield farmers” obtain, with the greatest potential increase in yields being in rain-fed areas.

The importance of watershed for the Government of India in witnessed by the large resources invested. The Government has spent US$ 6 billions on watershed program through the ministries of Agriculture, Rural Development and Environment and Forest.

4.3.8 The Common Features of the watershed Development Model

- Capturing the power of group action in the village, between villages and from federations, e.g. capturing economies of scale by collective marketing.
- The construction of basic infrastructure with contribution in cash or labour from the community
- Better farming techniques, notably the improved management of soil, water, diversifying the farming system and integrating the joint management of communal areas and forest
- The involvement for the provision of basic services and infrastructure
- The establishment of village institutions and links with the outside world
- Improved relationships between men and women
- Employment and income generation by enterprise generation in predominantly but not exclusively agricultural related activities

4.3.9 Water Considerations

Some facts and observations:

- ‘There are three things important to poor villagers in the rain-fed areas, Water, water and water’. Water is used for human and livestock drinking, for irrigation and supplementary irrigation, for domestic and village industrial use and for sanitation.
- Irrigation accounts for one third of the water used in agriculture, two thirds is rain-fed, yet water management is commonly talked about in irrigated areas but rarely for rain-fed areas. This is an example of how the distinction between irrigated and rain-fed areas is unhelpful.
- Widespread improvements to groundwater tables and soil and surface water storage, but, especially in the drier areas, dropping groundwater levels due it over-exploitation by bore wells, first leave the drinking water supplies of the poor high and dry and then pose environmental problems. The remedy would be to regulate and introduce management strategies, including pre-negotiated social regulations.
- An opportunity to substantially improve the productivity of rainfall with an integrated approach to soil-rainfall harvesting and soil fertility management which embraces seed choice, seed priming, balanced nutrient management, agronomic and husbandry techniques, strategic or supplementary irrigation, and the avoidance of waste.
- Efforts to date have primarily focused on people endowed with the resources to take advantage of modern technology. There is great scope to profoundly improve equity in the access and use of water with pro-poor and gender-sensitive technology and communal management of water supplies, small scale irrigation schemes and capacity building of communal water management institutions.
- How moving the average location of water harvesting structure towards the upper parts of the watershed and the average type more towards pits, earthen checkdams and cheaper concrete structures, the cost to harvest a m^3 is lowered, the distribution of benefits is more equitable and fewer professional engineers are needed.
- The main recommendation emerging is for the perception about water in rain-fed areas to change, and for water policy to expand from augmentation of supply to water demand management and water use efficiency, paying especial attention to prioritizing drinking water needs, regulating groundwater extraction, providing incentives for efficient irrigation methods and low water requiring crops and disincentives for the opposite, and promoting participatory monitoring and management of all water resources in the watershed.

Degradation of land resources due to water erosion, wind erosion, nutrient depletion and accumulation of salts and other toxic elements, water logging and loss of biodiversity is reaching alarming levels in India. Rain-fed agriculture is complex, diverse and risk-prone and is characterized by low levels of productivity and low input usage. These areas witness acute moisture stress during critical stages of crop production, which make agriculture production vulnerable to pre and post production risks. Development of watersheds/catchments is one of the most trusted and eco-friendly approach to manage rainwater and other natural resources.

4.3.10 Watershed Development policy: Governmental Guidelines

Several government departments and state governments took up watershed development program until 1997, watershed development projects have been taken up under different programs, launched by the Government of India. Notably, the Drought Prone Area program 1987. The common guidelines for all the programs under the Ministry of Rural Development were developed in 1994 and have been implemented since 1995. The following guidelines were used by the central-sponsored schemes or the watershed development under the Ministry of Rural Development and the Ministry of Agriculture:

- More equitable distribution of the benefits of land and water resources development and the consequent biomass production, and greater access to income generation opportunities and focus on farm resources development.
- Participating villages should be selected based on the community's willingness to provide voluntary contribution and take over management of the assets created through the project when the project activities cease.
- At least 5% of the cost of investment should come from the village community or Panchayats or users, who are likely to derive the benefits of such investments.
- At least 10% of the cost of investment on individual works on private property must come from the beneficiary users (5% for schedule castes, schedule tribes and people below poverty line.
- Large population of schedule castes and schedule tribes depends on it.
- Preponderance of wastelands and common lands.
- Contiguous to another watershed, which has already been developed.
- Watershed treatment technologies and alternate land uses with emphasis on low-cost structure, vegetative barriers, farmers' innovations and production technologies.

- Participatory rural appraisal methods and community organization techniques, group behavior and convergence of services.
- Project management tools and techniques.
- Administrative and accounting procedures, management and recording procedures, inspection and audit, computerized and report writing, etc.

4.4 Policy Aspects

This section describes the various initiatives, policy and institutional measures, in India to promote biodiesel crops and agro forestry.

4.4.1 Promotion of Biodiesel Crops

Biofuels have gained importance across the world in recent times. Government of India (GoI) has also provided major emphasis to biofuels, particularly biodiesel in meeting the energy requirements of the country. The country's bio-diesel programme is based on Tree Born Oil (TBO) derived from non-edible oil seeds, primarily *Jatropha curcas* and *Pongamia pinnata*.

In order to streamline the activities, a National Mission on Biodiesel (NMB) has been constituted with Ministry of Rural Development as the nodal agency. The NMB will be implemented in two phases. The first phase, consisting of setting up demonstration projects in both forest and non-forest lands, was proposed to be launched in 2003 and to be completed by 2007 covering an area of 0.4 million ha. This phase was expected to yield about 3.75 tons of oil seed per hectare annually (Planning Commission, 2003). The expected annual biodiesel production from this phase was 0.48 million tons at the rate of 1.2 t/ha/year. A trans-esterification plant of biodiesel production capacity 80,000 tons per annum was to be set up as part of this phase. Because of delay in necessary approval from the government and lack of fund approval from the government and lack of funds, the work under this phase started in 2006. The second phase (2007-12) was designed as a self-sustaining expansion programme, to produce sufficient quantity of biodiesel to achieve a 20 % blend by 2011-12. This phase expects to cover around 11-13 million ha of wastelands with Jatropha. The programme has almost been shelved now due to lack of funds, and the increasing concern regarding diversion of farmland for growing biodiesel crops.

Though there has been a lull at the central government level after the initiation of the mission, some state governments have taken very pro-active measures to promote bio diesel programmes in their respective states.

Table 1 summarizes major biodiesel initiatives by various state governments. The initiatives are at the early stage and there exists a wide variation of policies, institutional mechanisms as well target land for raising Jatropha. Though both Chhattisgarh are Uttarakhand are targeting public-private partnerships.

Table 5: ***Steps taken by State governments to facilitate biodiesel activities***

State	Initiatives
Andhra Pradesh	• Formulated a draft biodiesel policy to facilitate establishment of biodiesel crops in approximately 0 .75 million ha • Proposed to set up a biodiesel board • A separate department to coordinate activities to raise biodiesel crops in 0.73 million ha of culturable wastelands • Announced a minimum support price (MSP) of Rs 6 for Jatropha seeds
Chhattishgarh	• Established an exclusive authority: Chhattisgarh Biodiesel Development Agency (CBDA) • MSP of Rs 6.5 for Jatropha seeds • Joint Venture Company (JVC) with Chhattisgarh Renewable Energy Agency (CREDA) is the institutional mechanism for private sector investment in biodiesel activities. Revenue wasteland would be leased to JVCs
Orissa	• Declared a policy in August 2007 for cultivating Jatropha in 2 million hectare of wastelands • Orissa Renewable Energy Development Agency (OREDA) will act as the Nodal Agency for bio-diesel development in the state. • The government will encourage private entrepreneurs to set up biodiesel units by providing back end credit and subsidy.
Rajasthan	• In January 2007 Rajasthan Government announced a draft biofuel policy for the state. • The Government has appointed Rajasthan Biofuel Development Authority as the nodal agency
Tamil Nadu	• 50% subsidy on planting material for Jatropha and other bio fuel crops • The subsidy available to agro-processing industry will be extended to biofuel and biodiesel extraction plants
Uttarakhand	• Established Uttarakhand Biodiesel Authority, with Forest Department as the facilitator • Biodiesel Development Activities would be undertaken on a public private partnership basis.

4.4.2 National Biofuel policy

Notwithstanding the lack of progress with the biofuel mission, the central cabinet has approved a biofuel policy to promote biofuels in the country. The policy clearly excludes cultivation of biodiesel crops on fertile irrigated lands. The salient features of the policy, as given in the press release by Ministry of New and Renewable Energy, are (http://pib.nic.in/release/release.asp?relid=42733):

- An indicative target of 20% by 2017 for the blending of biofuels (bio-ethanol and bio-diesel).
- Biodiesel production would be taken up from non-edible oil seeds in waste / degraded / marginal lands.
- The focus would be on indigenous production of bio-diesel feedstock, and import of Free Fatty Acid (FFA) based such as oil, palm etc. **would not be permitted.**
- Biodiesel plantations on community / Government / forest waste lands would be encouraged **while plantation in fertile irrigated lands would not be encouraged**.
- Minimum Support Price (MSP) with the provision of periodic revision for bio-diesel oil seeds would be announced to provide fair price to the growers. The details about the MSP mechanism, enshrined in the National Biofuel Policy, would be worked out carefully subsequently and considered by the Biofuel Steering Committee.
- Minimum Purchase Price (MPP) for the purchase of bioethanol by the Oil Marketing Companies (OMCs) would be based on the actual cost of production and import price of bi-ethanol. In case of biodiesel, the MPP should be linked to the prevailing retail diesel price.
- The National Biofuel Policy envisages that bio-fuels, namely, bio-diesel and bio-ethanol may be brought under the ambit of “Declared Goods” by the Government to ensure unrestricted movement of bio-fuels within and outside the States.
- It is also stated in the Policy that no taxes and duties should be levied on bio-diesel.
- A National Biofuel Coordination Committee, headed by the Prime Minister and a Biofuel Steering Committee headed by Cabinet Secretary would be set up.

4.4.3 Promotion of Agroforestry

The farm forestry programmes in India, along with other components of the social forestry programme, started in late 1970s on the recommendations of the National Commission on Agriculture (NCA 1976). The NCA recommended using private farm land and community lands for growing fuel wood and fodder to meet rural people's subsistence needs. However, the experience of the past decade is that the main motivating force behind farm forestry has been to grow wood for the market, and not for meeting the subsistence needs.

The National Forest Policy (NFP) 1988 gave further thrust to farm forestry by stipulating that forest based industries should meet their raw material requirements by establishing a direct relationship with the farmers. The Amendment to the Forest (Conservation) Act in 1988 restricted leasing of forestlands to private sector for industrial plantations and thereby gave further impetus to development of direct relationships between the private sector and farmers. The National Environmental Policy 2006 also emphasizes promotion of private and farm forestry and also calls for private sector participation in environmental conservation and management.

Despite enabling polices the long term success of the farm forestry programme was limited. The literature on private and farm forestry has identified several barriers to the spread of such forestry in India:

➲ Felling and Transit Restrictions

A major constraint which has emerged in the farm forestry programme is the whole legal arrangement which puts restrictions on tree-felling, transportation and sale. At present, in a number of states, restrictions have been imposed on tree felling, which has discouraged farmers from adopting farm forestry. Many states have taken steps for liberalisation of these restrictions. For example, Eucalyptus and Poplar have been exempted from the category of requiring felling permit in some parts of UP and in many states but, this is not widely known to the farmers. The felling and transit restrictions imposed by many of the states have resulted in enormous transaction costs and even higher miscellaneous costs, thereby proving a serious bottleneck for raising trees on private lands under farm-forestry.

Many states have taken steps for liberalization of these restrictions. For example, Eucalyptus and Poplar have been exempted from the category of requiring felling permit in some parts of UP, and most commercially important species have been exempted from felling and transit regulations in Haryana. This along with a series of other initiatives have resulted in making Haryana a success story in farm forestry (see section below).

➲ Inadequate information flow

Farmers have been constrained by lack of adequate technical know how regarding choice of species, planting pattern, quality of seedlings, harvesting practices and so on. A systematic approach towards providing farmers with the necessary information is lacking at present and so is coordination among the various agencies associated with farm forestry.

➲ Lack of quality seedlings

The farmers are facing problems in procuring high quality seedlings. A number of private nurseries have sprung up in the last decade. These nurseries supply poor quality planting material and there is no mechanism at present to regulate this supply. High quality fast growing seedlings are essential if farm forestry is to be a success and these alone can facilitate commercial viability of farm forestry.

➲ Marketing problems and lack of market information

The private farmers are plagued by market based barriers as well as lack of knowledge of marketing strategies. The market based barriers are threefold: poor transport infrastructure, poor information flows about markets and prices and capture of a lion's share of the timber market by the state government. Though the National Forest Policy 1988 has sought to halt the practice of concessional supplies to industries, the State Forest Development Corporations are still one of the dominant suppliers of timber, and supply to industries at prices below the market rates. This acts as a disincentive for farmers both in terms of price as well as volume.

4.5 Financing mechanisms

4.5.1 Financial Institutions & Banks - Bioethanol

Discussions with some major Public Sector banks have revealed that they have financed a large number of sugar mills and distilleries in the past and continue to do so. The distilleries financed are those, which are generally engaged in the manufacture of Rectified Spirit, Extra Neutral Alcohol, Industrial Alcohol and Potable alcohol – country liquor, Indian made foreign liquor, etc. Majority of Ethanol projects have been set up by sugar mills because they want to diversify and improve their profitability and use molasses for value added products rather than selling it. Many of these mills have used their own investments to set up Ethanol Plants

4.5.2 Financial Institutions & Banks – Biodiesel

Only a few Biodiesel plants are being financed as the economic/commercial viability of such projects is still in doubt. This is primarily due to:

- High cost and limited availability of feedstock, which constitutes most important component of cost of production.
- Low price of Biodiesel announced by the Government in its Biodiesel Purchase Policy.
- Lack of Policy for biodiesel especially non-enforcement of any mandatory provisions or incentives in order to make biodiesel competitive in its early stage.
- Lack of experience in financing such Projects.
- Risk associated with new technologies and products.

However, NABARD has given consent to re-finance Banks to promote plantation of Biofuels by growers/farmers/entrepreneurs. A number of Banks have also come forward to give loans to undertake Tree Born Oil Seeds (TBOs) plantation, which may be re-financed by NABARD. NOVOD Board has also introduced a scheme for financing of TBO plantation which involves providing subsidy for such projects.

The Government of India in the Demonstration Project also has envisaged a substantial portion of subsidy for undertaking plantation on 400,000 ha, possibly under the National Rural Employment Guarantee Act (NREGA) that focuses on the poor of the country and by means of additional subsidy by the Centre.

➲ Availability of Finance & Role of Banks / Financial Institutions

Since it takes a minimum of 4 to 5 years for the plantation to mature and start giving saleable quantities of seeds, the moratorium period for payment of interest and loan amount should be at least 5 years. Banks are normally not giving loans with such a long moratorium period. It is necessary for the financial institutions such as NABARD and banks to modify their terms for this Program. Since the oil seeds price has to be low in order for Biodiesel to compete with diesel, the interest rates have to be low so as not to put additional financial burden on the grower. The Government of India has to come out with a policy to support low rate of interest.

4.5.3 General Terms & Conditions for Biofuels

- **Amount of loan:** Amount of loan sanctioned is need-based depending on project requirement and its debt servicing capacity. Loan is sanctioned only after ensuring viability of projects. Generally term loans with a debt service ratio between 1:1 to 2:1 are made available by Bankers/FIs.
- **Interest Rate**: Interest rates of banks vary depending on Prime Lending Rate (PLR)/Prime Term Lending Rate (PTLR) a spread to cover the costs and risks of the banks. For term loans and working capital loans, interest rates may vary based on the banks internal rating of the borrowers, which is linked to compliance of certain financial/operational parameters, conduct of the account, compliance of terms/conditions of sanctions etc. For term loans of new units, higher interest rate is generally stipulated. However, lower interest rate can be stipulated for term loans and working capital loans, respectively at the level of banks' Head Office.
- **Margins:** Margins i.e. promoters contribution varies from 25% to 40%. Power to relax the margin depending upon merits of individual case maximum by 5% to 15% is permitted at various levels of sanctioning authorities.
- **Repayment Period:** Working capital loan facilities are renewed annually, while term loans are repayable in a period of 3-7 years depending upon the units' profitability and repayment capacity. For Horticulture or TBO plantation the Banks may modify the moratorium period as the commercial yields may start only in 3 to 7 years. For term loans sanctioned to new biofuels production units, a moratorium period of 1-2 years is also permitted depending upon merits of individual case.
- **Securities:** The working capital loans are backed by primary securities of raw materials, stock-in-process, finished goods, stores/spares etc, while term loans are backed by block assets like – land/building, plant/machinery, furniture/fixtures etc which are financed by a bank.

4.6 Conclusions

India has a large diversity of traditional agro-forestry systems, aimed at multiple benefits. The focus of these traditional agro-forestry systems is crop production and trees are grown in rows along with crops or along boundary or bunds. Biofuel crops can be incorporated into traditional agro forestry systems, without affecting the production of food crops. In some situations, biofuel crops (such as Pongamia on bunds) could indeed enhance crop production. Modern agro forestry systems consist of growing block or dedicated plantations of tree species such as Eucalyptus, poplar, Teak and Casuarina, largely for commercial purposes. These modern agro forestry systems could be adapted to include biofuel crops, better than monoculture tree plantations, such as Pongamia, Mahua, and oil palm. Shrubs such as Jatropha could be grown on marginal crop lands as monoculture crops. Any large-scale production of biofuel crops, tree species or shrub species could potentially adversely compete with food crops. Thus modern commercial production of biofuels should be on highly degraded lands and wastelands, which have low potential for food production.

The demerits of cultivation of bio-energy plantations under agro-forestry could possibly include competition for land for food and fuel. Food security has multiple dimensions: availability, access, stability and utilization and a key determinant of all of these is how access to land is distributed and controlled within society (FAO, 2007). It is an ongoing debate as to how the large tracts of uncultivated lands in India should be put to productive use and whether commercial fuel plantations to meet the country's energy requirements should be given preference over agricultural food crops which are important to meet the food requirements of the increasing Indian population. If there are no guidelines, biofuels production on commercial scale could lead to several adverse environmental aspects.

Therefore, in order to use agro-forestry systems for biofuel production and sustainable development in India, research, policy and practice will have to focus on improving the traditional and modern agro-forestry practices, enhancing the size and diversity of agro-forestry systems by selectively growing trees and designing context specific and multipurpose agro forestry systems for biofuel production.

5.0 THAILAND

5.1 Introduction

This task includes a literature review for documenting best practices, successes and failures on improved agricultural and agro-forestry systems in Thailand. National policies and strategies addressing the implementation of bioenergy and biofuels will be described. Emphasis will be on the promotion of cassava production and utilisation, increase in biomass resource potential and improved energy crop yields.

The success of the royal projects in water management and soil improvement will be examples for the best agricultural practice for Thailand.

However, development and deployment of bioenergy is challenging. Technical and non-technical barriers will be listed. Finally, lessons learnt from failures will be given.

5.2 National policy and strategies addressing the implementation of improved energy crops and agroforestry systems

5.2.1 Background of national policies and strategies for bioenergy and biofuels

Reserved energy in Thailand has been decreasing due to the marked increase of energy demand especially for transportation and industrial sectors. Approximately half of the country's primary energy demand is imported. It is therefore necessary for the country to develop alternative fuels to compensate the use of fossil fuels in order to help the country to be energy self-reliant. The National Energy Policy focuses on following issues:

- Establish the regulatory framework for electricity and natural gas industries
- Enhance energy supply: Energy security (self sufficiency)
- Promote energy saving and energy efficiency
- Promote renewable and alternative energy: Reduce imports and diversify fuel types and sources
- Market-based pricing structure: Reflect true cost in a transparent manner and promote competition
- Set mandate on clean energy: Alleviate impacts on environment
- Promote public and private participation in policy formulation

It has been found that bioenergy has the highest potential compared with other renewable energy sources. Biomass which can be used not only for power generation, but also for producing biofuels for transport has also been found to be more cost effective than other types of renewable energy.

As the majority of energy for the transport sector comes from petroleum oil, almost all of which is imported, the Thai government has set ethanol and biodiesel as priority alternative energy sources in its national plan. Measures undertaken to accomplish this goal include monitoring and regulating the pricing of alternative energy, R&D support, and public awareness campaigns. The New Energy Strategy Plan, approved by the cabinet on 17 May 2005, provides for reducing the oil input for transportation by 25 % in 2009 with the use of natural gas, ethanol blended gasoline 37 (gasohol) and biodiesel. By 2011, it is planned to have ethanol contribute with 10 % and biodiesel with 3 % to the fuel consumption of the transport sector. Ethanol and biodiesel are renewable energy, which will not be depleted and which will help increase the prices of agricultural products while reducing oil import and hence saving foreign currency. Moreover, their selling prices are not expensive and these biofuels are clean energy, contributing to reduction of environmental impacts and global warming problems.

In terms of heat and power, apart from the active government campaign in 2005 on several energy-saving and energy-efficiency programs, policy measures to promote renewable energy for electricity production was also implemented, including price incentives, tax benefit and so on.

Details of policies, status of implementation and level of success will be described as followings:

➲ Gasohol

Gasohol is now widely recognized in Thailand and the number of gasohol stations is in rapid expansion. Currently, the gasohol sold in all petrol stations has the volumetric proportion of bio-based ethanol of 10 % or also known as E10, with a more limited number of stations also selling E20 (20 % bio-based ethanol). The gasohol is blended to have the octane number of 95 or it is altogether called gasohol 95. There is also gasohol 91 but with a more limited availability.

In 2004, the Ministry of Energy launched the Gasohol Strategic Plan, after which some policy measures and targets have been revised. Since then, imported methyl tertiary butyl ether (MTBE) has been phased out and no longer used in unleaded gasoline. The government has also developed specifications for gasohol 95 and performed emission tests on engines. To promote gasohol consumption, following measures have been implemented.

- Retailed price of gasohol E10 is 2 THB/liter lower than gasoline
- All government office cars are enforced to be fuelled with gasohol

- Public relation of warranty of gasohol utilization in all gasoline vehicles that are manufactured since 1995. In addition, public relation campaigns employed by private sector have also helped to successfully raise public awareness and acceptance.

In 2005, the government has set a target that the gasohol consumption would reach 8 million liters/day by the end of 2007 and 20 million liters/day or the ethanol consumption for E10 gasohol of 3 million liters/day by 2011. In 2006, gasohol consumption has reached 1,184 million liters, rapidly grown from 60 million liters in 2004. This is equivalent to the drop of demand for ordinary gasoline (Octane 95) by 34 %, and the rise of gasohol consumption by 83 %. In the same year, the government planned to replace gasoline (octane 95) with gasohol 95 by January 1, 2007, but the full replacement was delayed over concerns that the existing ethanol production capacity would not meet the demand. Finally, from the beginning of 2008, all the petrol stations in Bangkok have stopped the sales of gasoline and have only gasohol 95. The expansion of gasoline replacement to all petrol stations in Thailand is still in progress until 2012 when it is planned that all petrol consumed will be gasohol 95 by law.

Now, it is apparent that ethanol-blended gasohol has gained popularity in Thailand at the expense of ordinary gasoline. With the tax reduction for E20 and E85 cars as a different means to promote the use of ethanol, the lower car prices will make cars fuelled with gasohol or in the future pure ethanol even more attractive. E85 will be an important energy option for Thai people amidst oil price hikes. However, the Ministry of Energy will also keep monitoring the equilibrium between the use of agricultural products for energy production and that for food production.

In addition to the promotion on the users, the fuel ethanol business has been liberalized to encourage the establishment of ethanol plants. As a result, there are now 45 registered ethanol plants with an anticipated production capacity of 10.9 million liters/day. Presently, there are only 8 operating ethanol plants with production capacity of 848,320 liters/day, and 12 additional plants under construction. These facilities are expected to operate at 2.6 million liters/day to be sufficient for the full replacement of gasoline by gasohol 95, as well as gasohol at higher ethanol proportions (i.e. E20 and E85). Most of the facilities produce molasses-based ethanol with a few plants using cassava as raw materials. Exportable supplies of molasses and cassava, which is also used for ethanol production, will tighten over the medium term when all production facilities are fully operational.

➲ Biodiesel

Biodiesel can be produced from palm oil and coconuts as well as other oil plants, like soy beans, peanuts and Jatropha. The government plans to have biodiesel widely available as an alternative to pure convention diesel to ease their reliance on imported energy. The biodiesel production for B5 biodiesel has been targeted to reach 4 million liters/day by 2011.

In 2005, a budget of 1.3 billion Baht (or about 32.5 million US$) was approved for biodiesel development during the 8 years' period, from 2005 to 2012. As a first initiative, an agreement has been signed between the Department of Alternative Energy Development and Efficiency (DEDE) of the Energy Ministry and the Thai Military Bank to conduct a 300 million (6 million £) feasibility study on a prototype biodiesel production complex in Krabi (a province in the south of Thailand located the palm oil plantation and processing).

In 2006, diesel consumption was hit by the substitution of natural gas and biodiesel in transportation activities. However, considering the domestic popularity of biodiesel, it is still far behind gasohol due to limited supplies and the lack of clearly defined incentives for biodiesel investment. On April 2, 2007, the Energy Policy Management Committee agreed that all high-speed diesel production must contain biodiesel B100, 2 % by weight, as of April 2, 2008. The Committee will provide a refund, at a rate determined by the Committee, to diesel manufacturers of biodiesel B2. In addition, the government will lower an amount of fee paid for biodiesel B5 manufacturers to the Conservation Fund, which will lower the cost of biodiesel B5 by 0.70 THB/liter.

In order to increase production of raw materials to meet the demand of biodiesel for B2 and in the future B5, the government plans to expand palm plantation by 6 million rai (~0.96 million hectares) by 2012. In addition, the government plans to encourage palm plantations in Laos, Cambodia and Burma on a contract-farming basis. The Cabinet approved a budget allocation of 1,300 million baht (approx. USD 34 million) to promote palm production in 2005. It is estimated that, if the palm oil expansion succeeds, biodiesel production could reach 8.5 million liters/day (3,100 million liter/year) by 2012, which is equivalent to 10 % of total diesel demand. However, current lucrative rubber prices are likely to discourage the replacement of old rubber trees for new palm trees. The Office of Agricultural Economics reported that planted area for oil palm has increased steadily from 344,000 hectares in 2004 to 438,000 hectares in 2007.

Two large petrol companies in Thailand, PTT Public Company Limited (PTT) and Bangchak Petroleum Public Company Limited (BCP), currently owns 511 stations supplying biodiesel. According to the Department of Energy Business, the sales of biodiesel B5 in the whole month of April 2007 were 32.22 million liters, which is equivalent to 1.07 million liters/day.

1. The PTT group plans to produce 1.0-1.5 million liters per day once biodiesel use becomes mandatory. The PTT has begun building a biodiesel plant, called Thai Oleo Chemical Co., Ltd. (TOL), which is scheduled to complete and operate by the end of 2007, with a production capacity of 600,000 liters/day. A biodiesel plant under the joint venture between PTT and Bio Energy Plus Company has been completed with the current capacity of 10,000 liters/day. The plant may be extended to 200,000 liters/day in the near future. PTT also has a joint venture with Southern Palm Company to build a biodiesel plants in Surat Thani Province in 2008 with production capacity of 300,000 liters/day.

2. Bangchak Petroleum Public Company Limited (BCP) also successfully develops its own biodiesel B100 production unit from used oil with total capacity of 50,000 liters/day. BCP recently reported its plan to open new production facilities in 2008, which will add another 400,000 liters/day to its current production capacity.

➲ Biomass for heat and power

The Energy Conservation Promotion Program (ENCON), as the government's renewable energy strategy, was established under the Energy Conservation Promotion Act of 1992. It was the first major initiative by the Thai Government to promote renewable energy and energy conservation. A renewable Small Power Producer (SPP) program which provided subsidy of up to 1 US cent/kWh was launched in 1995 and 16 biomass power projects were approved for about 200 MWe. The present installation is estimated at 2,000 MW. The ENCON Program also provided financial subsidy (for system construction) of pig farm biogas projects amounting to nearly 28.6 million USD during 1995-2004.

As a result of recent oil price hike, the Thai government in August 2003 launched an Energy Strategy for Competitiveness, which set the following goals for renewables:

- Increasing the contribution of commercial renewable energy from 0.5 % in 2002 to 8 % of the final energy consumption in 2011.
- Impose 5 % RPS (renewable portfolio standard) for the power sector until 2011.
- Furthermore, targets for the use of biofuels in the transport sector have also been set: 3 ml/d of ethanol as E10 gasohol and 4 ml/d of biodiesel for B5 in 2011.

Because of the immense importance of biomass as an alternative, clean energy source in the context of Thailand, several policy initiatives to promote increased use of bioenergy have been introduced since the promulgation of the Energy Conservation Promotion Act in 1992. Prominent among them are the Very Small Power Producer (VSPP) and Small Power Producer (SPP) regulations, which paved the way for state electric utilities to make power purchase agreements (PPA) with renewable power producers on either "firm" or "non-firm" basis. Under these regulations, subsidies (drawn from the Energy Conservation Promotion Fund) are provided to the lowest bidders of VSPPs and SPPs in each round of call for tender. This measure has been successful in attracting investors to a certain extend. However, because of the rapid rise in the cost of biomass residues, particularly rice husk, and technical and financial barriers in grid connection, the regulations have recently been revised to render them more attractive. In particular, a special electricity buy back rate in the form of an "adder" on top of the normal retail or wholesale rate – depending on the size of the power plant -- has been introduced as an incentive for various types of renewable energy technologies. The adder for electricity generated by using biomass as fuel is 0.9 US cents per kWh and the offer is valid for seven years for each contract, while the retail and wholesale rates are approximately 7 and 9 US cents per kWh, respectively. The size range of VSPP has also been expanded from 6 to 10 MW.

Analysis shows that this incentive scheme is attractive for the case of co-generation but not sufficient for the case where electricity is generated as the sole product using condensing turbines. Therefore, it is recommended that more attractive feed-in-tariffs be introduced in such a way that it reflects the external costs of electricity generation.

To promote power generation using renewable energy, the government also considers introducing more incentive measures besides the existing "Adder" measure in order to induce investment in power generation using all potential types of renewable energy, including biomass.

Promotion will also be made on the development of prototype energy villages, emphasizing the application of traditional cultures and way of living of the villagers as the basis for energy management within individual villages so that they could become self-reliant.

5.3 National policies and strategies addressing the implementation of improved energy crops and agroforestry systems

Because of the important role of fuels for transport in Thailand, the promotion of biofuels became a national agenda following the recent hike in world oil prices.
Targets have been set for their use for 2011: 3 ml/d of ethanol or 10% of total projected gasoline consumption (E10) and 4 ml/d of biodiesel or 5% of projected biodiesel consumption (B5). Key policy measures that have been introduced to promote the use of ethanol include the pricing of E10/95 gasohol (premium or octane 95 gasoline mixed 10% of ethanol) at 7 US cents cheaper than the premium gasoline by the waiver of excise tax and contribution to the Oil Fund on the part of ethanol. To ensure investor confidence, it has also been planned that the sale of premium gasoline would be completely phased out from the market and be substituted by E10 when the problems associated with the use of gasohol in some engine types is resolved.

However, the policy that set the selling price of ethanol with the Brazilian export price as reference plus transportation cost is deemed not attractive for investors.

Therefore, a suitable pricing mechanism that takes into account the external benefits of ethanol has to be established.

The key policy issues of biodiesel are inadequate supply of palm oil and the high production cost. Thus it is essential to increase the palm oil feedstock by plantation expansion, promoting better agricultural practice, and enhance palm oil yield through the use of biotechnology. The issue of biodiesel pricing has been recently dealt with by the government. A subsidy of about 35 US cents per liter has been provided for refineries to purchase biodiesel so that the entire high speed diesel market will be substituted by B2 by the end of 2007.

Because of the complexity of the biofuel industry and trade, it is recommended that a high level, multi-stakeholder committee be set up to coordinate and resolve all issues associated with the entire supply chain, be they of a legal, regulatory, market, financial or technical nature, in a holistic fashion.

5.3.1 Cassava production and utilization in Thailand

Three main raw materials are used for ethanol production in Thailand: sugarcane, molasses, and cassava. The current capacities of raw materials for ethanol production are shown in Table 6. Due to the limited availability of sugar cane, and the increased cost of molasses, cassava appears have great potential.

Table 6: ***Raw material capacity for ethanol production***

Raw material	Amount of raw material for ethanol production *(million ton/year)*			
	2008	2009	2010	2011
Sugar cane	0.00	18.0	30.0	43.0
Molasses	1.58	1.01	0.78	0.54
cassava	1.83	1.25	1.61	2.56

Cassava is a crop that can grow in poor soil under harsh conditions, with little maintenance. Cassava is largely grown in the eastern, northeastern and central parts of Thailand. The average yield per hectare for all farmers in Thailand is 16.5 tons, which is higher than the world average. Approximately 22 million tons of cassava fresh root were produced in 2004, with the following breakdown: chips (30%), pellets (26%) and starch (44%). Of this production, Thailand exported 79 % of the chips, 59% of starch, and 100% of the pellets. Although exports of pellets and chips have gone down since 1990 due to the decreased demand from EU, exports have been increased, due to strong demand from China. Almost one million tons were used in Thailand in 2003, mainly for production of monosodium glutamate, sweeteners, and other food related products. Due to the decreasing trend in the price of starch and hard pellets, the utilization of cassava for ethanol production was promoted. This not only helped to stabilize the price of starch and hard pellets, but it also supported the government's renewable energy program. The utilisation of cassava fresh root is expected to continue to increase, and to reach 4.7 million tons in the year 2007/2008.

As shown in Table 7, the production of cassava has steadily increased during the 1970s and 80s through expansion of the planted area, but has decreased again since early 1990s. Despite the total planted area remained unchangeable, the production of cassava has increased by improving the national average yield to approximately 20t/ha, while the global average efficiency for cassava production was approximately 11tonnes/hectare in 2004. The current market price is about THB 1.3 to 1.5 per kg. By increasing the market price, the productivity figure could be boosted to 32tonnes/hectare. The higher price would stimulate use of fertilizer and improved crop management methods. The Thai government is heavily promoting conversion to gasohol. Major production problems are declining soil productivity, soil erosion and long drought period.

Table 7: ***Cassava production in Thailand***

Year	Plantation Area (1,000 ha)	Production (1,000 tons)	Productivity (ton/ha)
1995	1,294.88	16,217	12.52
1996	1,261.60	17,388	13.78
1997	1,265.12	18,084	14.29
1998	1,071.04	15,591	14.56
1999	1,152.00	16,507	14.33
2000	1,184.96	19,064	16.09
2001	1,106.88	18,396	16.62
2002	995.84	16,868	16.94
2003	1,029.60	19,718	19.15
2004	1,081.12	21,440	19.83
2005	1,043.84	16,938	16.23
2006	1,109.28	22,584	20.36
2007	1,196.64	26,411	22.07
2008*	1,168.27	27,618	23.64

Source: Office of Agricultural Economics: http://oae.go.th
*Estimated data

Research and development in Thailand has focused on a breeding program for increasing root yield and starch content; adaptation for unfavorable conditions; and resistance to plant diseases. Information on cassava, including the 12 cassava cultivars developed by the Rayong field crops centre and Kasetsart University, has been widely disseminated to farmers. A special effort has been made to raise awareness about the importance of soil conservation.

With the vision of enhancing the value of cassava products, a number of development strategies are proposed to increase cassava production:

- Use the entire fresh root yield to produce approximately equal shares of chips and pellets (50 %) and starch (50 %);
- Establish a research cluster for Thai cassava;
- Take government actions to support a high price (i.e. THB 1.50/kg) for fresh root cassava;
- Continue the income-oriented policy for farmers;
- Switch to use high-yield varieties;
- Set a short term target yield at 18.75 tons/hectare, and a medium-term target at 31 tons/hectare;
- Continue to expand starch exports world wide, especially in Asia markets; and
- Promote ethanol production for domestic use.

Research and development in ethanol production technologies includes:

- Cassava starch processing: the process includes cassava collection, transportation, chopping, washing, rasping, starch extraction and separation and ultimately starch hydrolysis.
- Cassava chip processing: the process includes cassava collection, transportation, chopping, sun drying, and finally starch hydrolysis.
- Starch hydrolysis steps: three processes can be distinguished into conventional, current and future process.

The "conventional process" includes milling and mixing, liquefaction, saccharification, fermentation, and finally distillation for recovery of ethanol. In the "current process", the saccharification and fermentation processes are conducted simultaneously, prior to distillation for ethanol recovery; this allows for energy savings and reduces time in the production process by 24 hours, compared to the conventional process. In the process to be developed in the future, there will be no cooking step, so that liquefaction, saccharification and fermentation will take place in a single step -- following the milling and mixing step, and prior to the distillation step leading to ethanol recovery. This novel process will contribute to further optimization of ethanol production with regard to time and energy savings.

Numerous by-products are produced as a result of ethanol production from cassava, with various end uses. Distilled Dried Soluble (DSS) are sold as animal feed. Fuel oil and acetaldehyde resulting from the distillation process can be sold commercially, and part of the waste resulting from the fermentation step can be used as bio-fertilizer.

5.3.2 Opportunities to increase contribution of bioenergy

Opportunities still exist to increase the contribution of bioenergy in three main categories as follows:

- Biomass residues from agriculture and forestry
- Energy crops on current agricultural land
- Biomass on marginal land

However, such an undertaking is a complicated process as there are several barriers to be overcome.

- Biomass residues from agriculture and forestry – Production of agricultural residues can be increased through the following means:
  - Increasing the production of selected crops, e.g. sugarcane and oil palm through reducing planted areas of other crops.
  - Increasing the production of biomass residues of existing crop plantation areas through developing crop varieties with high biomass yields.
- Energy crop from agricultural land – Since it is not feasible to increase agricultural land, an increase in energy crop production could be achieved through the following means:
  - Reducing land for food production – As Thailand has been producing surpluses of food and has been a major food exporting country; it is possible to increase the production of energy crops by reducing the land areas for producing food. However, this approach requires efficient management of land uses, taking into account the trade-offs between economic benefits of food and fuel productions.
  - Increasing crop yields through genetic improvement – It is possible improve the crop yields through genetic improvement. For this approach, it is necessary to initiate R&D in genetic engineering with the purpose of improving yields of the main crops.
- Production of biomass on marginal lands – In Thailand degraded forest accounts for more than 15% or 7.5 million hectares. In principle, degraded forest can be used for biomass production for energy purpose. However, several obstacles have to be removed. The main problems to be addressed include:
  - Institutional and legal barriers in gaining access to use the degraded forest.
  - A large part of degraded forest is occupied illegally by the rural population.
  - The know-how on producing biomass on degraded land is still lacking.

5.3.3 Research and development promotion

Both policy and technology development types of research are needed to promote the bioenergy industry in Thailand.

For technological issues, some of the most pressing issues for biofuels are the improvement of feedstock production yield, particularly palm oil, cassava and sugar, and the improvement of their conversion efficiency so as to reduce the fuel production cost. Of secondary importance are investigations on the effects of biofuels on engine parts and their solution. For biomass to heat and power, the central question is the logistics of collecting and transporting agricultural residues of greatest potential, namely rice straw and sugarcane leaves and trash, the key challenge being the small scale and non-mechanized nature of Thai agriculture and the traditional believes and practices of the farmers. Another issue is the upgrading of heat and power generating technologies to more efficient ones, particularly high efficiency steam turbines, at an affordable cost.

International research collaboration is also a tool to accelerate the development of bioenergy. Thailand has research collaboration with the New Energy Development Organization (NEDO), Japan, to initiate some bioenergy projects, including:

- Development for the efficient disposal of co-fermented methane from chicken litter and agriculture waste composed oil/fat
- Bioethanol engine applicable test for heat pump use
- Gasification of cassava waste for combined heat and power generation
- Ethanol production from molasses and bagasse in the sugar factory

For policy issues, the key policy questions concerned with are the issue of appropriate pricing structure of biofuels and the level of subsidy, and the appropriate feed-in45 tariffs for electricity generated by biomass. A long-term issue associated with large scale bioenergy production is sustainability, as most of the biomass resources used for energy purposes in Thailand are concurrently important sources of food and fodder.

Thus such practices would not only affect food security, but also alter land use patterns and biodiversity. Therefore in-depth analyses and reliable data that would support decision making and planning are highly essential.

5.4 Best practices in agricultural sector in Thailand

5.4.1 Water management

➲ Water resources and situations

Water is essential for life and all economic activities. Statistics of the annual average rainfall from the year 1995 to 2004 shows continuous decreasing rainfall since 1999.

However, in 2005 Thailand was hit by several depressions causing floods in the north and northern regions. Due to 25 watersheds development and management, the water impoundment capacity can reach up to the total volume of 73,700 million cubic meters. For underground water resources, it was estimated from the 12 basins with underground water of 15,877 million cubic meters/year that could be potentially developed at about 3,175 million cubic meters/year, where the upper and lower Chao Phraya Basin have high yield potential. Drought situation in Thailand tends to be increasingly serious. It is found that water demand for all activities in 2001 is around 67,052 million cubic meters. In 2005, Thailand faced severe drought due to 2 months delaying of the previous year seasonal rainfall, causing water shortage in many reservoirs. The situation was worse by increasing water demand from various sectors.

Water shortage in the eastern seaboard during mid 2005 was very severe, especially in Chonburi and Rayong provinces where conflicts regarding water usage took place among communities, agricultural and industrial sectors. Ministry of Natural Resources and Environment by Department of Underground Water Resources has developed underground water to increase water resources within the areas.

Heavy flood problems also took place in 2005 in several areas of the country, such as the areas of Yom, Chee, Khong, Ping, the east coast, and the lower Chao Phraya river basins. Regarding water quality, there were 4 out of 49 rivers and 9 fresh water resources under survey that water quality are classified as very low. Those are the lower Chao Phraya, lower Tha Chin, lower Lam Takong, and Song Khla Lake.

To solve water resource problems efficiently, cooperation and coordination from all concerned sectors is needed, especially all various government sectors need to work in harmony. Major activities included in the action plan are the rehabilitation of natural water resources, the repairing of pipe water systems, the flushing of underground wells, repairing tap water systems, cleaning shallow bodies, construct new deep wells as well as repair and construct new dams and weirs at upstream areas to retard water flow.

- **The royal project for improving water management: The Monkey Cheeks (Kaem Ling) Project**

On the 14th of November, during the heavy floods throughout the country, His Majesty advised those concerned in solving the problem that the “Monkey Cheeks Project” provides the solution to the flooding problem in the Bangkok Metropolis. The Monkey Cheeks project is a water organization system for the flooding season to prevent as well as reduce flooding in the lower Chao Phraya river by draining the water ways such as ditches and canals (or klongs) into small reservoirs. This is similar to the monkey holding the banana bits in its cheeks. Water is drained into the sea when the sea water level reduces. The Monkey Cheeks project is one that relies on nature to solve problem in the flood prone areas.

5.3.2 Soil improvement

➲ Land resources and land use

Thailand has total area of 320.7 million Rais which consists of agricultural land of 131 million Rais or about 40% of the country area. The country has been facing problems of deteriorated soil and improper land use for decades. Improper land use management and deforestation have resulted in severe erosion in many areas of the country. In some areas of the non-utilized land, it is found that the serious soil loss was greater than 20 tons/rai/year. In addition, saline soils and acid soils in several areas also need special treatment. Department of Agricultural Economics reported about land use and type of agricultural holding area that there are somewhat change in type of agricultural holding area during 1998-2001. In 2001, there were about 65 million rais of paddy field and 28 million rais of field crop areas. Concerned organization has continuously carried out plans and activities for soil rehabilitation and conservation. Those activities include growing Vetiver grass to prevent erosion, promotion of organic farming, remediation of saline soil and other special problem – soils, and revision of laws related to land use.

Land use surveys showed that soil resource problems involved a total of 210 million rai in 2002. Soil resource problems are classified into two types: (a) degradation of soil quality, such as saline soil, eroded soil, and sandy soil, and (b) inappropriate land use. Agricultural land holding has declined from 26 rai per household in 1992 to 23 rai per household in 2001. Another problem is poor distribution of land ownership.

To solve or reduce these problems, measures have been implemented, including:

- Enhance and promote the local governmental organizations to oversee the use of water resources in sustainable manner by encouraging public participation.
- Announce mud slide risk areas, and establish mud slide monitoring network and warning system.
- Introduce appropriate land use planning based on the land's carrying capacity by relocating people from the land area where slope is higher than 35 degree, restoring the land for reforestation, promoting public education in agriculture to slow down water velocity and prevent land slides, constructing check dams, investigating land rights and land reform within national reserved forest areas, clear zoning of land use, reallocating land for agriculture, rehabilitating the ecosystem through reforestation, and so on. To accomplish these, a clear direction must be set and communicated to all concerned.

➲ The royal project for soil improvement: The Aggravating the Soil (Klaeng Din) Project

"Aggravating the Soil" A Royal Theory During the royal visit to the people in Narathiwat Province in 1981, His Majesty the King observed that after the swamp lands had been drained to expand agriculturally productive areas and to reduce flooding problem, the soil had grown strongly acidic and that crops planted by the farmers had failed. His Majesty then called on all government agencies to search together for ways in which to improve these swamp lands of perennially stagnating water for maximum use in agriculture, bearing firmly in mind the impacts of such improvements on the ecology. The strong acidity was due to the fact that the swamp soil was composed of a 1-2 meter layer of organic matter or decomposed plant residue underlain by bluish grey mud with high content of pyrite (FeS_2). When the soil dries, pyrite releases sulfuric acid as it oxidizes.

The Pikun Thong Royal Development Study Centre was put in charge of the Project which His Majesty named Klaeng Din. The Project studied the naturally-occurring process of acidification of the sulfur-bearing peat soil. The activities consisted of the alternate drying and flooding of the soil to accelerate the reaction of pyrite, to the point where the soil becomes extremely acidic and crops cannot be grown productively. The next step was to search for counter-measures. The methods of solving the strongly acidic soil problem based on His Majesty's idea are as follows:

- Solution by controlling the ground-water level – To prevent the release of sulfuric acid by the soil, the ground water must be kept above the layer of mud to prevent the pyrite from oxidizing.
- Soil improvement according to His Majesty's "Klaeng Din" Idea – There are 3 methods to be chosen according to the conditions of the soil:
  - Using water to remove soil acidity: Besides reducing acidity and increasing the soil pH, flooding the soil also dilutes the toxic iron and aluminum solutions. Additional applications of nitrogenous and phosphatic fertilizers will make the crops productive.
  - De-acidifying soil by using lime mixed with topsoil such as marl and lime dust. The amount of lime used depends on the degree of soil acidity.
  - Using lime in combination with soil flooding and control of groundwater level. This comprehensive method yields the best results for very strongly acidic soil that has lain idle for a long time.
- Adjusting the soil surface by
  - Making it slope sufficiently for the area to be drained
  - Reshaping or rearranging the paddy field or its boundary ridges and bunds in such a way that water can be stored and/or drained at will.

- Cultivating crops on raised beds – This method can be used for cultivating field crops, vegetables, fruit or other tree crops that generate a high cash return. However, to be sure of obtaining a good return on crops grown on raised beds, irrigation water is needed for filling and refilling the ditches with fresh water to reduce acidity. Cultivating crops on raised beds should take into consideration the flooding in the area. If the danger of flooding is too great, planting tree crops should not be risked on raised beds or the height of the beds should be reduced and the tree crops replaced by annual or vegetable crops, grown in rotation with rice.

The suitable procedure for improving strongly acid soil for agricultural use depends on the types of crop cultivated and cultivated areas. For example,

- Rice cultivation in irrigated areas, e.g. for soil with pH under 4.0, apply 1.5 tons of lime per rai; while for soil with pH from 4.0 to 4.5, apply 1 ton of lime per rai.

Rice cultivation in rain fed areas, e.g. for soil with pH under 4.0, apply 2.5 tons of lime per rai; while for soil with pH from 4.0 to 4.5, apply 1.5 ton of lime per rai.

After applying lime, turn the soil over and then cover with water for 10 days.

Drain water to remove toxic substances and re-flood prior to transplanting.

- Cultivation of Annual Crops - Vegetables:
    - Raise beds, 6-7 meters across, with 1.5 meter-wide drainage ditches that are 50 centimeters deep.
    - Turn the soil over and leave to dry for 3-5 days.
    - Make ridges, each 1-2 meters wide and 25-30 centimeters high, on the raised beds to facilitate drainage and prevent the beds from being slushy when watering or raining.
    - Apply liming material to reduce soil acidity. Use 2-3 tons of lime dust or marl per rai. Mix with the soil and let stand for 15 days.
    - Apply 5 tons of compost or organic fertilizer per rai, one day before sowing. This makes the soil more friable and improves its structure.
    - Selected Field Crops: These can be grown in two ways: i) Growing field crops on raised beds involves one single cropping and preparation of the land according to the method discussed above for vegetables; ii) Growing field crops as a second crop after the rice-growing season follows much the same method as used for field crops in general. However, it may be necessary to raise the beds about 10-20 centimeters higher than those on higher ground in order to prevent any unseasonal rain water being retained in the area. If lime has already been applied, probably no more needs to be added.

- Cultivation of Fruit Trees
  - Build a big earthen embankment around the entire area to be cultivated to prevent rainy season flooding and install a pump to provide drainage when needed.
  - Raise beds for cultivation as described earlier for strongly acidic soil.
  - As the water in the drainage ditches will be acidic, pump in fresh water when acidity becomes strong, approximately every 3-4 months.
  - Keep the water in the drainage ditches above the level of the pyrite-bearing mud and thus prevent the oxidation process from increasing acidity in the soil.
  - Scatter 1-2 tons per rai of lime, either calcium oxide, marl or lime dust, over the entire area to be cultivated.
  - Use the spacing appropriate for the crop to be cultivated.
  - Dig holes 50-100 centimeters deep and 50-100 centimeters wide where each tree will be planted. Keep the excavated topsoil and subsoil separated, and expose them to sunlight for 1-2 months to kill germs in the soil. Mix the topsoil with compost or manure and also with some subsoil, and re-fill the hole with the mixture. For this purpose, use 1 kilogram of compost per ton of soil, mixing it well with 15 kilograms of lime per hole.
  - Control weeds, diseases, insect pests, and water the plants in the usual manner.

Fertilizer use depends on the requirements and type of tree grown.

5.4.3 Development of Plant Species for Improved Yield and Quality

Production of ethanol comes from sugarcane/molasses and cassava; while the production of biodiesel mainly comes from oil palm. It is necessary to increase the productivity by enhancing efficiency of production or productivity per area. Due to the high productivity per area in case of Brazil and Australia, their production cost of ethanol is lower than in Thailand. Especially for Brazil, their production cost of ethanol is lowest in the world.

Currently, the average productivities of sugarcane, cassava and oil palm are 11.8, 3.5 and 2.8 ton/rai respectively, when their maximum potential could give 45, 13 and 15 ton/rai respectively. Genetically improved sugarcane and cassava test planted under appropriate conditions have already shown to give a higher productivity than the average productivity. For example, cassava series KU 50, Rayong 9 and Rayong 7 can yield 6 ton/rai. Multi-location tests of sugarcane plantation in the country also showed that many plant series yield more than 20 ton/rai. Genetic improvement, selection of good series and plantation management (i.e. irrigation and fertilizer) can largely improve productivity per area of energy crops in Thailand. In long term, biotechnology will assist the species improvement to provide theory productivity of each energy crop.

From the data of plantation area and genetic potential of energy crop, it is estimated that Thailand has great potential to increase the productivity per area and less or no need to increase plantation area in case of sugarcane and cassava. However, expansion of plantation area for oil palm is still necessary.

The development of improved energy crops has to focus on 2 different issues. The first is to genetically modify the plant species to have high resistance to insects and diseases, for example, palm with high resistance to insects, sugarcane with high resistance to worm and cassava with high resistance to viruses. Development of plants that can be grown in unsuitable plantation conditions, for example, sugarcane that can grow in draught areas. The rate and efficiency of photosynthesis are increased so that plants are faster growing and hence high productivity. The plant internal structures of sugarcane can also be modified to be more appropriate for the fermentation process to yield high sugar rate. The second issue deals with the development of microorganisms that help improve genetic modification, for example, the development of enzymes to convert sugar and cellulosic materials into more fermentable sugar. Nevertheless, application of genetic engineering raises concerns in biological, environmental and food safety and this therefore needs to be assured before commercializing and recommending to agriculturists.

The government and private sectors worldwide have intensively invested in biotechnology research for biofuel applications. In Thailand, DNA technology is used for plant improvement, e.g. the jasmine rice series 105 that can survive in sudden flood for 15-21 days and fast recover to its normal condition.

5.5 Challenges in the Development and Deployment of Bioenergy in Thailand

The economic potential of biomass as an energy source is much lower than the technical potential. To exploit its full potential, several barriers will have to be overcome. Barriers to bioenergy development and deployment are outlined. Policy measures, including R&D, that are necessary for promoting bioenergy are highlighted.

5.5.1 Policy Barriers

Although the Thai Government has been fairly proactive in energy policy and implementation during the past 20 years, the energy policies have not been very effective. The problems of energy policies in Thailand include the following:

- Frequent policy changes – There have been frequent changes in energy policy due to frequent changes of Government and minister in charge. These changes have discouraged investments in renewable projects and have slowed down the implementation of policy measures for promoting renewable energy.
- Inefficient policy implementation – Implementation of government energy policies have not been effective due mainly to inefficiencies in the bureaucratic system and policy changes as discussed.

5.5.2 Problems related to biomass feedstocks

➲ General problems

It is difficult to collect large quantities of biomass wastes due to their disperse nature. Most types of biomass are too bulky and costly to transport. The availability of some types of biomass is seasonal and annual production fluctuates from year to year depending on climatic conditions. The costs of biomass wastes also fluctuate widely, depending on production output and economic conditions.

➲ Competing uses

Apart from energy, biomass and biomass wastes are widely used for other purposes:

- Wood wastes and bagasse are used to make particle boards and paper.
- Rice husk is used as fuel in brick production and other rural industries.
- Palm oil is used in food and cosmetic industries.
- Cassava is used to make modified starch and animal feeds.

➲ Difficulty in increasing biomass feedstocks

As discussed earlier, increasing biomass for energy purposes from the current agricultural land and marginal land is a complicated undertaking. Policy, institutional, technical and social issues will have to be seriously addressed.

5.4.3 Institutional barriers

Institutional barriers include the following:

- Lack of a neutral national regulatory body.
- Conflicting policies of different ministries.
- Poor coordination among several government agencies involved in renewable energy promotion and development.
- Lack of cooperation and understanding from power utilities.
- Complication in the implementation of the operation plan for increasing biomass feedstocks.

5.5.4 Ineffective promotional mechanisms

Several incentive schemes for promoting bioenergy have been initiated by the governments since 1990. However, these mechanisms have not been very effective.

Some suggestions for improvement include the following:

- Implementation of more efficient financial and tax incentive schemes.
- The level of financial incentives (feed-in tariffs or adders) needs to be regularly adjusted.
- A neutral body should be set up to oversee and arbitrate issues concerning the production and sale of electricity from biomass.

5.5.5 Weak energy science, technology and innovation (STI) system

➲ The STI System

In principle the strength of the STI system of a country depends on the followings:

- R&D capability in the public sector and universities
- Technology development and manufacturing capability of the private sector
- Government strategies
- Effectiveness of the HRD system

➲ Energy research and development

One of the key issues is the lack of a national energy R&D roadmap that would serve the goals of the national energy strategies. The funding support for energy R&D is inadequate. Most energy R&D activities are undertaken by the public sector and not all of them are responsive to national needs. The involvement of the private sector in energy R&D is lacking. The national R&D capability needs to be strengthened urgently.

➲ ***Capability of the private sector***

The habit of relying on imported, turn-key solutions for most renewable energy projects is a major barrier for private companies to get involved in energy technology development and manufacturing. The role of the government in promoting technical capability in the private sector has also been limited. Although incentive programs covering tax reductions and soft loans for R&D activities in the private sector have been initiated, they have not proved to be very effective. Technology support programs run by different agencies are not well funded, nor are they well coordinated. A well integrated national program for strengthening the energy STI system through financial and taxation incentives, technology procurement policy, technology market development and technology transfer through trade and investment, is desirable.

➲ ***Human resources development***

Several public institutions have been established to develop energy human resources specializing in energy technology, energy management and energy R&D. However education programs of these institutions do not fully address the national needs for energy manpower. In addition funding support to these institutions is not adequate to educate highly qualified personnel in sufficient number.

5.5.6 Lack of reliable information

Although a non-profit organization called "Biomass One-stop Clearing House" has been set up recently to provide technical and financial information on bioenergy systems to interested public, there is still a large information gap on the availability and advantages of bioenergy technologies. It is envisaged that building confidence in bioenergy technologies through demonstration of successful cases are essential. In addition basic technical information including the current production of agricultural products, current yields of biofuels per unit area that can be produced from various crops and requirements on standards of biofuels should be widely disseminated. Otherwise, it may lead to wrong decisions by energy planners and farmers, as happened in the recent past.

5.5.7 Public misconception on the safety of power plants

Low confidence in coal and hydro power plants have led to opposition even to biomass fueled plants, as a large section of the population do not differentiate between coal based and biomass based plants.

The advantages of bioenergy, especially its clean burning characteristics and the fact that it is CO_2 neutral, should be highlighted.

5.5.8 Technical Barriers

Several bioenergy technologies (e.g. small-scale biomass gasification and technologies for converting municipal wastes to energy) are not fully nature. Technical problems still exist, which have discouraged users from adopting these technologies. Most imported advanced bioenergy technologies are still too expensive and therefore not feasible economically. In addition most imported technologies have to be adapted so that they could be operated satisfactorily on local fuels that have different properties from those for which they were designed.

5.6 Failure and lesson learnt

5.6.1 Resource potential and logistics for biomass power plants

The government promotion of renewable energy utilisation has attracted power plant investors. A number of biomass power plants, especially rice husk due to its suitable properties for thermal conversion, have been largely increased. Most of rice husk power plants are located in the central part of Thailand, where rice is widely grown and the husk is produced in the local mills.

However, without consideration of power plant zoning and logistics of rice husk, the heavily increased demand of rice husk feedstocks has become the major non-technical barrier to operate the power plants. The rice husk power plants as well as other users of rice husk as co-processed fuels or for other purposes have been competing to get the rice husk and therefore the price has gone up more than 5 times in many areas. So far, there are a number of rice husk power plants that are not being in operation due to the lack of feedstocks.

5.6.2 Resource potential for biofuel production

Surging global demand for energy crops for production of alternative fuels has sparked a series of efforts within the Agriculture Ministry to lift the country's output of such crops, particularly palm and tapioca, from a limited plantation area. This year, the Energy Ministry also plans to raise the amount of biodiesel progressively, from 2 % mixed into the B2 fuel that all retailers will be selling next month to 5 %, 50 % and eventually 100 %, or pure biodiesel. The plantation areas have to be further expanded and therefore seedlings to suit each area need to be prepared and new technologies with which to raise crop yields need to be researched.

Last year, Thailand produced 7.27 million tons of palm kernels, which produced 1.24 million tons of palm oil. Of this, 850,000 tons were used domestically and the rest exported. Palm-oil production is expected to climb to 1.47 million tons this year, but domestic demand is forecast to rise to 920,000 tons, due mainly to the hunger of biodiesel plants. It is expected that this domestic demand will grow to 980,000 tons next year and 1.2 million tons in 2012.

To ensure the smooth conversion of additional palm oil into biodiesel, the Industry Ministry would need to entice manufacturers to set up plants around new plantation areas. Palm kernels must arrive at factories within 24 hours of being harvested, so these facilities must be located within a 200-kilometre radius of plantations. Although there is no guaranteed price for palm kernels, the higher demand will keep the price above 3.50 baht (11 US cents) per kilogram. Farmers are able to break even at 2.50 baht (8 cents) per kilogram, and the current price is 5 baht (16 cents).

With prices continuously escalating, it is foreseen that controlling consumer prices will be difficulty. To ease speculation-driven shortages, the ministry recently allowed imports of palm oil despite the possibility of hurting domestic prices, with a new crop of palm kernels expected to reach the market next month.

Aside from palm oil, the Commerce Ministry is also expected to suffer a sugar-driven headache. Due to ongoing disputes with sugar mills, farmers who suffered from low prices last year may turn to other crops. This will hurt the country's 11 ethanol plants, which need sugar molasses as a raw material. These plants will need 1.87 million tons of molasses this year, but output will be only 1.48 million tons. However, it is hopeful that once sugar prices go up, farmers will once again plant sugar cane. But the yields need to be increased. Also, farmers might be more enthusiastic about planting sugar cane if there were a benefit-sharing scheme between sugar mills and farmers for revenue from molasses. At present, farmers make money only from sugar cane.

It would also be a plus if domestic sugar prices were allowed to move in line with world market rates, because this would encourage sugar mills to sell syrup for ethanol production rather than turning it all into sugar for export. Thailand's sugar production this year is expected to be about 7 million tons. Of this, 5 million tons will be exported.

The tapioca prices are now attractive, i.e. at 1.90 baht (6 cents) per kilogram against a farmer break-even point of 1.20 baht (4 cents). Still, with higher demand for ethanol production from limited plantation areas, the Agriculture Department faces the need to raise tapioca yields from 3.2 tons per rai to 3.5 tons. Because corn is more expensive, China and Europe need more tapioca for animal feed and energy production. This will raise prices further and could lead to farmers switching land from sugar cane to tapioca. Last year, 7.3 million rai was planted with tapioca, producing 26.72 million tonnes of cassava root. The area is expected to increase marginally to

7.4 million rai this year, for an output of 27.97 million tons. At present, domestic consumption demands 6 million tons. The rest is exported. As more farmers turn to higher-priced crops, this will inevitably lead to smaller areas of food crops, and food prices will rise as a consequence. As supply and demand pressures intensify between the need for energy and for food, agricultural zoning is not working. In this situation, consumers will have to bear higher food prices. Therefore, cooperation between the Agriculture, Energy, Industry and Commerce ministries was essential in setting a national agenda. The Agriculture Ministry will also have to investigate whether farmers are really benefiting from higher prices for farm goods or simply being forced to bear higher costs of living like everyone else.

5.6.3 Effect of single crop plantation on soil condition

Single crop plantation has a number of negative effects on soil condition as well as other environmental problems.

➲ *Degradation of soil quality*

Conventional agriculture always uses model of mono cropping (Agricultural pests are often specific to the host - a particular crop and will multiply as long as the crop is there). So it also always intensifies water, chemical fertilizer (e.g. global mean fertilizer use more than doubled from 34 kg/ha of cropland in 1964-1966 to 86 kg/ha in 1983-1985, and expansion of irrigation from 13 to 15 % of the world's arable land between 1974-1976 and 1984-1986) and pesticides to exploit soil's productive capacity to obtain high yield. These caused erosion of soil (mono-cropping cannot prevent from erosion of soil) and degradation of soil quality (existence of heavy metal in soil from pesticide) over years. Beside intensified crop, in order to increase production, conventional agriculture also uses expansion of cultivated area to solve this. In some situations, flood, drought can appear, areas of arable soil can be transformed into desert and they impact on environment by climate changes. These are negative impacts, not only on agricultural soil and environment nowadays but also on future generations.

On the other hand, the use of fertilizers can affect on soil quality by making acidified soil and it is difficult to grow crops on it with a high yield. When using these chemicals, they are also destructive to the environment. It occurs very often when these chemicals run-off the farmland during and after rainfall and drain into nearby rivers and streams. This influx of chemicals can result in the extinction of species, and thus adversely affects the local biodiversity. Additionally, most of these pesticides have a wide spectrum of activity and as they are broadcast in sprays, they are applied against ecosystems, rather than directly to pests.

➲ *Pollution of soil, water and food with pesticides and nitrates*

Chemical fertilizers and pesticides used in conventional agriculture unarguably benefit the increased crop yield. However, their residues can at the same time be leached into soil and water, which seriously affect beneficial soil organism systems and acidifying soil or make soil no longer suitable for plant growing. Others parts of residues can evaporate in form of gases such as N_2O, NO_2. Gases from these or other activities (e.g. tilling of soils which permits oxidation of organic matter, producing CO_2, emission of large amounts of N_2O from cultivated soils, or application of fertilizers increases N_2O release by plants) will also contribute to greenhouse gas - global warming.

Problem of water pollution is largely known. Chemical fertilizers and pesticides leached into soil and contaminating sources of water, even in lower levels, can affect the growth of crops, such as lower the crop yield, and if in heavy level, crops can die. If these chemical fertilizers leached into soil and run into river or sea by ground water, they will become nutrients for algae or seaweed. These plants will grow rapidly and use up oxygen in the water. Other plants then cannot live anymore.

➲ *Reduction of ecological diversity and human society*

Conventional agriculture causes the reduction of ecological diversity, which also leads to reduced sustainability. When using pesticide to control pests, beneficial organisms or living animals having weak resistance to pesticide (e.g. bees, and earthworms) may die.

Beside impacts on environment, conventional agriculture also affects strongly on human society.

- Excessive application of fertilizers and pesticides are not only unhealthy for the consumers, but also unsafe for the farmers who must be exposed to them.
- When products of over-nitrate-used crops are harvested, they are very difficult to preserve. That is due to the high content of water and damages by pests.
- The lifetime will then become very short and therefore lower the economic value of product. This in turn will induce more use of pesticide to control pests to maintain yield.
- During agricultural burning; dust from tillage, traffic and harvest, pesticides drift and nitrous oxide emissions from the use of nitrogen fertilizer cause air pollution.

From above, it can be clearly seen that conventional agriculture can give high crop yield, but also has many negative impacts on environment and human society. In order to solve and restrict these negative impacts, new solutions to agriculture production needs to be applied. The use of compost, manure, or other organic matters is an option to replace chemical fertilizers; while application of integrated pest management, biological pesticides, insect trapping by the use of lures such as pheromones, biological control methods can replace the use of chemical pesticides.

However, application of organic agriculture is relatively new and to implement widely dissemination to farmers for good understanding and efficient practices (e.g. timing for plantation or best rotation combinations of crops) is necessary.

6.0 MEXICO

6.1 Introduction

In Mexico people that have lived for centuries in landscapes with rich biodiversity have based their strategy for survival and economic development on this diversity. In the following some remarkable examples of successful strategies will be described, placing them within their social, environmental and economic context.

The first part offers a general description of the institutional, regulatory and policy context of Mexican agriculture, presenting the land tenure regime in a historical perspective, water use regulatory framework and a description of current policy instruments for agricultural support.

The second part describes some successful agricultural systems that have evolved in Mexico, starting with an ancient and original production system that originated before the arrival of Europeans in America and allowed Mexico's City urban development. The fact that this system is still practised today, more than 500 years later, gives an idea of its sustainability. Then we will describe how waste water irrigation systems in Valle del Mezquital have contributed to solve the environmental problems caused by urban growth in Mexico City for more than a century, in the world's oldest waste water irrigation district. In the same region agaves are planted in non irrigated lands for "pulque" production and soil conservation works for protection. The section ends with the description of other agaves and cactus use, in traditional and input intensive agricultural production systems, as examples of the economic and cultural importance of semi arid plants. Some facts about the potential of other less known arid and semi arid plants as a source for oil and other industrial products will be presented, in order to emphasize the vast opportunities that research could open in the benefit of semi arid and arid land people.

The third part deals with shortcomings and failures of agricultural development projects in Mexico under bioenergy development context.

6.2 Institutional framework for Mexican agriculture

6.2.1 Land tenure

Land tenure system in Mexico is derived from two different arrangements: (1) the system developed by the native indigenous population and (2) the system brought by the Spanish. The land tenure system of native societies was a patriarchal village-type landholding with a communal character. However, the communal system went under an extensive modification, gradually creating individual holdings. During the colonial period, the trend moved towards the accumulation of land in few hands. This unequal distribution of land and other minor factors were responsible for Mexico‘s War of Independence at the beginning of the 19th century. Around fifty years later under Porfirio Diaz rule, rapid economic growth brought industrialization, flourishing plantation economies and natural resource exports. Landholding concentration became an even more important social unrest factor. Together with industrial worker conditions were the origin of the 1910 revolution. Land redistribution became part of the commitments of the post revolutionary government.

Land redistribution was slow at first and proceeded throughout Mexico for more than 80 years. During this time labor productivity in farming evolved to allow a larger surface to be worked by a farming family, the surface that was considered too big for a family farm in 1940 was not the same in 1980. In Mexico a maximum limit on privately owned land is set by law to avoid latifundia, as stated by Article 27 of the 1917 constitution.

Land distribution occurred gradually over decades. However, since the 1940‘s a new agrarian bourgeoisie started to monopolize high productivity lands, which became available when irrigation infrastructure was completed. This was possible thanks to legal loopholes and political and financial acquaintances. Corruption of state officials also facilitated extra legal land grabbing. So, currently in Mexico a small minority number of powerful, well capitalized enterprises hold the best land, control the country's agricultural economy and export markets. In contrast to a vast majority of impoverished small holdings of ejidos and indigenous communities who lack technology, financial resources, credit, access to markets, information and training. Under the Agrarian Law, ruling the constitutional amendments of 1992, ejido and community legal rights and obligations are stated, giving the ejido or community general assembly the legal right to decide on two regimes of land use within the ejido: Common use or individual parcels use. The under common use land cannot be sold; on the contrary, individual parcels that get the status of private property can be sold.

There are 29,942 agrarian properties in Mexico, of which 8000 concern indigenous peoples, 63% of these are ejidos and the other 37% are communal lands. With population increase the surface per tenant in the ejidos has been atomized. This fact poses a great challenge for agricultural development, in particular in a context of scarce employment opportunities in rural and urban areas. In high production areas, land leasing, contract agriculture and other arrangements have grouped areas to increase agricultural operation efficiency.

At present, most of the support programs of Mexico‘s government tend to support the entrepreneurial development of ejidatarios.

6.2.2 Water resources

Mexico has a mean annual rainfall of 780 mm, about 27% of which becomes runoff of about 410 billion m^3 per year. Renewable groundwater is estimated At 63 billion m^3 per year, 48 billion from natural recharge and another 15 billion from deep percolation associated with irrigation projects. Additionally there are an estimated of 110 billion m^3 of non-renewable ground water that could be available for one-time use. Climatic regions vary greatly from tropical rainforests with over 3000 mm of annual rainfall in the south to arid deserts with less than 100 mm in the north. Runoff variation is even more extreme, from over 2 million m^3 per square kilometer per year in the wettest areas to essentially zero in the dryest.

In the dryer parts of the country, precipitation and runoff are highly erratic with large variations from year to year and extreme seasonal differences. In these areas, rainfall occurs during a 2-to 4-month period and it is related to thunder storm and hurricane activities which can be very intense and cause flash flooding. Runoff is directly associated with precipitation events and most streams and even rivers dry up during periods of no rainfall.

Mexico is a country of approximately two million square kilometers with about 103 million inhabitants at the end of 2005, compared to a population of about 25 million in 1950. Population has increased in each part of the country, but it has been more important in the northwest, northeast and central regions, precisely the areas with most severe water scarcity. So population and economic activity are not located where water is available. Less than a third of total runoff occurs within 75% of the territory where most of the country's largest cities, industrial facilities and irrigated land are located. Consequently, water from surface runoff or groundwater is increasingly in short supply to support economic growth. This causes conflicts over the available surface water and over pumping of underground sources. Environmental degradation and water pollution problems worsen the situation. In some sites, paradoxically, water management structures have changed runoff regime, and water abundance causes severe problems of land drainage and flooding.

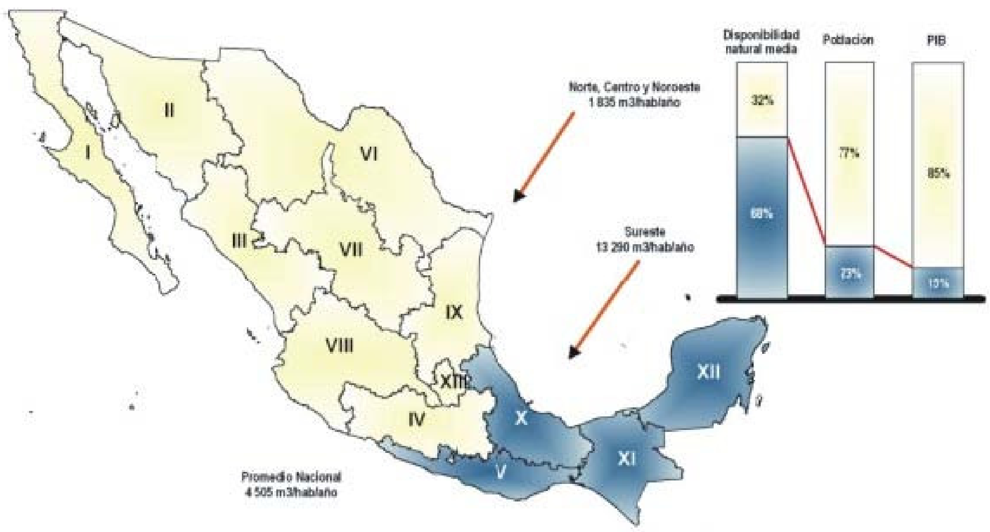
In this context it is evident that management, conservation and allocation of water resources are a complicated task. The increasing demand on the nation's water has reached the limit of its availability in many regions. Continued growth will depend on making water available to those sectors that require it in sufficient quantity and adequate quality, managing conflicts between urban and rural users, neighboring cities, and between states sharing a watershed.

Surface water has played a crucial role in Mexico's national and regional development. For over 60 years, the expanding use of surface water for irrigation, municipal and industrial purposes has been based on the development of hydraulic infrastructure. Further dam and other hydraulic infrastructure construction will be increasingly difficult, as the most economically viable water resources developments have been completed.

Two million hectares of irrigated agriculture, 55 million city dwellers and more than half of the industrial production in the country are dependent on groundwater for their supply. In most cases alternative sources of water are either not available or too costly. This has led to extraction in excess of recharge for most aquifers, which represents a major problem in the arid and semi-arid regions of Mexico, where not only most of the population and industrial production is located but irrigation is also a major water consumer.

The National Water commission has identified and characterized 600 aquifers and performed hydro geological assessments on many of them. They have determined that 100 of these aquifers are presently overexploited. (World Bank 1996)

Contraste entre el desarrollo y la disponibilidad de agua



Fuente: Integrado por la Subdirección General de Programación. CNA.

Water resource localization in contrast to population and economic activity

➲ *Water Legal and Institutional Background*

Before the Spanish conquest in 1521, the relationship of the Mexican people to water was both religious and practical. On the one hand, worship to water deities was common and, on the other, practical situations generated rules stating who could use water, how to solve conflicts among water users and how to cope with floods. The social organization allowed the construction of water supply, irrigation and flood control works and navigation systems.

During the 300 years after the conquest, water belonged to the Spanish crown and a royal grant was required to access to its use. Management of grants passed under Mexican government control after independence in 1821. The current law and regulations have their legal support on the Mexican constitution issued in 1917, the most important points relevant to water resources management are:

- The State shall ensure that all social and economic activities will be undertaken with due care of the environment.
- Article 27. Water within Mexico's territory is national property, water management is a state responsibility and the state can grant "concessions" for water use.
- Article 115. Municipal governments, with assistance from state governments, are responsible for municipal water supply systems.

As a state owned resource in the past, water resource development had two driving forces which were not always compatible: urban water supply and irrigation and hydroelectric power development. Back in 1926, the National Irrigation Commission was established and some years later, in 1937, the National Power Commission (CFE) to develop power utilities, as electrical energy generation, still a state monopoly, that only recently has allowed some exceptions. Both entities developed hydraulic infrastructure for irrigation and power. Irrigated lands were developed in most parts of the country. To manage these irrigated lands, the National Irrigation Commission became the Ministry of Water Resources (SRH). This ministry continued building infrastructure and operated irrigation districts within a regional organization, on the basis of watersheds, that includes territory of several states. These authorities called Commissions after the countries main rivers. The watershed authority or commission had among its responsibilities the operation and maintenance of hydraulic infrastructure and irrigation district management, with ample power and budget, resulting in a heavy state influence. While the agriculture ministry dealt with rain fed traditional agriculture, the ministry of hydraulic resources dealt with irrigated agriculture, increasing the technical and productivity gap between both systems.

With a growing population urban water supply started to compete with irrigation for scarce water resources, with growing water scarcity, increasing water pollution by sewage and industry became an issue during a period of economic crisis in the 1980's. A body was created, the "National Water Commission" (NWC), in February 1989 to facilitate structural reform in the water sector. During 1992 a new water law was enacted, which defined the NWC as the sole federal water authority in the country. Initially, it remained attached to the Ministry of Agriculture and Water Resources, but in 1995 it moved to the new Ministry of the Environment. The 1992 law incorporated structural reform in water management. The law was based on a combination of regulatory and economic instruments to enhance sustainable water management. In April 2004, the water law was substantially amended and set the base for water rights management. The new law includes following regulatory, economic, and participatory instruments:

Water Concessions: water use by individuals or legal associations needs a concession granted by the federal executive through the NWC for a period of 5œ 50 years. This concession concerns a specific water source and a specific water use; in the case of irrigation a specific plot and to be transferred it needs NWC's agreement. Table 1 presents the different categories of freshwater use in Mexico for 2002 in terms of annual concessions, volume and number of users in the Water Rights Public Registry. The range of water users is very wide; for instance, a user in agriculture can be an individual farmer or an irrigation system of more than 10,000 hectares, an urban/domestic user can be a few households sharing one single water source or Mexico City's supply system, including hundreds of water wells and transferred surface water from a neighboring watershed hundreds of kilometers away. By 1992, there were an estimated of 300,000 users. However, only 2,000 of these users had a formal water use concession. Ten years later, 327,650 users have been granted with a formal concession. Among Mexico's slightly over 100 million inhabitants, more than 20 million live in Mexico City and water supply for the city is a growing challenge.

Water Rates: Rates were set for water use as a public good and for the services provided by the state. This means setting the rates for concessions and sewage discharge permits on the basis of economic instruments such as the "user pays" and "polluter pays" principles-operational. In principle as in practice there are still short falls in the coverage of such payments. The rate for water charges depends on the specific use and the relative scarcity of the water source, the rate for wastewater disposal charges depends on the pollutant load and the risks involved. Concessions for irrigation have a preference rate but they are set in a volume per area basis which does not induce water efficiency. Excessive regulation makes it difficult to comply with the law and it is still the NWC who decides in case of conflict. Since water rights tradability is limited, the short duration of concessions may restrain investment. In conclusion, water regulations have still to be enforced correctly, to really provide a rational and sustainable water management system. Irrigation administration has its pitfalls and some regions face water scarcity for irrigation and urban water supply. Waste water treatments are not at the required levels.

Table 8: ***Water use concessions in Mexico according to Water Rights public register 2002***

Category	Volume (billions of cubic meters/year)	Estimated number of users
Hydropower	145.6	88
Agriculture and livestock	56.1	185,856
Urban and domestic (a)	9.6	133,404
Industry (b)	6.9	8,302
Total	**218.2**	**327,650**

(a) Includes industry supplied by water mains.
(b) Self-supplied industry, including thermal power plants.

Source: National Water Commission.

In major areas of Mexico water availability is limited and biofuel production is going to compete with food production for this scarce resource. A water opportunity cost and benefit analysis is needed to judge the feasibility of using water for a specific purpose in a certain place. This won‘t be easy given the legal framework for water management.

6.3 Agricultural and Rural policy instruments

6.3.1 Background for recent agricultural policy

During 1976 an economical crisis caused the Mexican currency a loss of half of its value, ending a period of steady economic growth. Two important factors underlie this crisis: country‘s wealth had concentrated in few hands and a rapid population growth led to the concentration of vast proportion of the population impoverished in growing urban slums. Securing food supply for these slums became a national issue, shifting the focus from agricultural policy to food policy, under the name “Sistema Alimentario Mexicano“ (Mexican food system), Food self sufficiency was abandoned as an objective to support an agricultural trade balance. Food supply for the growing urban population needed grain imports; in order to pay for them, those agricultural products in which Mexico had a comparative advantage had to be exported.

Six years later, in March 1982, a second devaluation, due to excessive debt service, almost collapsed Mexican economy. The exchange rate rose from 22 pesos per dollar to 150 pesos per dollar in a few months with a hyperinflationary process. This crisis gave way to a structural adjustment policy with the intervention of the IMF, International Monetary Fund. Structural adjustment aimed to reduce government expenditure. For agriculture, it implied dismantling government owned enterprises and government institutions related to agriculture. These firms and institutions were involved in input supply: fertilizers and seeds, financial services: credit and insurance, commodities: coffee, tobacco, sugar cane, cereal and pulse storage, agricultural research and extension, water management and irrigation infrastructure maintenance. Within the food sector the State was involved in the marketing chain of some commodities, milk, maize, pulses and maize flour. Some of these state owned firms were involved in subsidies distribution to farmers and consumers.

After the dismantling, some of the services once provided by state firms and institutions were taken over by the private sector, though the coverage was restricted to those sectors and geographic areas where these activities could be profitable, leaving most of the least favored peasants unattended. An illustrative example is agricultural research, which has not yet recovered from the 1982 crisis. Links between research, farmer's problems and needs are weak. Extension service is not directly linked to research, as it is done by private individuals or firms, nor does it have the needed influence from organized farmers. Infrastructure and service supply in rural areas is poorly developed; in particular schooling level of rural population is certainly a limiting factor to new ideas and innovative forms of farmer organization (See table).

Table 9: ***Schooling for population of 15 years and older***

% of population 15 years and older	Rural	General Population	Mexico City
illiteracy	21 %	9.6 %	3 %
average schooling years	4.8	7.6	9.7
primary education	24.6 %	51.6 %	71.6 %
population 15-19 years in school	28.9 %	46.7 %	64.4 %

Source: 2000 census INEGI

In this context it is not surprising that most of rural population currently lives under severe poverty.

During the years after 1982 agricultural exports, mainly fruits and vegetables, increased as the exchange rate made exports very attractive. Mexico joined the GATT and started signing free trade agreements, the most important among them being North American Free Trade Agreement, signed in 1994. This agreement will bring complete liberalization of agricultural imports by January the 1st 2008, till now there has been a gradual withdraw of tariffs and taxes. In a free trade context, Mexican agriculture dwells in a much more competitive environment, though most of Mexican farmers lack a support structure to succeed.

6.3.2 Poverty eradication programs

A poverty eradication program has huge influence in rural areas; it is intended to bridge the inter-generational transmission of poverty by helping the young generation through the difficulties to advance in schooling. The program, currently called "Oportunidades", started as Programa de Educación, Salud y Alimentación (Education, Health, and Nutrition Program), known by its Spanish acronym, PROGRESA. The program has a multiplicity of objectives and it aimed primarily to improve the educational, health, and nutritional status of poor families, particularly of children and their mothers. PROGRESA provides cash transfers linked to children's enrollment, regular school attendance and clinic attendance. The program also includes in-kind health benefits and nutritional supplements for children up to age five and for pregnant and lactating women. Program's expansion across localities and over time was determined by a planned strategy that involved the annual budget allocations and logistical complexities associated with the operation of the program in very small and remote rural communities (such as verification that the localities to be covered by the program had the necessary educational and health facilities).

The program started in August 1997, incorporating 140,544 households in 3,369 localities. In its final phase during early 2000, the program covered nearly 2.6 million families in 72,345 localities in all 31 states. This constituted around 40 percent of all rural families and one ninth of all families in Mexico. The program's total annual budget was in 1999 around $777 million, equivalent to just under 20 percent of the federal poverty alleviation budget or 0.2 percent of gross domestic product (GDP). After 2000, when the government changed, the program received a new name, "Oportunidades", and since 2006 it includes a payment of $250.00 pesos a month for adults above the age of 70 years old in beneficiary households. As part of an overall strategy for poverty alleviation in Mexico, PROGRESA works in conjunction with other programs that are aimed towards developing employment and income opportunities (such as Programa de Empleo Temporal [PET]) and facilitating the formation of physical capital, such as the "Fondo para la Infraestructura Social Municipal" (FISM). In Mexico, PROGRESA represents a significant change in the provision of social programs. First, in contrast to previous poverty alleviation programs, PROGRESA is aimed at the household level to ensure that the resources of the program are directly delivered to households in extreme poverty; that is, households that can most benefit from the program. General food subsidies, such as the tortilla price subsidy (Subsidio a la Tortilla [TORTIBONO]) are widely acknowledged to have had a high cost on the government budget and a negligible effect on poverty because of the leakage of benefits to non-poor households. In addition, more decentralized, community based, demand-driven programs such as the earlier anti-poverty program Programa Nacional de Solidaridad (PRONASOL) during 1988 and 1994, were thought to be susceptible to local political influences and not very effective at reaching the extreme poor. Under PROGRESA, communities are selected using a marginality index based on census data. Then, within the selected communities, households are chosen on the basis of socioeconomic data collected for all community‘s households. The program acts simultaneously upon health, education, and nutrition, delivering its resources to mothers, recognizing their potential to use resources effectively and efficiently to address immediate family needs.

➲ *Description of the Educational Benefits and Program Requirements*

Education is seen as a pivotal component of PROGRESA, reflecting the strong empirical link between human capital, productivity, and growth, but especially because it is seen as a strategic factor in breaking the vicious cycle of poverty. Investments in education are therefore viewed as a way of facilitating growth while simultaneously reducing inequality and poverty. The program‘s stated objectives are to improve school enrollment, attendance, and educational performance. This is intended to be achieved through four channels:

- A system of educational grants
- Monetary support for the acquisition of school material
- Strengthening the supply and quality of education services
- Cultivation of parental responsibility for, and appreciation of the advantages stemming from, their children‘s education. These are obviously interrelated, so that each is thought to enhance the effectiveness of the others in improving attendance and performance. The system of educational grants is intended to encourage regular and continuous attendance, especially for females. This is reflected in two crucial design.

For a more detailed description of the various anti-poverty programs in Mexico, see Skoufias E. (2005) IPFRI features. First, the size of the grant increases through grade levels. Second, at the secondary level, grants are higher for females. This last feature is meant to address the cultural gender bias against female social participation, as well as being an attempt to internalize education externalities that accrue to other families after women marriage. The level of the grants was set with the aim of compensating for the opportunity cost of children‘s school attendance.

➲ *Description of the Health and Nutrition Component*

The health and nutrition component can be seen as a collection of a number of interrelated subcomponents, namely:

- A basic package of primary health care services
- Nutrition and health education and training for families and communities
- Improved supply of health services (including annual refresher courses for doctors and nurses)
- Nutrition supplements for pregnant and lactating mothers and young children.

Although the general focus is on improving the health and nutritional status of all household members, special emphasis is placed on the welfare of mothers and children.

➲ *Monetary Transfers Received by PROGRESA Beneficiary Households*

For 2006 the program covered 5 million families. Under 2007 operation rules for "Oportunidades" payments are as follows:

Food support month 180.00 pesos /family Monthly Scholarships:

3th grade primary 150.00 grade primary 240 year secondary 350 boys 370 girls High school 585 boys 675 girls 655 boys 760 girls Plus a payment of 160 pesos for school materials in September and 80 pesos at school year. A payment of 250 pesos for any adult of more than 70 years. Currently several federal programs exist to fight poverty and support farmers by direct payments or subsidize small farmers, to promote the integration of farming with industry and to increase added value to crops.

The most important agricultural support program is Procampo. PROCAMPO was implemented in Mexico in the winter 1994, the agricultural season following NAFTA's commencement. The program was designed as a 15-year transition to free trade and it is expected to end in 2008. Eligibility, and therefore the maximum level of PROCAMPO transfer payments, vary across households and they are based on household behavior during the pre-PROCAMPO period. PROCAMPO provides eligible agricultural producers with a fixed payment per hectare. This payment is decoupled from current land use and it is the same across the whole country. Eligibility's level is dependent on the total hectares of nine key crops (corn, beans, rice, wheat, sorghum, barley, soybeans, cotton and safflower) that were planted during the three agricultural years prior to and including August 1993. Latter in 2001 the program was extended to any licit crop or ecological project under the ministry's of environment supervision. Eligibility was actually given to land parcels and those with usufruct over these land parcels, not particular farmers, and payment should go to whom ever is planting the property, whether owner, renter or sharecropper. The eligibility roster was fixed prior to commencement of the program. Theoretically, the farmer who receives a payment for a particular property may change depending on who is using the land, though in practice most benefits accrue to the owner, either directly or through the rental price. Since there are potentially two agricultural seasons per year, PROCAMPO payments may be received up to twice a year, though in general only farmers with access to irrigation can take advantage of the second agricultural season. Payments correspond to the amount of land currently under production, which cannot exceed the amount of land registered in the eligibility roster. Farmers must prove that the parcel is currently under production, but monitoring of actual planting is haphazard, and many devices are employed to skirt this requirement. However, given that the program is based on past agricultural production and the requirement that farmers continue producing or that they participate in an official environmental management program, the intervention is closely and intentionally linked to agricultural production.

Since PROCAMPO is distributed on a per hectare basis, larger farms have tended to get higher total transfers. SAGARPA (1998) data state that households with less than 5 hectares make up 45 percent of recipients, but receive only 10 percent of total transfer payments. However, PROCAMPO provides a uniform payment per hectare regardless of yield or if the output was sold on the market. PROCAMPO thus over compensates smallholders who may have had limited yields and reaches households who did not benefit from pre-NAFTA price supports since they had no marketed surplus. Current changes to the program include moving payments to prior to planting, so that farmers are able to directly use the transfer for the purchase of inputs and thus avoid paying high interest rates. This enhances the value of PROCAMPO as a mechanism to overcome credit market failure and increases the likelihood that the transfer will be used for agricultural investment. A new plan allows farmers with an investment plan to move forward in time all future PROCAMPO payments into one large payment (PROCAMPO, 2001).

Beneficiaries are defined in the operation rules published in the DOF (Diario Oficial de la Federación) on February the 20th, 1994, and regulations are published every year.

The end of Procampo is programmed for December the 31st 2008.

6.3.4 Farmer support programs

Other programs include subsidies for investment in more productive machines or processes, risk sharing in new enterprises and facilitating small farmer‘s access to credit by helping small farmer organizations overcome high transaction costs and get warranties needed to borrow money. Coverage and scope of these programs are quite limited, as often the research to support innovation is lacking, which increases investment risk. In an expensive credit environment, this results in chronic shortage of productive employment in most of the agricultural regions of the country, especially in the south. Young generations are forced to migrate towards cities or to the United States, remittances from abroad are now the second national source of foreign currency for the Mexican economy and an important source of income for rural families. A more detailed analysis of current agricultural policy can be found in OECD 2007.

6.3.5 Forestry support programs

Since 2001 the National Forest Commission manages several support programs for the forestry sector. Since 2007 the various programs for forest development have been united in an only program known as "PROARBOL"

The program includes direct transfer payments for the following concepts to the owners of forest land:

➲ ***Forest planning and development***

Regional forest management studies: this category supports the elaboration of forest appraisal and planning studies, at regional level. These studies are the required technical instrument for forest management; it is a legal requirement for forest use. Forest management programs: this category supports the elaboration of forest management studies at plot level. These are a legal requirement for forest use. They include the payment for environmental impact assessment study in the case of native forests.

Forest development and organization: this category deals with forest development and enhancing forest owner organization.

Forest production and productivity: Including following concepts:
Forest management: for execution of forest management and silvicultural management practices and operations to increase forest productivity as thinning, replanting, clearing and follow land management.

Forest land use diversification: This support is foreseen for promoting alternative use of forest resources as nature tourism, hunting activities, wild life and flora conservation and other similar practices.

Commercial forest plantations: For the establishment of commercial wood plantations Conservation and restoration of forest lands: for realization of soil and water conservation structures or soil restoration.

Reforestation: to promote tree planting and forest vegetation for restoration and conservation purposes.

Soil conservation: for soil conservation, restoration and fertility management, Forest fire prevention and control: to support forest fire control and prevention, Forest pest management and control, Environmental services: to promote and develop environmental service markets in forest ecosystems, Increasing the competitiveness level, equipment and infrastructure: For investment in equipment, tools or infrastructure to increase forest productivity or value added to forest products.

Productive chain development: For investment in the development of forest product productive chain development, Technical and preventive audit and forest certification: To promote sustainable forest management certification, including studies and the necessary investment to increase forest protection and to facilitate entrance to national and foreign markets.

Training and forest sector capacity building: for human resource development in forest management and productive activity diversification to enhance value added to forest resources and forest industry.

The program is in its seventh year and it has had some pitfalls, especially in the states where forest personnel for undertaking studies are scarce. Sometimes forest management has found some resistance from environmental authorities, especially in tropical forests where an environmental impact assessment is necessary and the duties to pay to environmental authorities for the paper work are very high. This has prevented many management plans authorizations.

Another problem has to do with small scale forest management, which lacks efficient industrialization equipment and limits the integration of forest operations with industry. (DOF 20 Feb. 2007)

6.4 Case studies of innovative agricultural systems.

6.4.1 Valley of Mexico and Chinampas

The Valley of Mexico, a land locked basin of approximately 7000 km^2, where Mexico City, one of the largest cities of the world spreads today, has been inhabited since prehistoric times. At the time of the Spanish conquerors arrival, during the early sixteenth century, Tenochtitlán, the Aztec empire‘s capital, was the largest city in the new world.

Valley of Mexico's ancient map

It is evident that for urban development to take place not only an ample food supply is needed, but also a system to handle wastes and excreta to avoid the risk of epidemics. An ample food supply implies an efficient method to manage soil fertility. These two conditions were met with an agricultural system called "Chinampas" developed in the lacustrine environment of the Valley of Mexico.

The name chinampa derived from the nahuatl word chinamitl, which means reed fence or hedge, and it designates a square plot surrounded by water in at least 3 sides. The plot was made by limiting an area on the lake with reed fences and adding mud from the shallow lake, till the land emerged from the lake's surface, then willow trees were planted to hold the borders of the field.

Chinampas allow an intensive agriculture; fertility is maintained by periodically adding mud that is rich in organic matter from the sediments of the lake bottom. Periodic removal of sediments and the aquatic plants growing on the lake's surface allowed water treatment and kept an ecological equilibrium. The lake produced an ample population of crustaceans and fish that complemented the diet. Water weeds and insect larvae were used as fowl feed. The aquatic fauna attracted migratory birds.

During the dry season the chinampas are irrigated with lake water. Mild winters allow a continuous cropping throughout the year; land use intensity is increased by producing crop seedlings in a small plot and transplanting. Seedlings are grown, by preparing a seed bed consisting of a 5 cm layer of mud exposed to the sun to dry. When it is almost dry, it is cut in squares of 5 cm wide and long. A seed is planted in the center of each block, which is called chapin; seedling develops during the initial phase of the crop to be later transplanted.

The chinampas have allowed continuous cropping during centuries, complemented with the availability of clean water from springs and streams flowing from surrounding mountains and they made a healthy environment in the valley. By the end of the 19th century the system still provided most of the vegetables and horticultural crops needed for the 541,000 inhabitants of Mexico City; some portions of chinampas survive today producing ornamental plants and other crops to remain profitable.

Urban growth expansion in the Valley has always been linked to hydraulic works. The first one was the construction of a dike to separate the salted waters of Texcoco Lake from the fresh water lakes, which made one only lake during the rainy season. This dike was constructed before the Spanish conquest.

As population expanded during colonial times, a waterway was opened to drain the lakes and make more land available to build or farm and also for flood control.

At the beginning of the 20^{th} century, a second waterway was opened to expand the water extraction capacity. These waterways transport run off and waste waters to the Mexquital Valley where they are used for irrigation since then.

The remarkable environmental management in the Valley of Mexico continues to address the needs of one of the largest cities in the world; the agricultural system that allowed the region to become an urban center is still practised, thus Mexico City's population has grown from 1,776,000 in 1940 to 22 million today. Chinampa area is now a natural reserve which still produces many local crops to prepare delicacies, with local plants as capulín Prunus mexicana and white zapote Casimiroa edulis, a native avocado, among the most important.

6.4.2 Agave use and pulque industry in the Mexquital Valley of Hidalgo

The Mexquital Valley is a semi arid valley in the state of Hidalgo; it is located 60 km north of Mexico City. It is formed by three plains of different altitude, separated by mountain chains. The north plain lies at 1700 to 1850 meters above sea level, the central plain which lies at 1900 meters above sea level and the southern plain at 1950 m above sea level. The valley is the home for the Otomi ethnic group, and it has a population of 495,000 inhabitants, most of them involved in agriculture. There are two irrigation districts: "Distrito 03 Tula" and Distrito 100 Alfajayucan; both of them use waste water from Mexico City for irrigation. The irrigated area amounts 83,000 ha. (See table 10). Waste water irrigation started with the completion in 1903 of the canal de Tequisquiac, which drains runoff and sewage from Mexico City to the Mezquital valley, together with "Tajo de Nochistongo", that was constructed years before.

Table 10: ***Irrigation data for the Valle del Mezquital, 1993-94***

Irrigation System	Irrigated Area (ha) 1	‰ area under culture2	Users	Water volume (106 m 3/a)	Production value (million us$)
Distrito 03 (Tula)	45,214	55,258	27,894	1,148	73
Distrito (Alfajayucan) 100	32,118	22,380	17,018	651	24.3
Private Units	5,375	5,450	4,000	96	0
TOTAL	**82,707**	**83,088**	**48,912**	**1,895**	**97.3**

1. Irrigated area refers to areas with irrigation infrastructure
2. Area under crops includes areas with more than a culture in the year

Source: Comisión Nacional del Agua (CNA), Distritos de riego, Mixquiahuala, Hidalgo, México, 1995.

Most of this waste water receives no treatment. Until the 1960's, sedimentation in water ways and storage period in reservoirs provided treatment and allowed the water to be used without major health risk to produce vegetables. But Mexico City's population growth increased the organic and chemical load which resulted in health problems. To avoid health hazards the cropping pattern changed from vegetables to alfalfa and maize. The dissolved organic matter in irrigation water enhances fertility and irrigation districts are on average more productive per area than other similar lands. (See table 11)

Table 11: ***Crop yield in tons/ha in the Mezquital Valley 1990-92***

Crop	National mean	Mean in mezquital	IIN irrigated area of hidalgo	Rain fed agriculture
Maize	3.70	5.10	3.60	1.10
Beans	1.40	1.80	1.30	0.49
Oats	4.70	3.70	3.60	1.70
Barley	10.80	22.00	15.50	13.50
Lucerne	66.30	95.50	78.80	0.00

Source: Secretaría de Agricultura y Recursos Hidráulicos (SARH), México 1994 (valores nacionales). CNA, Distritos de riego, Mixquiahuala, Hgo. México 1995 (datos del Valle del Mezquital).

As it has been said, at first waste water from Mexico City received treatment as settling solids sedimented during its flow in channels and natural oxygenation occurred during storage in reservoirs, but by 1980 concentration and quality of waste water started producing health problems. As this coincided with the UN WHO Water and sanitation decade, studies where made to asses the consequences of waste water irrigation on farm workers health.

Shuval et al., made a review on a World Bank document of several experiences around the world concluding that there are both: environmental benefits and health risks associated to waste water irrigation. The fertilizing value and its effect has been mentioned; health problems associated in the Mezquital Valley have been studied by Cifuentes et al. (1993). He studied the relation of waste water exposure and intestinal parasite and diseases among farm workers by two cross-sectional surveys, the first during the dry season and the second during the rainy season. The total studied population in the dry season included 2049 households: 855 families that work in raw waste water irrigated plots, (high exposure), 965 families that work in plots irrigated with water that comes from the Endho Reservoir (intermediate exposure) and 930 families working rain fed plots, so that they are not exposed to waste water (control).

The study indicates that the risk of Ascaris lumbricoides infection is much higher in the exposed group than in the control group (95% CL= 4.0-67.3 and 4.7-78.8). Children from exposed households were at higher risk of Diarrhea disease than controls (95% CL= 1.03-2.03).

Table 12: ***Prevalence of Ascaris lumbricoides, Giardia lamblia and Entamoeba histolytica among the studied population***

Age group	Exposure Groups		
	High	Low	Intermediate
	Waste water	Control	1st storage reservoir
Ascaris lumbricoides			
0-4 years	10 34/341	0.6 2/327	11.7 42/357
5–14	12.5 94/759	1.0 8/809	8.5 67/795
15 + years	4.5 60/1394	0.0 0/1243	2.5 39/1515
Giardia lamblia			
0-4 years	21.2 46/217	20.5 67/327	16.5 38/230
5-14 years	13.5 60/442	12.5 101/809	14.0 66/480
15 + years	4.5 16/347	4.0 48/1243	6.0 28/472
Entamoeba histolytica			
0-4 years	6.5 22/341	6.7 22/327	6.4 23/357
5-14 years	17.0 127/759	14.0 113/809	20.5 161/795
15 + years	16.5 229/1394	15.0 188/1243	17.5 262/1515

Source: dry season survey Valle del Mezquital 1991

Table 13: ***Diarrheic disease prevalence in relation to waste water exposure and age group***

Age group	Exposure groups		
	High	Low	Intermediate
	waste water	Control	1st storage reservoir
0-4 years	19.6 56/285	13.6 55/404	15.5 47/302
5-14 years	6.5 42/656	4.5 45/1028	8.0 51/631
15+ years	8.0 43/546	7.0 119/1749	8.5 53/631

Source: Dry season survey Valle del Mezquital 1991

➲ *Waste water microbiology*

The study reports that raw waste water has a high concentration of indicator microorganisms. 108 Faecal colliforms /100 ml and 70 Ascaris lumbricoides eggs/l; the content diminishes in water from Endho.

➲ *Non Irrigated agriculture in the Mezquital Valley*

In non irrigated areas of the Mezquital Valley there is an ample cultivation of various varieties of agaves belonging to the species Agave americana and Agave malpisaga. Their culture is mainly to produce "aguamiel", a sweet liquid used for drinking or fermented to produce "pulque". Pulque production is part of an ancient tradition and besides extraction of aguamiel all parts of the agave find other uses. Aguamiel is also concentrated by evaporation to produce "aguamiel" honey; the small flowering shoot (quiote) is eaten as a vegetable; fully developed and dry is used as construction material or burnt as fuel; the tender leaves or pencas of some species are eaten, the flowers are eaten as vegetables, the penca's cuticule is used to wrap the "mixiotes", a traditional meat based dish, prepared in a buried oven. The terminal spine is used to make jewelery and some authors relate that the spine and its attached fibers served as suture in prehispanic times. Even the insect's larvae that feed in the maguey are considered a delicacy, the white maguey worm Cossus redtenbachi and the red maguey worm Acantrocneme hesperians Lepidoptera.

Agaves are also present in soil conservation practices, as they are planted along contour lines to hold the border of terraces.

Nevertheless pulque has found a new market with the development of a In other regions of the state of Hidalgo in the late 19th century large pulque production states were formed to supply Mexico City's demand for this drink. With the arrival and popularization of breweries in Mexico, the "pulquerias", bars where pulque was served in Mexico City, have almost completely disappeared.

6.4.3 Agave use in the central valleys of Oaxaca and Mezcal production

Another important zone of agave production is located in the central valleys of Oaxaca, a mountainous state in central Mexico, home of several ethnic groups who have a rich traditional knowledge of managing natural resources.

The central valleys of Oaxaca are three rich agricultural valleys at different altitudes in the region surrounding the city of Oaxaca. Their mean altitude above sea level is 1500 m. It is a naturally rich region and has been site of human settlements since 400 BC when Monte Alban was funded.

The region comprises three valleys at different altitudes: "Etla" to the northwest, "Tlacolula" to the southeast and Zaachila-Zimatlan-Ocotlan to the south; surrounding mountains reach 2050 m above sea level. Climate in the region varies from hot dry to temperate humid; the mean annual rainfall is 727 mm, with rains during summer. The driest valley is Tlacolula and Etla is the most humid. The valleys have rich and fertile alluvial soils, and a high water table to provide water for irrigation. Nowadays water is pumped by motor pumps, but some years ago the plants were still watered using a "cántaro", a ceramic or metal container of approximately 14 liters capacity which was used to fetch water from the well and pour it to the growing crops. This labor intensive method had been used for centuries. Agriculture is also practised in the mountain slopes; success of crops is highly dependent on the availability of irrigation water. The environmental diversity within the valleys and its region has allowed a very diversified agriculture, in which the main products are maize and beans, population's staple foods, but as trade and markets are well developed within the region, multiple horticultural and industrial feed and food crops are grown under irrigation and also without. Slope farming needs soil conservation structures; terraces are formed following contour lines to prevent erosion, terraces are secured by planting agaves on the borders. Agaves, Agave angustifolia and Agave karwinskii, are used in various ways, among them mezcal production, a spirituous drink, being just another element in the agricultural production system where animal husbandry is an important element to supply dietary proteins, the manure for fertility management and traction force for wooden plows. Farmers in the central valleys of Oaxaca have breed many maize varieties, by selecting them under multiple criteria: yield, drought resistance, post harvest loss, water logging resistance, fertility needs and also quality to produce processed food products, tortillas, tamales and many other dishes, eaten every day or during special occasions or even for rituals. Most of the plots are planted to multiple crops, maize, beans and squash being the most important, but many others may be found. Maize is not only intercropped with other crops, but also different varieties are managed in the same plot, as the farmer may plant in the same field several varieties to reduce the risk of losing the harvest, if rains are scarce during the season or other environmental cause arises. Land tenure in the region is very fragmented; most peasants have very small plots of land, measured by the length of planting row. With this constraint it is not surprising to see a diversity of handcrafts and almost all land owners have multiple economic activities.

In the mountains nearby, oak and pine forest still provide timber for agricultural tools construction and firewood.

6.4.4 Tequila industry in Jalisco

Tequila is a spirit made by distillation of fermented juice obtained from the "piñas" of the blue agaves Agave tequilana. Traditionally the tequila region was restricted to the Valley of Tequila in Jalisco, formed by two municipalities, Tequila and Amatitlan. Tequila production has grown to be an important industry, since 1974 when the certificate of origin was first issued. This legal instrument certifies that tequila is produced according to a standard, from a particular plant grown in a limited area and it is regulated by an industry body, the Tequila Regulatory Council (CRT) by its initials in Spanish. The certified zone of origin now includes 180 municipalities in five Mexican states: Jalisco (124), Tamaulipas (11), Michoacan (30), Nayarit (8) and Guanajuato (7). Only on these municipalities blue agaves can be grown for tequila production.

The certificate of origin has been an instrument to differentiate tequila in the international market and it has allowed increasing profits in the industry, some part of the extra profit has been invested in research and development to enhance field productivity (CRT 2002). Securing a profitable market for agave producers, blue agave production is now almost completely in the hands of industry, in a vertically integrated agro industry.

Nevertheless, it is the best example of how a natural resource traditionally used can, with proper organization, become a profitable industry.

Tequila production is an example of how plants from the arid and semi arid lands can also be cropped under high input commercial systems.

Conclusion

Through the examples mentioned so far, it is evident that the arid and semi arid plant resources can be the base of economic activity. Many species are currently managed in Mexico, other species have a potential as resource and could be used for fuel or raw material production, if research is done in this direction. Some short notes taken from a research report done in the United States and published in 1990 will be quoted to show the potential of some species, the full report can be accessed in: (http://www.hort.purdue.edu/newcrop/proceedings1990/V1-232.html)

6.4.5 Semi arid and arid plants with potential to produce oils.

➲ *Jojoba [Simmondsia chinensis (Link) Schneid, Buxaceae]*

Jojoba is an evergreen woody shrub native of Sonoran Desert in southern Arizona, California and Baja California. In Mexico it is becoming one of the first new arid-land industrial crops to reach commercialization. Jojoba seeds contain 40-60% of a chemically unique oil, which is more accurately characterized as a long straight-chain liquid wax of non-glyceride esters. Its chemical structure is very similar too and it can substitute readily sperm whale oil, the importation of which has been banned in the United States since 1971.

Commercial plantings of jojoba have only been made within the past 10 years. By 1982, over 10,500 ha were planted in Arizona and California. Prior to this, the limited amount of jojoba oil came from hand-harvested wild stands in Arizona, California and northern Mexico. Most of this production was utilized by the cosmetic industry, and because of the limited supply, the oil commanded a relatively high price. Currently, plantings are estimated at over 16,000 ha, many of which are coming into full production.

➲ *Lesquerella, Bladder Pod [Lesquerella fendleri (Gray) Wats, Brassicaceae]*

Vegetable oils containing hydroxy fatty acids are of industrial importance as chemical feedstocks for the production of lubricants, plastics, protective coatings, surfactants and pharmaceuticals. The United States and other industrial nations depend completely on imported castor oil for their total supply of hydroxy fatty acids. For various economical reasons in addition to problems associated with seed toxicity, allergenic reactions of field and processing workers and disposal of toxic seed meal after oil extraction, castor beans are no longer commercially grown in the United States. Because of its high content of hydroxy fatty acid (ricinoleic acid), castor oil is classified as a strategic material.

The annual cost of importing some 40-45 thousand metric tons of oil is usually around $40-45 million. Recently, attention has been given to species of Lesquerella as possible new domestic sources of hydroxyl fatty acids.

Lesquerella seed meal composition and quality were comparable to those of other cruciferous oilseeds including rapeseed and crambe. The meals are thought to be potentially useful protein supplements for feed grains since they are relatively high in lysine. Glucosinolates were found in quantities similar to that of other cruciferous seed meals, but goitrogenic substances (thiooxazolidones) were not found to be present. Thus, potential for seed meals for animal feeds usage greatly enhances the economic viability of lesquerella as a new crop.

➲ *Buffalo Gourd [Cucurbita foetidissima HBK, Cucurbitaceae]*

The possibility of domesticating and utilizing buffalo gourd along with other perennial cucurbits as new sources of vegetable oils and proteins was first suggested by Dr. L.C. Curtis (1946). There was a brief flurry of interest in this regard in the late 1940s and early 1950s. The attractive potential for production of edible seed oils, seed proteins, root starches and other by-products in one plant under environmental conditions stimulated a new burst of activity in the early 1970s. This research was spearheaded by the late Dr. William P. Bemis and coworkers at the University of Arizona, Tucson. Buffalo gourd's potential as a new arid-land crop was clearly enunciated and reviewed by Bemis et al. (1978, 1979) and Hogan and Bemis (1983). Results of the various facets of about 15 years of excellent multidisciplinary research have been well summarized: composition and functionality of potential food ingredients (Scheerens and Berry 1986); agronomic research (Nelson et al. 1983, 1988); and domestication (Gathman and Bemis 1990). In spite of this sustained effort, essentially all research activity on buffalo gourd's development as a new crop has ceased. The question about why such a developmental program should fail after such a good, sustained research effort that was spent on species with such potentially desirable characteristics arises. Buffalo gourd seemed to be tailor made for providing these essential food components plus starch, which could also have industrial implications. In addition, three unique factors were combined in this one species: perennial plant habit; an asexual mode of reproduction in addition to normal sexual reproduction through seeds and a method of producing hybrid seed using gynoecy, and multiple yield components consisting of seed bearing fruits for oil and protein, roots for starch production, and vines for animal fodder.

➲ *Grindelia, Gumweed (Grindelia camporum Greene, Asteraceae)*

University of Arizona's Bioresources Research Facility conducted extensive research that surveyed and evaluated a wide array of desert plants for their biocrude production potential (Hoffmann 1983, McLaughlin and Hoffmann 1982, and McLaughlin et al. 1983). Biocrude is the hydrocarbon and hydrocarbon-like chemical fraction of plants that may be extracted by organic solvents and upgraded to liquid fuel and chemical feedstocks. They demonstrated that plants producing either latex or resinous exudates had the highest percentage of high energy extracts. On the basis of these observations, attention was focused upon those plants that produced resins. One of the most promising of numerous species investigated was Grindelia camporum, which is an arid-adapted, herbaceous perennial found in the Central Valley area of California. Preliminary agronomic, breeding and genetic research was initiated in 1981. Hoffmann and McLaughlin (1986) reported that tetraploid lines of G. camporum will produce about 11,350 kg/ha-year of biomass by harvesting the stand twice and applying about 750 mm of irrigation water. This level of irrigation is low compared to the amount of water applied to most crops currently grown in the Southwest (McLaughlin 1985).

G. camporum also has other characteristics that favor domestication. It has an upright, herbaceous growth habit. Many accessions have an annual life cycle and the ability to regenerate growth from the root crown to produce two crops in a single growing season. The species has good tolerance to salinity and diseases as well as drought.

➲ *Euphorbia, Gopher Plant (Euphorbia lathyris L., Euphorbiaceae)*

Euphorbia lathyris, a latex-bearing plant, received world-wide attention for several years as a possible source of liquid fuels. Dr. Melvin Calvin (1978, 1979) first brought attention to the plant as a candidate for "petroleum plantations" since he believed it to be adapted to dry, semi-arid lands. He estimated that energy plantations of this species would produce annual yields of at least the equivalent of 25 bbl of crude oil per hectare. He reasoned that cultivation of marginal semiarid arid and lands would make good use of the long growing season and the highly intense solar radiation in these regions. Another positive factor would be that such a cropping system would not be directly competitive with conventional food, feed, and fiber production systems. Unfortunately, the high hopes and expectations were not realized. A rather comprehensive three-year research program was undertaken in 1979 at the University of Arizona in Tucson. The results of this research are well summarized by Kingsolver (1982). In brief, the developmental program was initiated with a logical, multidisciplinary approach. Germplasm was collected worldwide from 50 sources on six continents. Germplasm evaluation was conducted in greenhouse and field studies in 1980 and 1981. Agronomic studies were conducted to determine various cultural and water requirements. The first planting as a summer crop was a complete failure. It was found that euphorbia could be grown more successfully as a winter crop. Under these growing conditions it used 710 mm of water (irrigation requirement of about 1,000 mm) to produce a maximum of 15 tons of dry biomass and the equivalent of 7.5 bbl crude oil/ha. This yield was only about 30% of that originally estimated by Calvin, and clearly uneconomical. Another factor concerning euphorbia‘s failure to develop into a successful new crop was the limited usefulness of the plants chemical composition. The oil of E. lathyris is similar to crude oil, so that it can be catalytically cracked to produce a significant portion of fuel fractions (Kingsolver 1982). However, since fossil fuel crude oil was and still remains relatively low priced and in good supply, competitive market factors effectively dampened enthusiasm and support to continue funding research on euphorbia and other potential plant oil sources. To have a fighting chance of reaching commercialization, a bioenergy crop needs to contain a chemical composition useful as a product or a feedstock for products that are in some way unique and significantly more valuable than crude oil. Unfortunately constituent analysis of E. lathyris did not identify any potentially useful bulk specialty chemicals. The limited supply of fossil fuels may one day confer an economical and energetic advantage to the utilization of such plants as E. lathyris. When this point is reached, research and development may succeed in domesticating E. lathyris for commercial production of biocrude oil.

6.5 Mexican indigenous agriculture

6.5.1 Evolution of Mexican indigenous agriculture

The different ecosystems that form Mexico‘s landscape and its biodiversity are the base for multiple cropping systems development and, as it has been said, they gave origin to many of the world‘s cultivated plants. The strategy deployed by Mexican indigenous farmers has been to diversify crops and natural resource use. In most parts of Mexico peasants have a plot to farm, which in some places is still managed under slash and burn system. They also grow trees and perennials in the space surrounding their home and obtain many natural products from the non cultivated areas, based in an ancient traditional knowledge. This strategy has been presented in the case studies.

In general, in low input traditional agriculture intercropping perennial and annual crops has been common, dealing with the spatial and temporal distribution of several crops, to achieve production, with an integrated soil fertility and pest management strategy, under systems recently grouped under the term agroforestry.

Mexico has multiple examples of such systems in most of the regions. Though, apart from some remarkable exceptions, most of these systems are not well suited to a commercial agriculture context, and they remain part of the survival strategy for peasants. Its greatest inconvenient being the long maturation period to get to a profitable production and the great need of labor to perform the daily maintenance tasks, as there has been very little research and development of specific machines and tools to enhance labor productivity in these systems. Research priorities have been very far from the small peasant since the 1960‘s, when an international effort to breed maize and wheat to respond to industrial inputs, chemical fertilizers and pest control chemicals, originated the green revolution. This movement had deep consequences for the traditional agricultural systems and increased the productivity gap between peasant agriculture and those areas apt for an industrial input intensive agriculture, which normally are the areas with irrigation.

From 20 million ha cropped in Mexico, 6 million have irrigation; the value of crops in the irrigated areas represents 55 percent of the total crop value, which means that in irrigated land productivity is 3.7 times higher than rain fed areas. Thus, it must be noted that some production of non irrigated lands is to supply the farm house hold, and it is not traded or counted in national statistics.

3.3 million ha of irrigated lands belong to 86 irrigation districts that currently operate in Mexico, 58% this land is social property under the “ejido“ regime, the rest is private property. There are 560,000 registered water users, a mean of 5.893 ha per tenant.

The most important crops in the irrigated areas are: maize, wheat, sorghum, cotton and sugar cane.

Although irrigation infrastructure is owned by the Government of Mexico, since 1989 the responsibility for operating many of the irrigation delivery Districts had been transferred to the irrigators, with management via a Board of Management comprising landowners with irrigation farms in the respective Districts. The Board is chaired by the President, who is also a landowner.

The irrigation land is generally cropped in commercial input and mechanized agriculture, sometimes under contract agriculture, as the land tenure structure in Mexico did not allow land concentration to form large farms. This fact has influenced labor productivity and mechanization. Plowing, other seed bed preparation operations and sometimes harvest is done by custom machine contractors; weed control is done by animal traction and crop spraying, by men with knapsack sprayers.

In conclusion, Mexican agriculture faces enormous challenges to supply the needed food and raw materials for the fast growing population. In this context bioenergy opens a new opportunity field, whose full potential needs a consensus among different economic agents, which is not easy to achieve.

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