

## 1 INTRODUCTION

In the early 1970s, the majority of global cashew nut production (68%) took place in Africa, including countries such as Tanzania and Mozambique (Azam-Ali and Judge, 2001). In 2006, the world production amounted to 3,218,349 ton from a total harvested area of 3,867,385 ha. In this year, the five main cashew-producing countries were: Vietnam, Nigeria, India, Brazil and Indonesia, totalling 79% of total world production and covering up to 73% of the harvest area (FAO, 2008). Since the last five years, Vietnam and Nigeria have been offering a tough competition to traditional cashew producers like India and Brazil. The cashew industry ranks third in the world production of edible nuts. In 2000, the world production was about 2 million ton of cashew nuts in shell with an estimated value in excess of US\$ 2 billion. India and Brazil are the major cashew exporters, with 60% and 31%, respectively, of the world market share (ITC, 2002; FAO, 2007).

In India, cashew ranks second among farms exports. India started to export cashew nut in the early 20<sup>th</sup> Century with a small quantity, which has increased along the years (ITC, 2002). In 2005, India produced more than 400,000 tons, i.e. twice the amount produced by Brazil. The major world importers of cashew kernels are the United States, the Netherlands, Germany, Japan and the United Kingdom. The cashew kernels are ranked, as either the second or the third most expensive nut traded in the United States covering a great variety of uses. Retail prices range from about US\$9 to US\$23 per kg depending on the quality of the nut (Azam-Ali and Judge, 2001). The traditional and extensive market connections of exporters from Brazil and India make it difficult for smaller exporters to make gains in the United States market (The Clipper, 1994). Importers may appreciate the low prices offered by small suppliers, but the lack of reliability in quality tends to make them favour the larger, more reputable suppliers. In 2005, India and Brazil were the major exporters of cashew nut in the world reaching 548 million tons. The worldwide cashew processing is very competitive and generally exploited by small-scale processors. In Brazil, cashew is a very attractive crop for small-scale producers because it requires few inputs and harvesting does not coincide with the peak labour demand for other food crops as beans and cassava, which are largely consumed domestically.

The economic value of cashew cultivation in Brazil was recognized during the Second World War, when there was a considerable demand for cashew nut shell liquid in North America. Owing to this, the expansion of the areas cultivating cashew began in the 1960s through governmental incentives. This increase in production allowed Brazil to set foot in the international market (Azam-Ali and Judge, 2001; Moreira, 2002). Cashew is predominantly a smallholder crop in Brazil with about 90% of cashew trees are grown by small-scale farmers (Azam-Ali and Judge, 2001). The smallholder

units are important economic-social groups within rural areas of North-east Brazil, supplying the domestic market with cash crops such as cashew. However, its production generally spans during just four or five months per year (Sietz *et al.*, 2006). Small producers constitute 70% of the cultivated area, possessing orchards of 10 ha on average (Meilwes, 2006). Cashew production is more significant in areas near to coastal regions, where cashew trees are under optimum climate conditions. In 2006, about 11% (or 710,404 ha) of cultivated area of permanent crops in Brazil was occupied by cashew crops. In Brazil, the cultivated area with cashew trees is restricted to the North, North-east and Centre-west regions (IBGE, 2007a).

The North-east is the most important region for cashew cultivation. The cashew tree has a great importance in the economy of North-east, mainly for maintaining the employment level and income of rural producers, as well as for providing a source of external resources to Brazil. According to EMBRAPA (2002), just the production chain of cashew tree in the State of Ceará involves about 300 thousand people. In 2003, alone the cashew tree production chain, covering 372,000 ha, produced 110,000 tons of cashew nut in shell and 32,000 tons of cashew kernels, with an export volume of US\$ 110 million, including US\$ 2.27 million for cashew nut shell liquid (known as CNSL) (FAEC, 2004). However, the cashew production chain in North-east is considered insufficient and the production segment, presently with low productivity, could compromise the whole business not just regionally but also nation-wide. This prevents the country from competing on the international agribusiness market (Almeida and Soares, 1995).

Currently, 90% of the total cultivated area of cashew trees is characterized by the presence of the common type, considered by most experts as the main reason for low productivity in the sector (Almeida and Soares, 1995; Andrade, 2004). Among several suggestions to increase the productivity of the orchards, the substitution of the common cashew tree type for the dwarf-precocious cashew tree is advocated. The dwarf-precocious cashew tree has a productivity rate of 1,300 kg/ha of cashew nut and could eventually reach 4,000 kg/ha under irrigation, compared to 220 kg/ha for the common type of cashew tree (Barros and Crisóstomo, 1995). Therefore, possible increase in production could stabilize the national market, whilst simultaneously raising the quality of cashew products. The low productivity of the cashew systems in the North-east is an enormous problem, resulting low profitability for the producers, mainly smallholders (Leite, 1994). The irregular production can discourage agro-industry and consequently induce a demand change by final consumers (Lima, 1988; Klemenz, 2004). Furthermore, the agricultural producers might find themselves unwilling to continue working in this segment, and would start shifting to other crops,

which in turn could eventually phase out cashew production in North-east Brazil. This possible trend should not be considered as an isolated factor in the rural sector.

Due to the downward spiral of cashew production, the Brazilian government established the PROCAJU project in 2000 in an attempt to stimulate and strengthen the cashew segment in the north-eastern region. The PROCAJU project involves six out of the nine north-eastern states, namely Bahia, Ceará, Maranhão, Pernambuco, Piauí and Rio Grande do Norte. In Ceará, the PROCAJU project involves 45 municipalities (Andrade, 2004). Besides the federal government, other Brazilian and foreign institutions, such as German research institutions, showed great interest in studying the problems concerning the cashew sector in the North-east region. Brazilian institutions included the Federal University of Ceará (UFC) and the Brazilian Enterprise for Agricultural Research (EMBRAPA). Whereas the German partners are the Unit of Tropical Agriculture of the Institut of Crop Science and Resource Conservation (INRES) of the University of Bonn and the Institute for Technology in the Tropics – ITT (University of Applied Sciences of Cologne).

This international partnership resulted in a common research project entitled: Potential analyses and development for an integrated utilization of cashew raw material in Ceará, Brazil. Therefore, the present study is a result of this bilateral cooperation project between Germany and Brazil. However, the main objective of the research was to assessment the cashew farming systems in the states of Ceará and Piauí, identifying main components that take part into the ecosystems. In order to accomplish this objective, it was important to:

- i. To describe general information about the cashew farmers and their systems (e.g. social composition, gender, production systems and agricultural practices); to identify the factors that affect the cashew nut productivity and; to characterize different types of cashew systems in both states.
- ii. To evaluate the litter fall and biomass partitioning between the common and the dwarf-precocious cashew types. In additional, to describe structure and parameters between the two types of cashew trees.
- iii. To relate inputs and outputs in the cashew systems using a common yardstick as well as the efficiency of the use of natural and economic resources in the systems.

## **2 LITERATURE REVIEW**

Agriculture has the important role of providing food for the rural and urban populations of any country. Agricultural needs are to increase annually, in order to keep up with the increasing world population. The most difficult challenges for agriculture are just beginning in spite of past improvements in food production (Pretty, 1995). In developing countries, food productivity has increased in the last decades, stirring various discussions about the process of the sustainable development in the world. The term of sustainability was earlier used in the context of productivity either as a descriptive feature of ecosystems (Becker, 1997). This author affirms also that the concept of sustainability is based on three aspects: ecological, social and economic. Sustainability is the ability of a system to maintain productivity in spite of a major disturbance (intensive stress) (Conway, 1983). In other words, this concept has a direct relationship with an agricultural potential of each country or region of the world.

### **2.1 Agro-ecological zones of Brazil**

Brazil is a country in South America with a territory of roughly 8,514,876 km<sup>2</sup>, of which 64% is considered potential farmland (FAO, 2004). The national territory extends from north to south over around 4,390 km (5°16'20" N to 33°44'32" S latitude) and from east to west over around 4,310 km (34°47'30" E to 73°59'32" W longitude) (IBGE, 2007b). Bounded by the Atlantic Ocean on the east, Brazil has a coastline of over 10,900 km in length. On the west side, in clockwise order from the south, the country has 15,719 km of borders with Uruguay, Argentina, Paraguay, Bolivia, Peru, Colombia, Venezuela, Guyana, Suriname and French Guyana (IPECE, 2006). Despite its vast territory, the population of Brazil is concentrated in the major cities of its coast. The population of Brazil amounts to 50 million families (or 180 million inhabitants) and 81% is concentrated in urban areas (IBGE, 2007b). Brazil has twenty-six states and one federal district, divided conventionally into five regions: North, South, North-east, South-east and, Centre-West.

According to IBGE (2007b) there are 5,564 municipalities in Brazil, which have municipal governments. Many municipalities are divided into districts, which do not have political or administrative autonomy. Each of the five major regions has a distinct ecosystem. The regional administrative boundaries do not necessarily coincide with ecological boundaries. The differences in physical environment, patterns of economic activity and population settlement vary widely among the regions. Brazil lies on the Equator and the Tropic of Capricorn. Each Brazilian region

has a typical fauna and flora for example the Amazon rain forest which is home to a vast array of natural species, flora and fauna and extensive natural resources (Appendix 1).

*Soils and Vegetation.* Brazil is characterized by a large diversity of soil types resulting from the interaction of climate, vegetation and associated material (Caldeiron, 1992). In Brazil, the diversity and potential uses are reflected particularly in each region of the country.

The North region covers around 45% of the surface of Brazil that comprises plains and low plateaus. The soils are deep, highly-weathered, acidic and of low natural fertility (EMBRAPA, 1999; IBGE, 1989). The soils are commonly saturated with exchangeable aluminium that is toxic for most plants species which considerably reduces the productive potential of the land (FAO, 2004). Except for the state of Tocantis, where the savannah (cerrado) plays a major role, the Amazon rain forest covers the North region. Hundreds of plant species with an economic or social value in the Amazon biome, including fruit-bearing, oil and medicinal plants were estimated (Vieira, 1999).

In the North-east, most soils possess medium to high natural fertility, but a large proportion is shallow due to a low degree of weathering. They are sometimes associated with salinity and high levels of sodium, which is the main factor limiting of productivity in the north-eastern region (Caldeiron, 1992). This region is mainly characterized by the biome of “caatinga” that extends over areas of north-eastern states (Andrade-Lima, 1981). The “caatinga” is characterized by xerophytic vegetation typical of a semi-arid climate. Various fruit species and medicinal plants have their centre of genetic diversity in the North-east and the use of local medicines is therefore common (Coimbra-Filho and Camara, 1996; Vieira, 1999). Several family species belong to the “caatinga”, e.g. Euphorbiaceae (*Sapium lanceolatum* Huber), Anacardiaceae (*Schinopsis brasiliensis* Engl.), Leguminosae (*Senna spectabilis* - DC.), Boraginaceae (*Cordia trichotoma* - Vell.) among others (Maia, 2004).

The Brazilian Central Plateau, which is a plain formed by natural erosive processes is located in the Centre-West region. Extensive areas in this region are composed of deep and well-drained soils with low fertility but easily corrected by liming and fertilization (IBGE, 1988). Most soils in this region possess favourable physical characteristics and topographical conditions which significantly contribute agriculture. The centre-western region has a low demographic density when compared to other regions. This could also be because the “Pantanal” as well as a small part of the Amazon rain forest in the north-west cover a part of its territory. The region is also covered by the “Cerrado”, which is the largest savannah in the world (Kaimowitz and Smith, 1999; IBGE, 1988).

The South-east region is characterized by plateaus and highland areas and its soils are predominantly deep and usually of low natural fertility. The soil in this region is generally composed of latosols (56%) and argilosols (20%) (EMBRAPA, 1999). Its vegetation is characterized by the appearance of tropical semiciduous forests. In the North of this region there is a semi-arid area with almost no vegetation. In the West and in the North-east there is the characteristic “cerrado” (similar to savannah) (IBGE, 1990).

In the South, the soils originated both from basic rocks and sediments viz.; latosols (25%), neosols (23%) and argilosols (14%) (EMBRAPA, 1999). The vegetation of the southern region consists of rain forest along the coast, called “Mata Atlântica”, with tropical semiciduous species in the North and in the West. There are also needle-leaved pine woods that cover the highlands and grasslands similar to the Argentine pampas covering the sea level plains (Caldeiron, 1992).

*Climate, temperature and rainfall.* More than 90% of Brazilian territory lies within the tropical zone, between the Equator and the Tropic of Capricorn. However, the climate in Brazil varies considerably from the mostly tropical North, where the Equator traverses the northern region, to temperate zones below the Tropic of Capricorn, which crosses the country at the latitude of the state of São Paulo, located in the south-eastern region (Appendix 2).

Brazil has five climatic regions: humid equatorial, tropical, tropical of altitude, tropical Atlantic and semi-arid/subtropical (Rao and Hada, 1994). The most part of North region is dominated by a humid equatorial climate and is characterized by average annual temperatures between 24°C and 26°C and annual thermal amplitude<sup>1</sup> of up to 3°C (Nimer, 1989). The northern region receives abundant and regular rainfall (more than 2,500 mm/y) and in the winter, the region can have cold fronts from the Antarctic polar mass (IBGE, 1989). The regions of Centre-west, North-east and South-east are dominated by a tropical climate, with hot and humid summers as well as cold and dry winters. In these areas, the temperature exceeds 20°C and the rainfall ranges from 1,000 mm/y to 1,500 mm/y (Nimer, 1979). The South region together with parts of south-eastern and of centre-western regions have a tropical altitude climate, with average temperatures between 18°C and 22°C and an annual thermal amplitude of 7°C - 9°C. The average rainfall is similar to that observed with tropical climate (Algarve and Cavalcanti, 1994). The North-east and part of the southern region are influenced by the tropic Atlantic climate. The temperature varies between 18°C and 26°C and the amount of rainfall is about 1,500 mm/y (Kousky, 1980). The north-eastern region is also

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<sup>1</sup> The thermal amplitude is the difference between the maximum and the minimum temperatures registered during one period.

characterized by semi-arid climate, with an average temperature of 27°C and rainfall that does not exceed 800 mm/y. The subtropical climate prevails in the regions of South-east, Southern and Centre-west and is characterized by average temperatures below 18°C with rainfall amounting to 1,500 mm/y to 2,000 mm/y (Kousky, 1979; Cavalcanti, 1982).

## **2.2 Agricultural structure in Brazil**

During the colonial period in Brazil (1500-1822), the national production was intimately linked with agricultural activities, mainly sugar cane planted along the coast using forced labour (manual slave labour), which used to be commonplace in agriculture. The first Portuguese colonialists adopted an economy based on the production of agricultural goods. Tobacco, cotton and some other agricultural products were produced but sugar cane was the main product at that time, also known in Brazilian history as the Sugar cane Cycle (16-18<sup>th</sup> Century) (Prado Júnior, 1974; Girão, 1964). Coffee was another important crop for Brazilian agriculture. It was introduced in Brazil in the early 18<sup>th</sup> Century, but was planted initially only to supply to the domestic market. Its production was concentrated in the mountain region (Mata Atlântica) near Rio de Janeiro. From the area close to Rio de Janeiro, coffee production moved along the Paraíba Valley toward the state of São Paulo which later became Brazil's largest export region in the 19<sup>th</sup> century (Prado Júnior, 1974).

Another important crop in the history of Brazilian economy was rubber, especially during the periods between 1879-1912 and 1942-1945 (during the Second War), known at the time as Rubber Boom and Second Rubber Boom, respectively. The cultivation of Rubber was concentrated in the North Region in the cities of Manaus, Porto Velho and Belém (Weinstein, 1983). Brazil has experienced in the last decades the greatest changes in the occupation of its agrarian space since the colonial period (IBGE, 2007b). In this periodo many agricultural products have been cultivated. Actually, the agriculture in Brazil is highly diversified and its impressive performance has placed the country among the world's competitive exporters of agro-industrial products (Jales *et al.*, 2006). From 1949 to 1955, the primary sector of the Brazilian economic activity contributed about a quarter of the national Gross Domestic Product (GDP). However, the Brazilian macroeconomic situation shows that the share of the primary sector declined from 21.36% in 1947 to 5.52% in 2005. This reduction in the agricultural sector is probably due to the fact that some areas of the agricultural sector are characterized by primitive and labour intensive production systems. However, other domains are producing intensively, with modern tools and dynamic processes. Nowadays, Brazil is considered one of the world's largest exporters of agricultural products.