Global Assessment of Biomass and Bioproduct Impacts on Socio-economics and Sustainability

Project No: FP7-245085

Global-Bio-Pact Case Study

Socio-Economic Impacts of the sugarcane-to-ethanol production chain in Costa Rica

WP 2,3,5,6 – D2.4

May 2011

Units

k: kilo, 10^3

M: million, 10^6

Area: hectare

1 ha = 1.43 mz (*manzana*)

Currency: Euro

Following exchange rates have been used in conversion

1 EUR = CRC 700

1 EUR = USD 1.4

EUReq stands for the converted value in EUR of values expressed in local currency

Time

d: day

h: hour

p.h: person.hour

yr: year

Volumes

kg: kilogram

l: litre

tn: metric ton. 1 tn = 1,000 kg

W: watt

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Contents

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Abbreviations

ASP	Protected Wildlife Area
CATIE	*Centro Agronómico Tropical de Investigación y Enseñanza*
CATSA	*Central Azucarera Tempisque sociedad anónima*
CST	Certification for Sustainable Turism
DIECA	*Directorio de Investigación y Extensión de la Caña de Azúcar*
FAO	Food and Agriculture Organization
FST	Forest Stewardship Council
GDP	Gross Domestic Product
IMN	*Instituto Meteorológico Nacional*
IDA	*Instituto de Desarrollo Agrario*
ISCC	International Sustainability and Carbon Certification
JAPDEVA	*Junta de Administración Portuaria y Desarrollo Económica de la Vertiente Atlántica Puerto Limón*
LAICA	*Liga de la Caña y el Azúcar en Costa Rica*
MINAE	*Ministerio de Ambiente y Energía*
MINAET	*Ministerio de Ambiente, Energía y Telecomunicación*
PNUD	*Programas de Naciones Unidas para el Desarrollo*
SEPSA	*Secretaria Ejecutiva de Planificación Sectorial Agropecuaria*
SINAC	*Sistema Nacional de Areas de Conservación*
UNA	*Universidad Nacional* (National University, Costa Rica)
USA	United States of America

Preface

by Copernicus Institute, Utrecht University (UU)

This report was elaborated in the framework of the Global-Bio-Pact project (Global Assessment of Biomass and Bioproduct Impacts on Socio-economics and Sustainability) which is supported by the European Commission in the Seventh Framework Programme for Research (FP7). Global-Bio-Pact is coordinated by WIP Renewable Energies and runs from February 2010 to January 2013.

A strong public debate on sustainability aspects for biomass use for energy and products emerged in the last few years in Europe. This debate focused mainly on negative social and environmental impacts. In consequence, several initiatives were set-up, which are engaged in developing tools to improve sustainability of biofuels. One option to improve the sustainability of biofuels is the application of certification systems.

The main aim of Global-Bio-Pact is the improvement and harmonisation of global sustainability certification systems for biomass production, conversion systems and trade in order to prevent negative socio-economic impacts. Thereby, emphasis is placed on a detailed assessment of the socio-economic impacts of raw material production and a variety of biomass conversion chains. The impact of biomass production on global and local food security and the links between environmental and socio-economic impacts are analysed. Furthermore, the Global-Bio-Pact project investigates the impact of biomass production on food security and the interrelationship of global sustainability certification systems with international trade of biomass and bioproducts as well as with public perception of biomass production for industrial uses. Finally, Global-Bio-Pact focuses on socio-economic sustainability criteria and indicators for inclusion into certification schemes, and the project elaborates recommendations on how to best integrate socio-economic sustainability criteria in European legislation and policies on biomass and bioproducts.

A core activity of Global-Bio-Pact is the description of socio-economic impacts in different countries and continents in order to collect practical experience about socio-economic impacts of bioproducts and biofuels under different environmental, legal, social, and economical framework conditions. The results of these surveys are described in different case studies:

- Biodiesel from soy in Argentina
- Palm oil and biodiesel in Indonesia
- Ethanol from sugarcane in Brazil
- Ethanol from sugarcane in Costa Rica
- Jatropha oil and biodiesel in Tanzania
- Jatropha oil and biodiesel in Mali
- 2nd generation biofuels and products from lignocellulosic material in Europe and North- America

The present report presents the Global-Bio-Pact Case Study for the sugarcane-to-ethanol supply chain in Costa Rica. This Case Study was elaborated by CATIE, the regional Research and Education Centre on Tropical Agriculture (www.catie.ac.cr).

1 Introduction

Costa Rica offers representative features of a tropical country with a long history of sugarcane production in a diversity of landscapes (coastal plain, central mountain). Its size and geography lead to models of relatively small-scale production. Its economy is quite open to international trade and investments. The USA, Colombia and Brazil are influencing biofuel technological developments.

Figure 1: Map of Central America

Sustainability certification is not a whole new theme in Costa Rica

The issues of sustainability and certification are important and current issues in Costa Rica, a country hosting biodiversity hotspots, touristic activities and dynamic agro exporting businesses.

Since long, Costa Rica has been trying to both defend its natural capital and take advantage of international investment and market opportunities for some tropical agricultural products (pineapple, ornamentals, coffee...) as well as for industrial and high-tech products (components for medical equipments, computer chips,...).

The country is therefore quite proactive in sustainability standards, engaged in different certification procedures with environmental and social standards, such as FSC (forestry), Rainforest alliance (coffee), CST (tourism), and already for sugarcane ethanol, the ISCC (International Sustainability & Carbon Certification).

Quite small-scale production schemes

As in its Centro American neighbour countries, climate conditions are favourable to high yielding biomass feedstock such as sugarcane and African palm.

However, geographical characteristics (central volcanic mountain range, coastal areas on both western and eastern fringes...) and active forest and biodiversity conservation policies make it impossible to think of large scale production schemes or, better said, "large-scale"

does not have the same meaning in Costa Rica and in South American countries such as Brazil or Argentina.

Little space for the expansion of sugarcane

Costa Rica has actively developed its agro-export sector, with quite high value-added products. Simultaneously land has growingly been solicited for urbanization and tourism.

Therefore the land where sugarcane is grown cannot increase much unless entering in competition with other land uses, agricultural and non-agricultural. However, decisions on agricultural land and practices must be considered within comparative outlooks, also accounting for complementarities between land uses (calendar of activities, market diversification, climate sensitivity…).

Ethanol production in specific circumstances

Costa Rica is dehydrating Brazilian ethanol, later exported to the USA with tariff exemption. Ethanol fuel can be produced out of locally grown sugarcane in two plants in the country, but has not started yet on an important and regular basis, because relative prices of sugar and ethanol do not provide adequate incentives. Therefore the evaluation of the socio-economic impacts of ethanol production is based on quite specific data and represent a rather *ex ante* evaluation of impacts that can be expected from the development of ethanol production in Costa Rica if the national biofuel programme aiming at substituting 10% of national fuel consumption were really implemented.

2 Case Study selection

Since the impacts of the production of biofuels and bioproducts depends on the investigated scale, different levels were considered in Global-Bio-Pact Case Studies, including the national, regional, and local/company/project level (Figure 2).

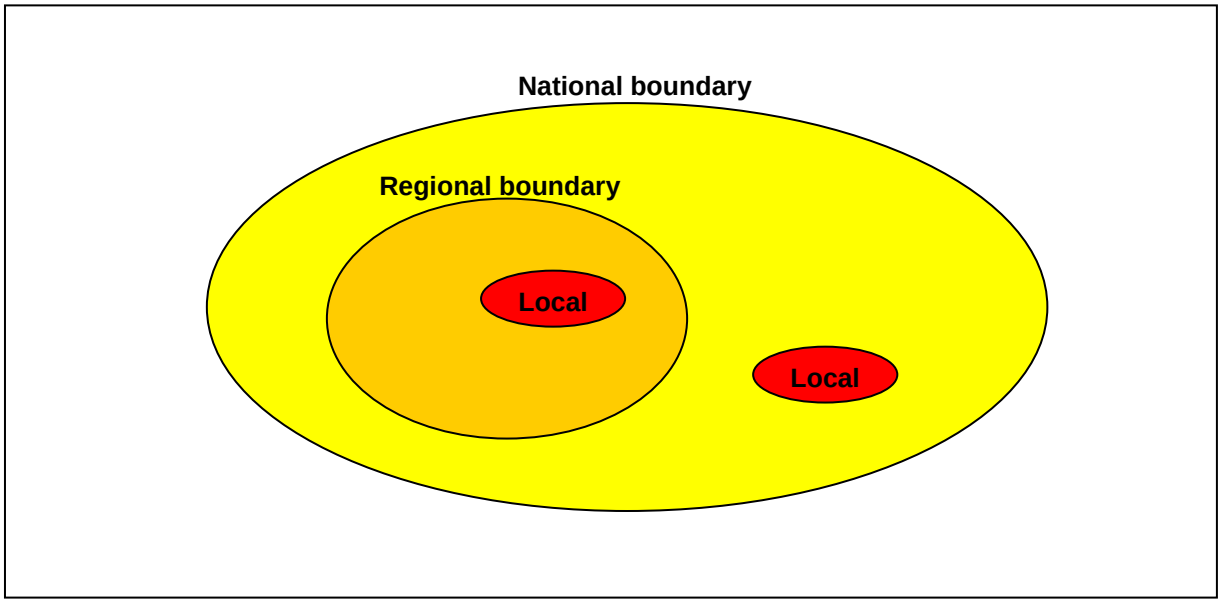


Figure 2: System boundaries of the Global-Bio-Pact project

However, given the small size of Costa Rica (51,100 km^2) and the limited volumes of sugarcane ethanol production (only 2 distilleries with a total capacity of 54 million liters), only the two following assessments were made (Figure 3):

- One study at national level
- One study at company level

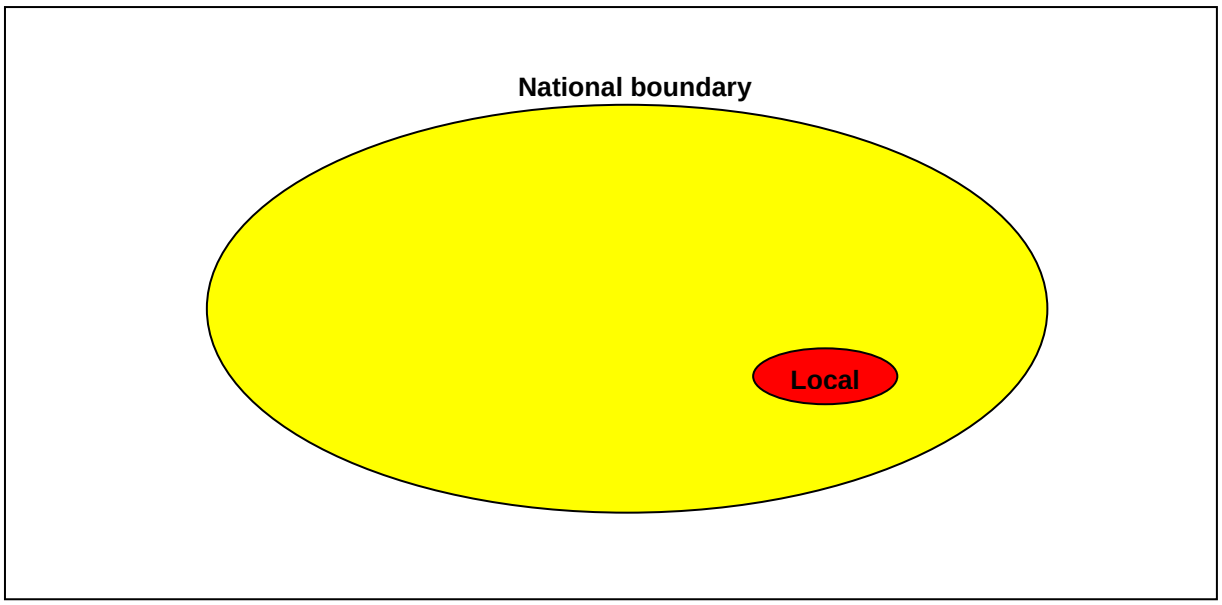


Figure 3: System boundaries of the Costa Rica case study

2.1 Case Studies at national level

The present report presents the Global-Bio-Pact Case Study for sugarcane ethanol in Costa Rica.

2.2 Case Study at local level

In the present report, CATSA case was selected.

CATSA is one of the two companies involved in the production of sugarcane and its transformation to sugar and ethanol. Its characteristics are not very different from Taboga, the other sugar mill with a distillery, located nearby. Access to information resulted impossible at Taboga.

3 General description of the Case Study

3.1 Case Study at the national level: Costa Rica

3.1.1 Land use

The area of Costa Rica is 5.1 Mha.

As synthesized in Wikipedia accessed in February 2011: "*Costa Rica is located on the Central American Isthmus, surrounding the point 10° north of the equator and 84° west of the prime meridian. It borders both the Caribbean Sea (to the east) and the North Pacific Ocean (to the west), with a total of 1,228 km of coastline [...]. Costa Rica shares a border with Nicaragua to the north and with Panama to the south.*"

The nation's terrain is coastal plain separated by rugged mountains, including over 100 volcanic cones, of which several are major volcanoes. The Central and Talamanca *Cordilleras* form the spine of the country and separate the Pacific and Caribbean watersheds.

Forest area is approximately 2.5 Mha: 2.4 Mha (FAO, 2010); 2.6 Mha according to (Mongabay 2011).

Table 1. Breakdown of forest types

Primary forest	0.623 Mha	24%
Other naturally regenerated forest	1.741 Mha	67%
Planted Forest ,	0.241 Mha	9%

Source: Mongabay 2011

Agricultural area is of 505,000 ha, 46% of which is dedicated to crops and the rest to livestock (SEPSA 2009)

Amongst Latin American and Caribbean countries, Costa Rica is a major producer of fruits and milk (Pardey *et al*., 2009) (Table 1).

Table 2. Distribution of agricultural land use

crops	***share of cropland (%)***
industrial crops (coffee, sugarcane, oil palm, orange, palm hearts, coco, cocoa, macadamia nuts, black pepper, tobacco)	53
fresh fruits (banana & plantain, pineapple, melon, watermelon, mango, papaya, strawberry)	22
staple crops (rice, maize, beans)	19
tropical roots and tubers (cassava, yam, ginger...)	4
vegetables (potato, onion, tomato, chayote)	1

Source: SEPSA 2009

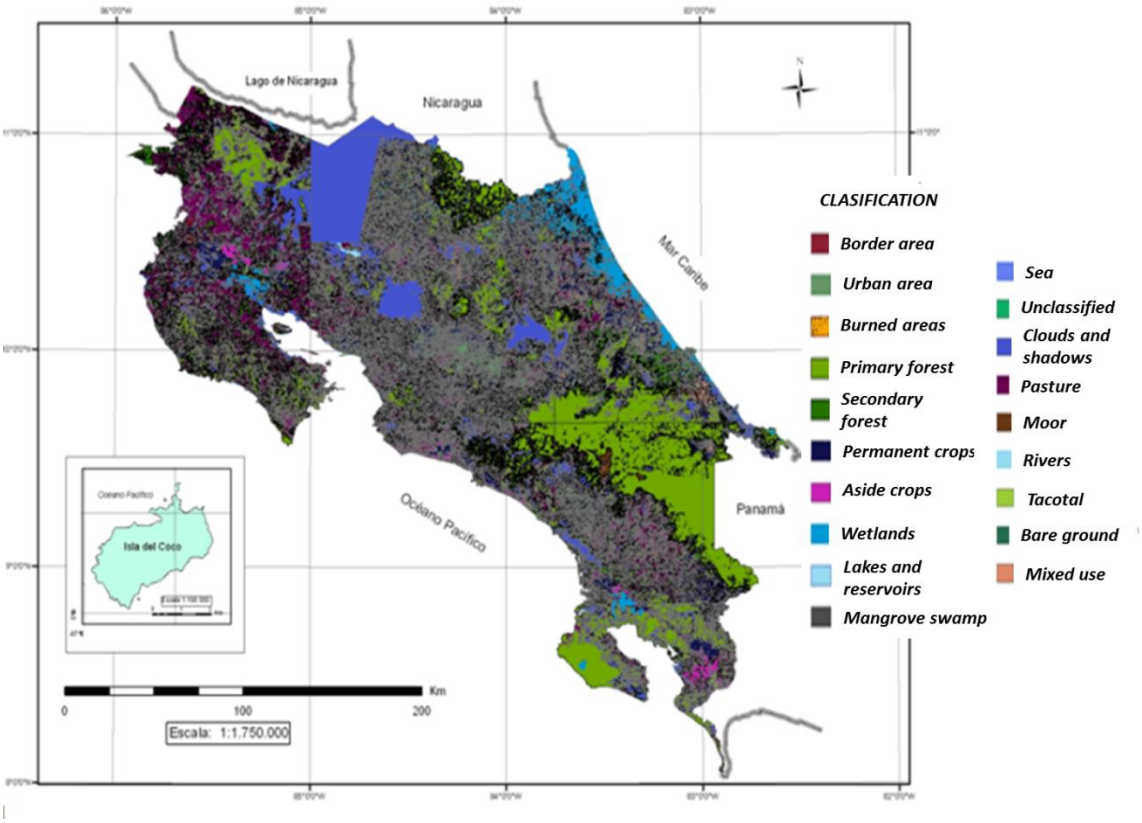


Figure 3. Map of land use in Costa Rica

Source: PNUD- IMN-MINAET 2009

3.1.2 Economy

A developing country of the upper middle income category, Costa Rica has relatively high economic indicators compared to its neighbour countries. However its economy is fragile, dependent on foreign investments, suffering inflation (8.3% in 2009) and the lack of maintenance and new investment in infrastructure. Unemployment rate is estimated at 7.8% for 2009, out of a labour force of 2.09 millions.

Though relatively low, poverty levels have not been reduced recently, fiscal and trade deficits are growing.

Gross domestic product is estimated at USD 35 billion for 2010, EUR 25 billion (BCCR 2011; CINDE 2009).

Per capita basis, GDP is then reaching USD 7,000 (EUR 5,000) on a nominal basis, USD 11,000 (EUR 7,860) on purchasing power parity (PPP) basis, approximately the same level as Belarus.

GDP growth has been negative since the 2008 recession: -1.1% GDP growth in 2009.

Table 3. GDP composition

sectors	*GDP (%)*
Manufacturing industry	18.4
Municipal, social and personal services	16.7
trade, restaurants and hotels	17.8
transport, storage and communications	9.1
agriculture, forest and fisheries	6.5
others (mainly services but also industry)	31.5

Source: MAG 2010; SEPSA 2009

The economy of Costa Rica heavily depends on tourism, agriculture, and electronics exports.

In the last three decades, the country has modified its productive structure. Electronics, pharmaceuticals, financial outsourcing, software development, and ecotourism have become the prime industries in Costa Rica's economy.

However, coffee, bananas, pineapple, sugar, lumber, wood products and beef are still important exports. Diversification efforts have led to develop economic activities of suppliers to processing industries (concentrates, juice, vegetable oils) and to tourism (Gómez 2008).

High levels of education make the country an attractive investing location, as well as its tax exemption regime in 12 *zonas francas*, mainly in the urban area of the capital city, San José and surrounding main cities of Heredia, Alajuela and Cartago.

Poverty is growing in Costa Rica, where 21.3% of the population is living below the poverty line, including 6% in extreme poverty, respectively 1,103,522 and 311,031 persons (INEC, 2010).

There are higher levels of poverty and it is more disperse in rural areas (26.3%) than in urban areas (18.3%) where poverty is more punctual (INEC, 2010, Céspedes y Jiménez 2009).

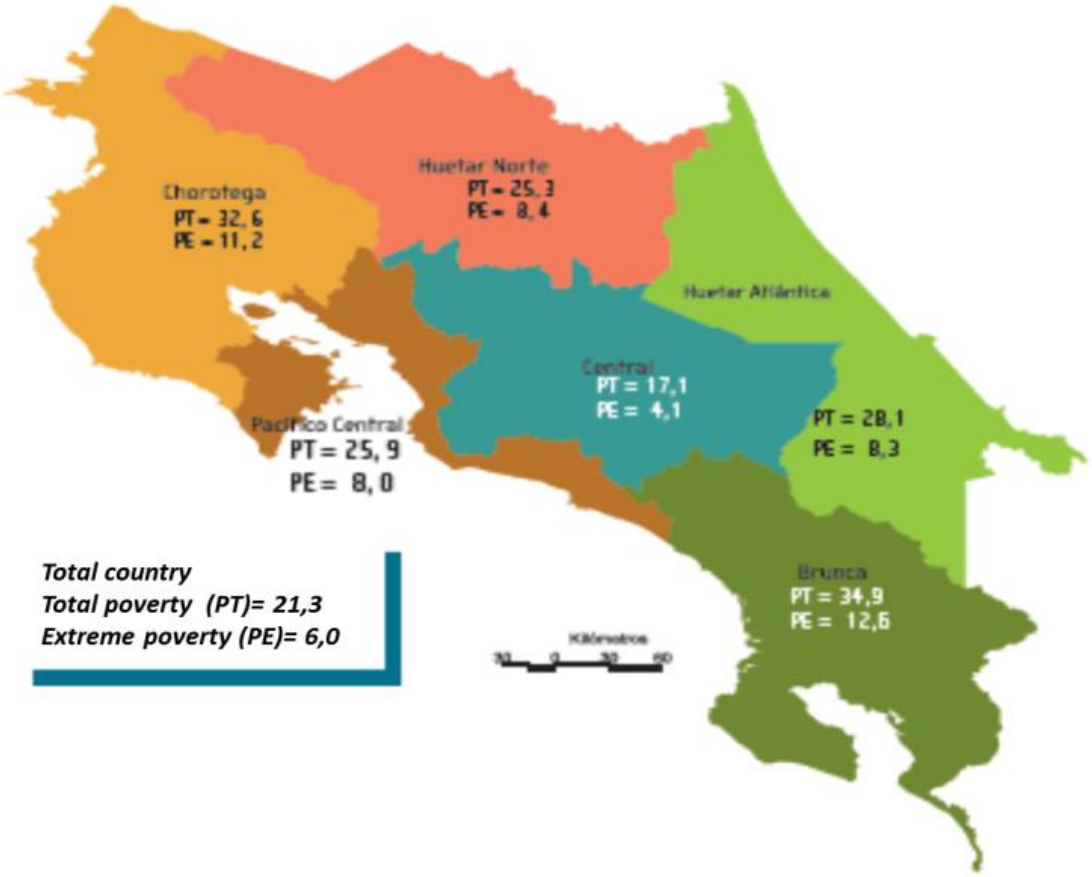


Figure 4. Poverty per region

"PT": beneath the poverty line, includes "PE": extreme poverty

Source: INEC (2010)

Costa Rica's Gini index calculated on 2003 data and reported in the 2007/08 UNDP, is 0.498. Though lower than in other Central American countries except for Nicaragua, the Gini index is increasing in Costa Rica. In its last edition (2011), the national programme "Estado de la Nacion" (www.estadonacion.or.cr/images/stories/informes/016/2-CAP%202.pdf) gives the following values: 0.374 in 1990, 0.412 in 2000, 0.406 in 2005, 0.421 in 2008 and 0.437 in 2009.

3.1.3 Population

The population of Costa Rica is approximately 4.6 million, principally in the 25-59 age range.

The annual population growth rate is estimated at 1.4%. Fecundity rate is 1.8, one of the lowest of Latin America. Immigration to Costa Rica (from Nicaragua and Columbia principally) is three to four times higher than emigration (to the USA principally).

As shown in the map, the most densely populated region in the Central Valley, where the economic activity is concentrated.

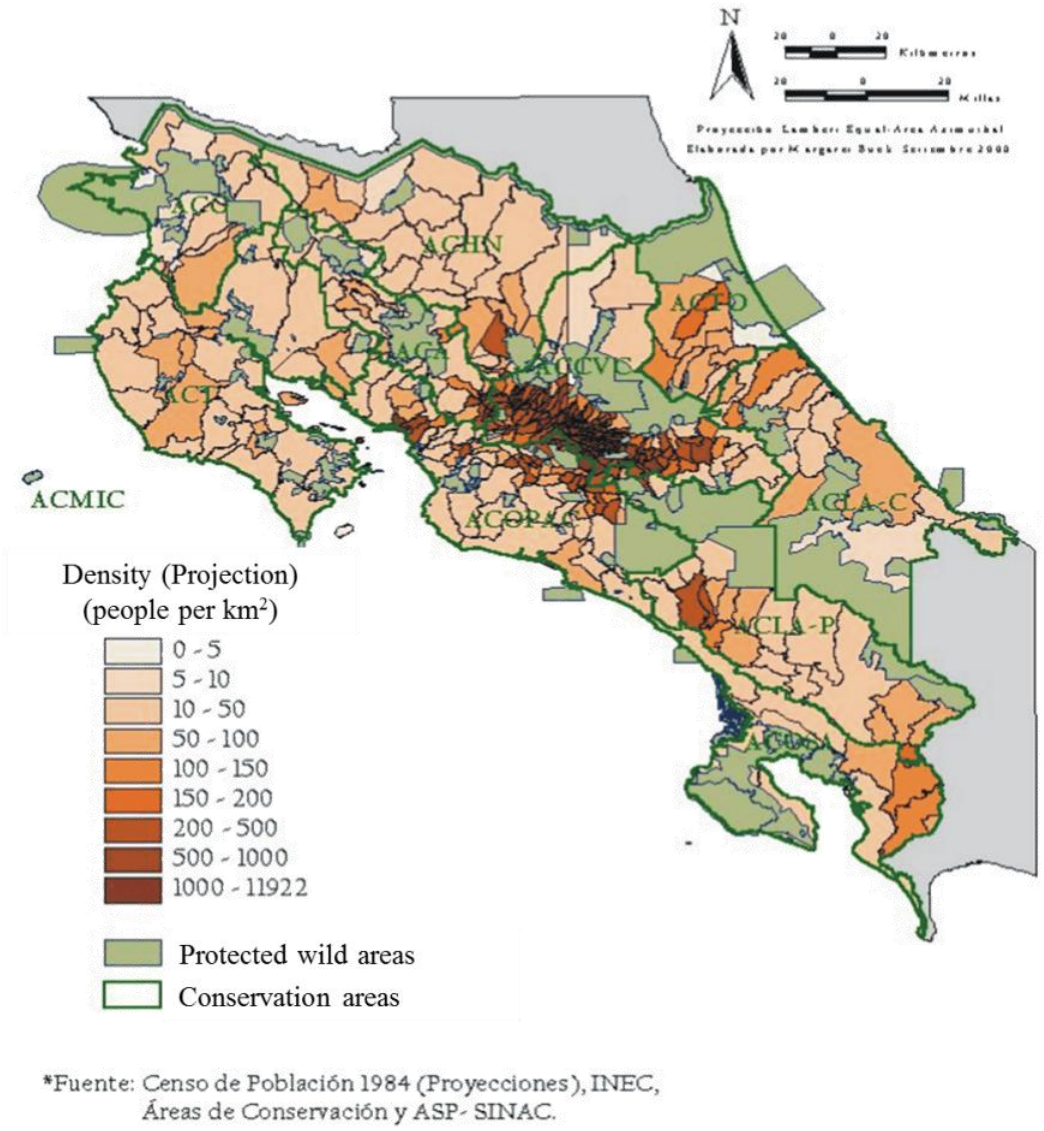


Figure 5. Population density (1984 census data)

Source: INEC 2010.

More than 95% of the population descends from European countries, mainly Spain, and 3% from Afro-Caribbean ones, mainly Jamaica.

Indigenous people represent 1.7% of the national population. They mainly live in Talamanca, in Limon province, with higher poverty levels than in the rest of the country. Costa Rica has 8 of the 14 ethnic groups living in Centro America (where the share of indigenous people is 24%). Additionally, Miskitos from Nicaragua and Ngäbes from Panamá come to work in Costa Rican agriculture mainly (Carballo 2004).

Life expectancy, 79.1 years, is the highest of Latin America. The literacy rate of 95% is amongst the highest, also at the world level for developing countries (INCAE 2010; CINDE 2009; PNUD 2009).

Labour force represents 52.1% of the population. The informal sector tends to increase (Tókman 2007; OMS 2009).

Households have an average composition of 3.7 persons, including an average workforce of 1.58. (MIDEPLAN 2010; INEC, 2010; Estado de la Región 2008).

Average annual income per household is estimated at CRC 804,336, approximately EUR 1,150;

33.7% of the households are led by a woman, 41% of these households are in extreme poverty.

3.1.4 Agricultural sector

According most recent data by FAOSTAT (year 2008 and 2009),

- Main agricultural land uses include (in decreasing order): coffee (99 thousand hectares in 2009), rice (63), palm oil (55), sugarcane (53), bananas (43), pineapples (39), cassava (30, starting to rise in 1989)), oranges (25, starting in 1984 and rising in 2004), beans (16), maize (11).

Between 1990 and 2005, areas with rice, beans, maize and sorghum have diminished by 52% (CEPAL, 2008b). Sorghum area that had risen in the 70's, and reached 25 thousand hectares, declined abruptly in 1984 and disappeared in the early 90s.

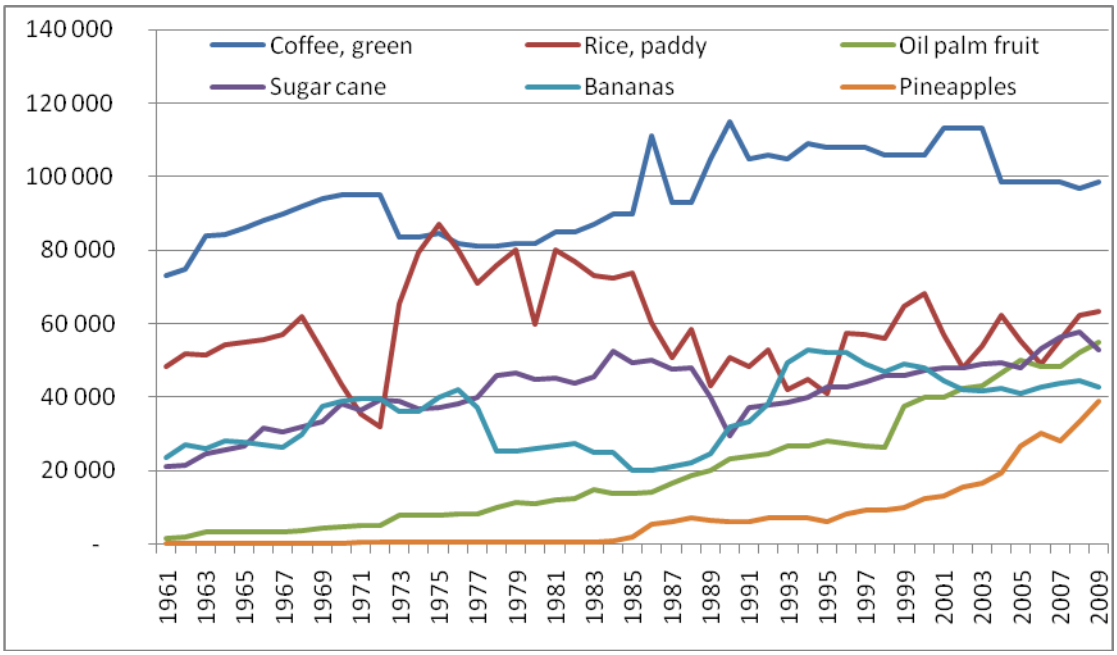


Figure 6. Evolution or crop areas for some of today's (2009) main crops in Costa Rica

Own elaboration with data from FAOSTAT (2011)

- In terms of production volumes, main production are (in decreasing order and as shown in the FAP table below): sugarcane (4.2 Mt), bananas (2.1), pineapples (1.7), cow milk (0.9), cassava (0.4), oranges, fruit fresh, rice.
- In value terms, the order changes: pineapples come first (US$ 325 million), then bananas (296), cow milk (237), cattle meat (182), chicken meat (124), coffee (88), sugarcane (86), palm oil (59), pigmeat (53), rice (52), orange (49).

Costa Rica is principally importing (in decreasing order in value terms): maize (US$ 191 million in 2009), food preparations (118), wheat (116), soybean (110), beans, rice, and other processed products.

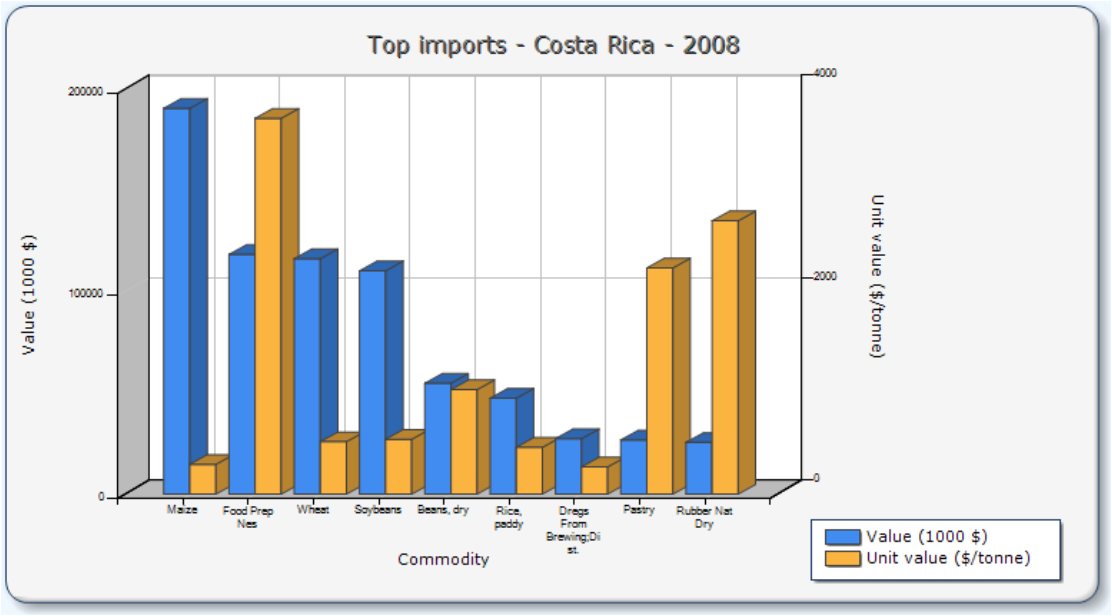


Figure 7: Top agricultural imports in terms of volume

Source: FAOSTAT, 2011

The country mainly exports bananas (for US $ 703 million in 2009), pineapples (575) and coffee (337).

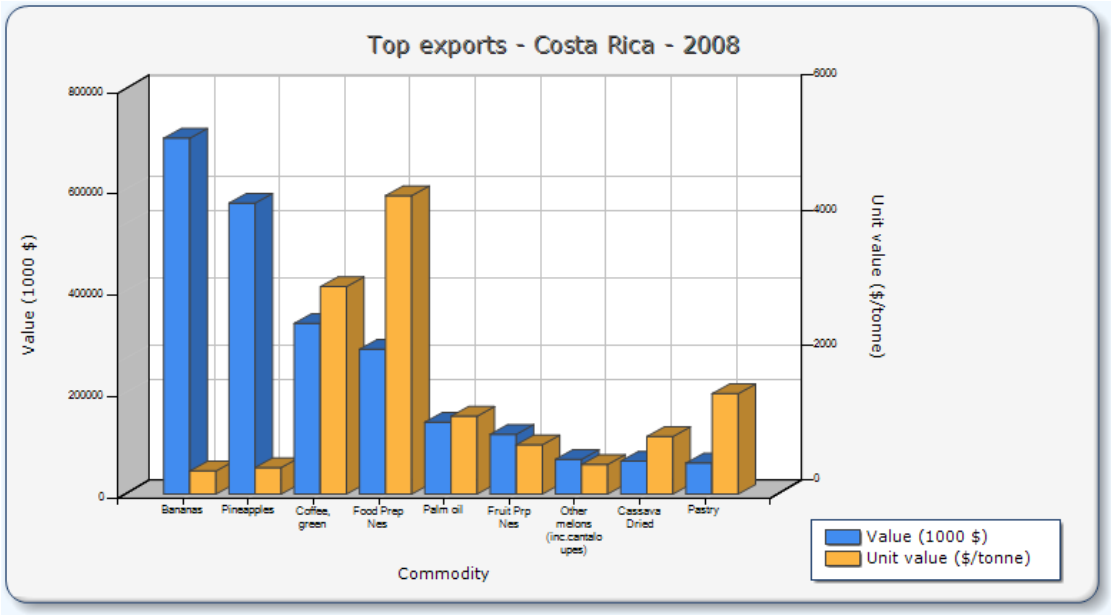


Figure 8: Top agricultural exports in terms of volume

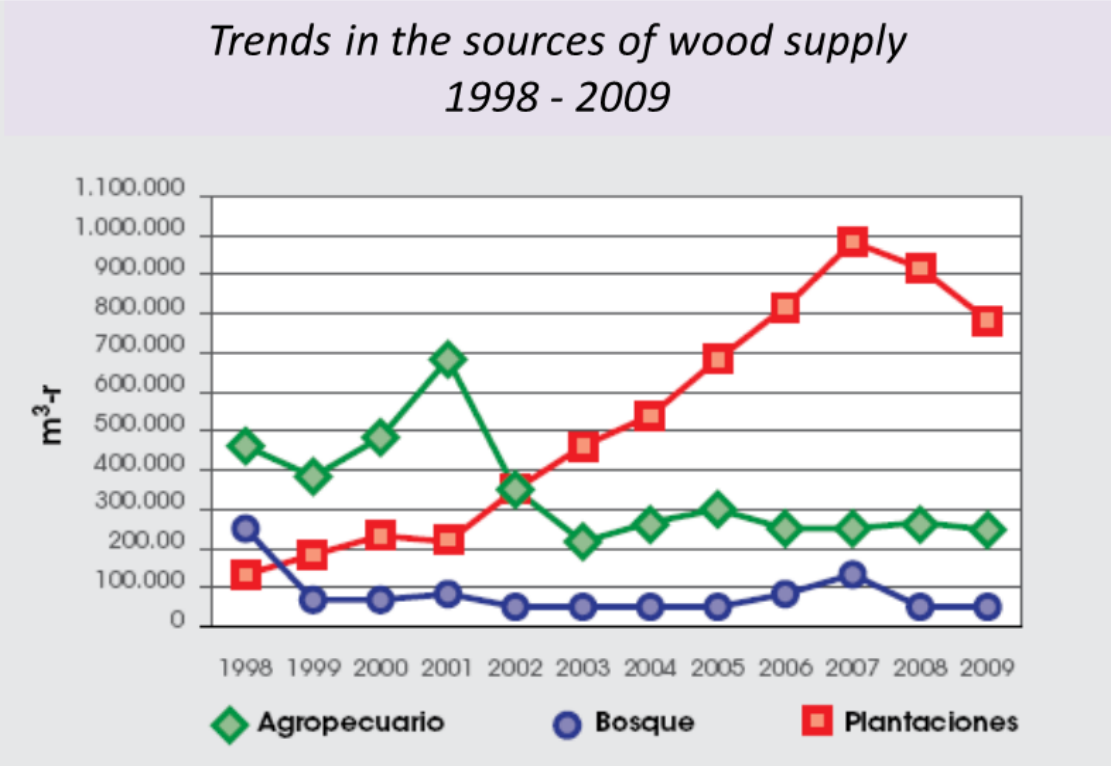
Source: FAOSTAT, 2011

3.1.5 Forestry sector

The importance of the forestry sector in Costa Rica and the rest of Central America is not completely evidenced by macroeconomic data on the contribution of the forestry sector to the PIB: approximately the equivalent of EUR 184 millions.

The demand for wood and wood products has traditionally been satisfied by land use change from forests, then by forest management and by trees from agricultural land, and now from forest plantations.

Registered forest plantations represent slightly more than 100,000 hectares, belonging to the administration, NGOs or private business (Sanchez-Azofeifa, *et al. 2006*). Tree species are principally Melina/*Gmelina arborea* used for dais/platforms and teak/*Tectona grandis*, exported to China and India. (Arce y Barrantes 2004, Corella 2009; Perez 2005; Piotto *et al.* 2002).



In green: from agricultural land. In blue: from forests. In red: from plantations

Figure 9: Evolution of the sources of wood (agricultural land, forest, plantations)

Source: Costa Rica Forestal 2009

After two years of global recession (2008-09), the forestry sector is recovering and reducing its supply deficit.

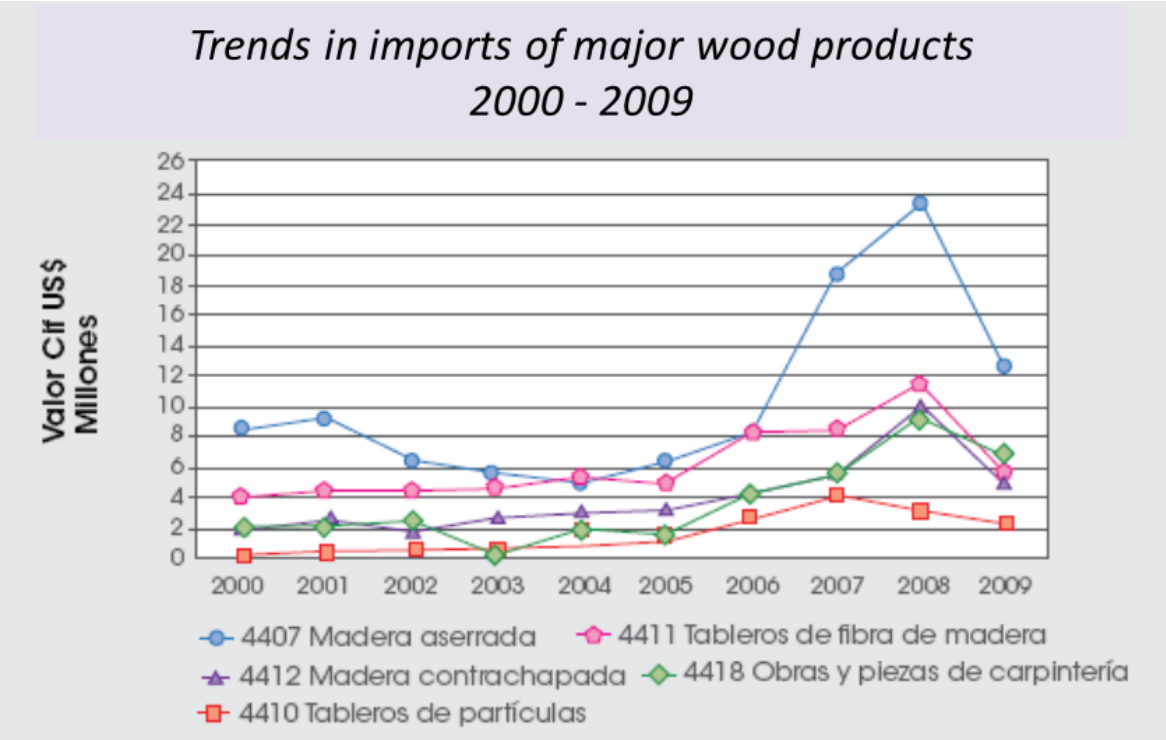
Employment in the forestry sector is estimated at around 18,000 jobs, including some 6,000 in the primary sector (harvest and in the appr. 150 sawmills of the country), 7,000 in the secondary sector (fabrication of furniture and other wood products), and the rest in trade, construction, transport and public sector.

The production of industrial round wood represents more than 1.1 million cubic meters over bark, and fuel wood less than 0.5 million cubic meters.

Around 5 million dais are produced and used in the agro exporting sector, principally for shipping bananas.

Wood deficit is increasing, especially for products such as sawn wood, carpentry, wood fibre boards, furniture and plywood.

Wood imports have been estimated to grow from US $95 millions in 2007 to US$ 126 million en 2010 (OET *et al*, 2008).



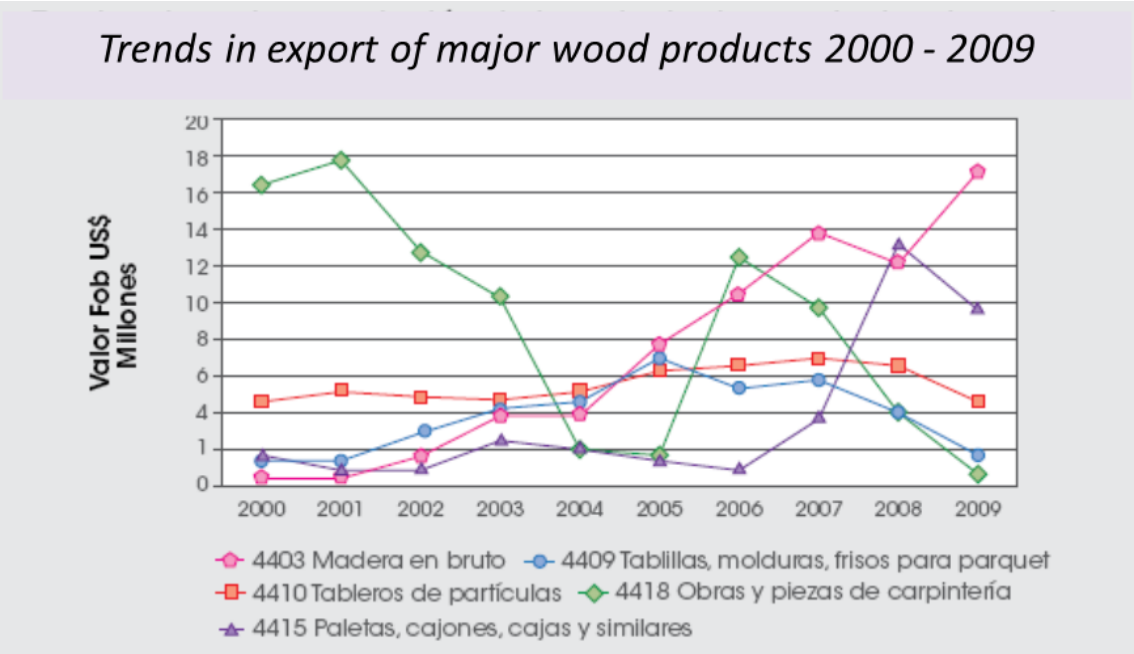
Blue circles: sawn wood. Pink hexagones: woodfibre boards. Purple triangles: plywood. Green lozenges: for carpentry. Red squares: particule boards.

Figure 10: Evolution of wood imports between 2000 and 2009, in US$ CIF

Source: Costa Rica Forestal 2009

Imports come principally from Chile and Argentina (sawn wood).

Exports go principally to India by far (62% in value terms) then the USA, El Salvador, The Arab Emirates and Guatemala.



Pink hexagons: uncut wood. Blue circles: for wood floor. Red squares: particle board. Green lozenges: for carpentry. Purple triangles: boxes.

Figure 11: Evolution of wood exports between 2000 and 2009, in USD CIF

Source: Costa Rica Forestal 2009

3.1.6 Land ownership concentration

Costa Rica had a agrarian land reform in the 60's.

Nowadays, properties with more than 500 hectares represent 1% of properties and 36% of registered land (Leonard quoted by CADETI 2004). The majority of the medium and smallholders own land on hill sides and of forest aptitude (CADETI 2004).

Though high relative to European standards, land concentration in Costa Rica is amongst the lowest of Latin America and the Caribbean, equivalent to land concentrations in Jamaica, Uruguay and Venezuela (Ferranti David et al., 2004).

According to Bertsch (2006), land concentration through acquisition by investors is due to three main factors:

- incentives on forest plantations, facilitating the purchase and gathering of small properties by investors;
- political stability (CEPAL 2008c);
- national policy on globalization with new agreements and treaties on free trade, generating an appropriate climate for attracting investments.

The general trend is the increasing shares of large firms in main agricultural productions. People working in the farm are increasingly employees of these farms (and decreasing share of smallholders). In Costa Rica, lawyers can also practise as notaries, what puts them in a privileged positions to know about best acquisition opportunities.

Costa Rica has a relatively simple land tenure regime compared with other countries of the Latin American region (Navarro, 2010). Land can be classified according to socio-economic and legal conditions:

- National Parks, Biological, National and Forest reserves;
- Protected Wilderness Areas with mixed State and private land tenure;

- Indigenous reserves;
- Private property.

The administration and management of land and natural resources is under the main responsibility of the MINAET (formerly MINAE), the ministry of environment, energy and telecommunications. Some minor overlap exists with agencies and organizations such as IDA, the Institute of Agrarian Development, for land purchase and redistribution (Joyce, 2010).

3.1.7 Food security

In Costa Rica, 26% of the households, 5% of the population, is estimated to suffer food insecurity, mainly because of poverty issues.

Main indicators on the determinants of food security are quite favourable: the Gini index is less than 0.5, availability per capita at 2,790 kilocalorie, relatively high public spending (Delgado *et al.* 2010).

However, what characterizes Costa Rica is the high share of imports in major food products (rice, wheat, beans, soybeans) as well as crop inputs, and its specialization in some non basic food crops for exports such as coffee and pineapple.

This situation makes the country very sensitive to exchange rate fluctuations, with food prices and the share of income used on food rapidly increasing when the national currency is losing value.

3.1.8 Energy sector

Energy resources in the country are renewable; Costa Rica is not exploiting any fossil energy sources, at least for the time being. Exploration of oil and gas took place in the last year and might lead to further exploration efforts and exploitations in the future, this possibility is controversial and currently debated.

Table 6. Commercial energy resource potential

Source	Theoretical potential	Identified	Degree of utilization (%)
Hydroelectric	25.500 MW	6.633 MW	21
Geothermal	865 MW	257 MW	64
Wind power	600 MW	274 MW	35
Solar power	10.000 MW	0,14 MW	minimum
Biomass	s.d.	7.953×10^3 Tn	13
Bagasse of sugar cane	s.d.	1.290×10^3 Tn	96
Wood	25.000×10^3 Tn	783×10^3 Tn	98
Biogas	9.981 TJ	5.206 TJ	1
Alcohol	32.556×10^6 l	115×10^6 l	0
Biodiesel	22.851×10^6 l	176×10^6 l	Minimum
Mineral coal	27×10^6 Tn	s.d.	0
Oil	$91,7 – 2.910 \times 10^6$ bbl	s.d.	0

Source: MINAET, 2011

Energy consumption has been constantly increasing as shown in the figure below.

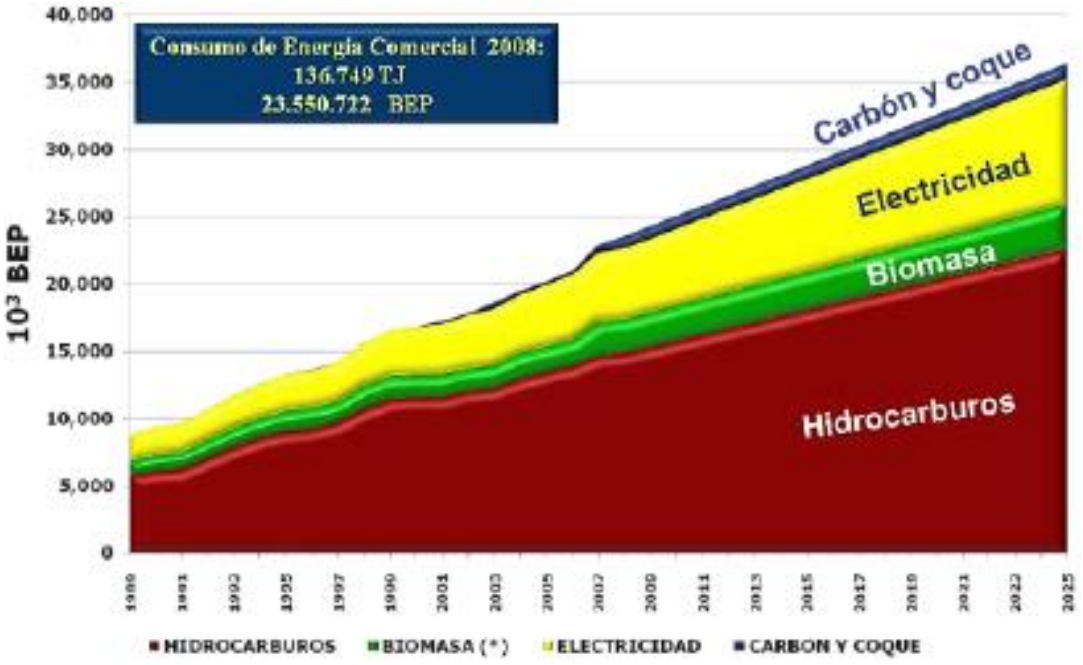


Figure 11. National consumption of commercial energy in 2008

Source: MINAET, 2010

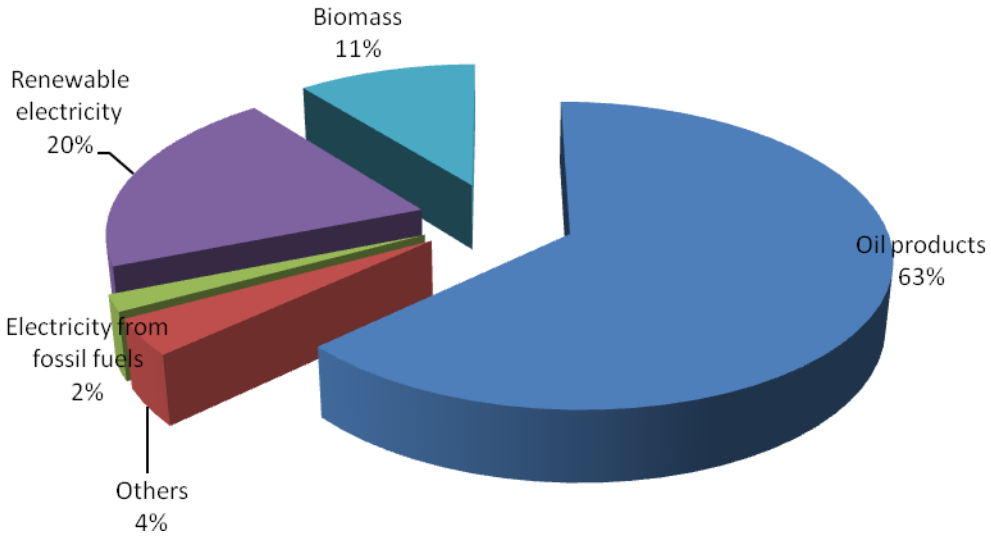


Figure 12. Structure of energy consumption in 2009

Source: MINAET, 2010

Electricity generation was of 9,503,622 giga watt-hour in 2009 (Orozco et al. 2009), distributed in:

- Hydro: 76.4%, with a dozen of plants
- Geothermal: 12.4%
- Thermal energy: 6.7%
- Wind: 3.8%
- Biomass: 0.7%. This share is maintained small by low sale prices offered to electricity independent producers. It could be higher given the large potential of pineapple and sugarcane harvest residues (Milhau & Fallot, 2011).

Solar energy has a small contribution, with isolated and connected photovoltaic systems (respectively 185 and 38 kW). Other sources include biodigesters (330 kW) and landfills (3.7 kW).

Less than 1% of the population is not connected to the national electricity grid.

The transport sector is consuming 76% of oil derivatives consumed in Costa Rica (Orozco et al. 2009).

Oil is entirely imported, some 21.5 million barrels generating an oil bill of approximately EUR 1,446 (estimate for 2011, by MINAET, 2011).

Costa Rica is producing 23.5% of the electricity generated in Central America and Panama, exporting part of it. The country has the potential to become a major electricity exporter if plans for new generating plants and a regional distribution grid are realized.

The problems in the energy sector include:

- A high dependency on import, hence the country's vulnerability to oil price fluctuations;
- The trend to a reduction in hydroelectricity capacities and potentials because of increasing water scarcity with climate change, of decreasing water quality with alluvia in agricultural watersheds, of vulnerability to earthquake in this seism prone country, of acceptability problems with new dam; of poor legislation on hydrological resources;
- The prohibition to generate geothermal energy in national parks and other protected areas (MINAET, 2008).

3.1.9 Policy framework

Costa Rica is a presidential representative democratic republic, with a multi-party system. Executive power is exercised by the president and his cabinet, the president being head of both the State and the government. Legislative power is vested in the Legislative Assembly. The president and 57 Legislative Assembly deputies are elected for 4-year terms.

The offices of the Comptroller General of the Republic, the Procurator General of the Public, and the Ombudsman exercise autonomous oversight of the government. The Comptroller General's office has a statutory responsibility to scrutinize all but the smallest contracts of the public sector and strictly enforces procedural requirements. Costa Rica has no military but maintains domestic Police and armed National Guard forces securing its interests.

The position of governor in the seven provinces was abolished in 1998. There are no provincial legislatures. In 2009, the state monopolies on insurance and telecommunications were opened to private-sector competition. Certain other state agencies enjoy considerable operational independence and autonomy; they include the electrical power, the nationalized

commercial banks (which are open to competition from private banks), and the social security agency.

In a nutshell, completing sectoral information given above:

- Energy policies focus on energy security and the regulation of prices;
- Agricultural policies promote specific crops following market opportunities and objectives of food security;
- Forestry policies include incentives for reforestation on the basis of payment for environmental services;
- Taxes and subsidies (www.costaricaweb.com/business/cindetaxes.htm)
    - Social contributions represent slightly less than 32% of total revenue. Taxes on income, profits and capital gains represent approximately 15% of total revenues, 25% of total taxes.
    - Individual Income Tax

        the taxation of individuals is based on the principle of territoriality: residents and corporations are taxed only income earned in Costa Rica. The tax year begins in October 1 and ends September 30.

        The following are subject to income taxation:

            Legal entities, the facto corporation, professional companies, and state enterprises which operate in the country; Branch offices, subsidiaries, or agencies of any non-resident which operates in the country; Trusts; Inheritances (as long as remaining indivisible); Individuals residing in Costa Rica regardless of nationality; Individuals hired in a professional occupation; Physical and legal entities not specifically mentioned and engaged in profit making activities in Costa Rica.

        The following are tax exempt:

            Government, local governments and autonomous and semi-autonomous organizations excluded by specific laws; Religious institutions regardless of creed; Associations, foundations, chambers, unions, political parties and other non-profit organizations; Employer -Sponsored Workers Associations (Asociaciones Solidaristas); Worker's Cooperatives; Companies under Free Zone status.

        Taxable income includes earnings from real property, investment of capital and other business activities. It also contemplates any increase in net worth during the taxable year, which cannot be justified by declared or registered income.

        Personal Income Taxes

            Employment income (on a monthly basis) of individuals is subject to a progressive tax of 0, 10% and 15%.

            The following rates are applied to taxable annual profits:

            - Profits up to the equivalent of EUR 2,049: Exempt
            - In excess of 2,049 up to EUReq 3,060: 10%
            - In excess of 3,060 up to EUReq 5,104: 15%
            - In excess of 5,104 up to EUReq 10,229: 20%
            - In excess of the equivalent of EUR 10,229: 25%

- Corporate Income Tax

  For Corporate entities the following tax table prevails:

  - Gross income up to EUReq 30,669: 10%
  - Gross income up to EUReq 61,690: 20%
  - Gross income over EUReq 61,690: 30%

- Tax on Corporate Assets: 10% on the assets of corporations whose assets exceed EUReq 42 857
- Property Tax:
  - The annual property tax is established on an annual basis and paid following the procedures established by each Local Government. The municipality may set its own rate not to exceed 1%.
  - There is a 3% property transfer tax, based upon the registered value placed on the property transfer deed at the time of sale.
- Tax on Distributed Profits / Dividends:
  - When the profits are distributed to corporation partners, the corporation, for payment to fiscal authorities must withhold a 15% tax.
  - When dividends are distributed by a corporation whose shares are registered in an officially recognized stock exchange, a 5% tax must be withheld only if the shares were acquired through a stock exchange.
- Sales Tax: 13%
- Fuel Taxes (extracts from Blackman et al, 2009)

"*The 2001 Law of Tax Simplification and Efficiency (No. 8114) replaced a complicated system of fuel taxes and fees administered by several regulatory agencies with a single tax administered by the Ministry of Finance. The tax is a fixed sum per liter for each type of fuel [...].*

In May 2009, the tax was 181 colones (EUR 0.26) per liter for regular gasoline, 189 colones (EUR 0.27) per liter for premium gasoline, and 107 colones (EUR 0,15) per liter for diesel [...] Because the fuel tax is a fixed sum, its percentage contribution to the total retail price of fuel depends on that pretax price of fuel. In recent years, this contribution has ranged from 28 percent to 52 percent for regular gasoline and has been within the range of the percentage contribution of fuel taxes in other Latin American countries [...]. The 2001 law that established Costa Rica's fuel tax mandated that revenues be allocated as follows: 66.4 percent to the Ministry of Finance (Ministerio de Hacienda), 29.0 percent to the National Road Council (Consejo Nacional de Vialidad, CONAVI), 3.5 percent to National Forestry Finance Fund (Fondo Nacional de Financiamiento Forestal, FONAFIFO), 1.0 percent to the University of Costa Rica (Universidad de Costa Rica, UCR), and 0.1 percent to the Ministry of Agriculture (Ministerio de Agricultura y Ganadería, MAG)."

- In July 2011, the Organization for Economic Cooperation and Development (OECD) removed Costa Rica from its "grey list" of tax havens after signing its 12th international agreement to exchange tax information. Costa Rica had been an important transit point not only for cocaine shipments but also for illicit financial transactions according to the International Narcotics Control Strategy Report on financial crimes published in 2011. Its removal from the OECD's list of tax havens may indicate further progress in

its battle to confront other financial crimes (http://insightcrime.org/insight-latest-news/item/1191-costa-rica-removed-from-tax-haven-grey-list).

- Major international treaties, namely on human rights and on environment, have been ratified in Costa Rica.

3.1.10 The sugarcane-to-ethanol supply chain in Costa Rica

Ethanol was produced out of sugarcane in 1918 already in Costa Rica. Since then there has been several intents to develop ethanol production, in periods of tensions on oil imports actually. However, the sugarcane-to-ethanol supply-chain is not fully established yet in Costa Rica. Paraphrasing and updating Murillo (2007), we can state that *despite the fact that in the country alcohol has been produced for 31 years and exported for 25 years, alcohol as carburant is still not part of the energetic matrix of the country*.

Some specific alcohol such as neutral alcohol for chemistry is produced out of part of the residual molasses generated during sugar production. Some ethanol fuel is processed out of hydrated alcohol imported from Brazil.

Nevertheless we shall consider what the sugarcane to fuel ethanol supply-chain would look like if the fuel ethanol was produced out of local sugarcane production, looking at the two plants currently producing alcohol out of locally generated molasses.

The general flow-chart of the supply chain below present the different steps and options of the production of the main and co-products.

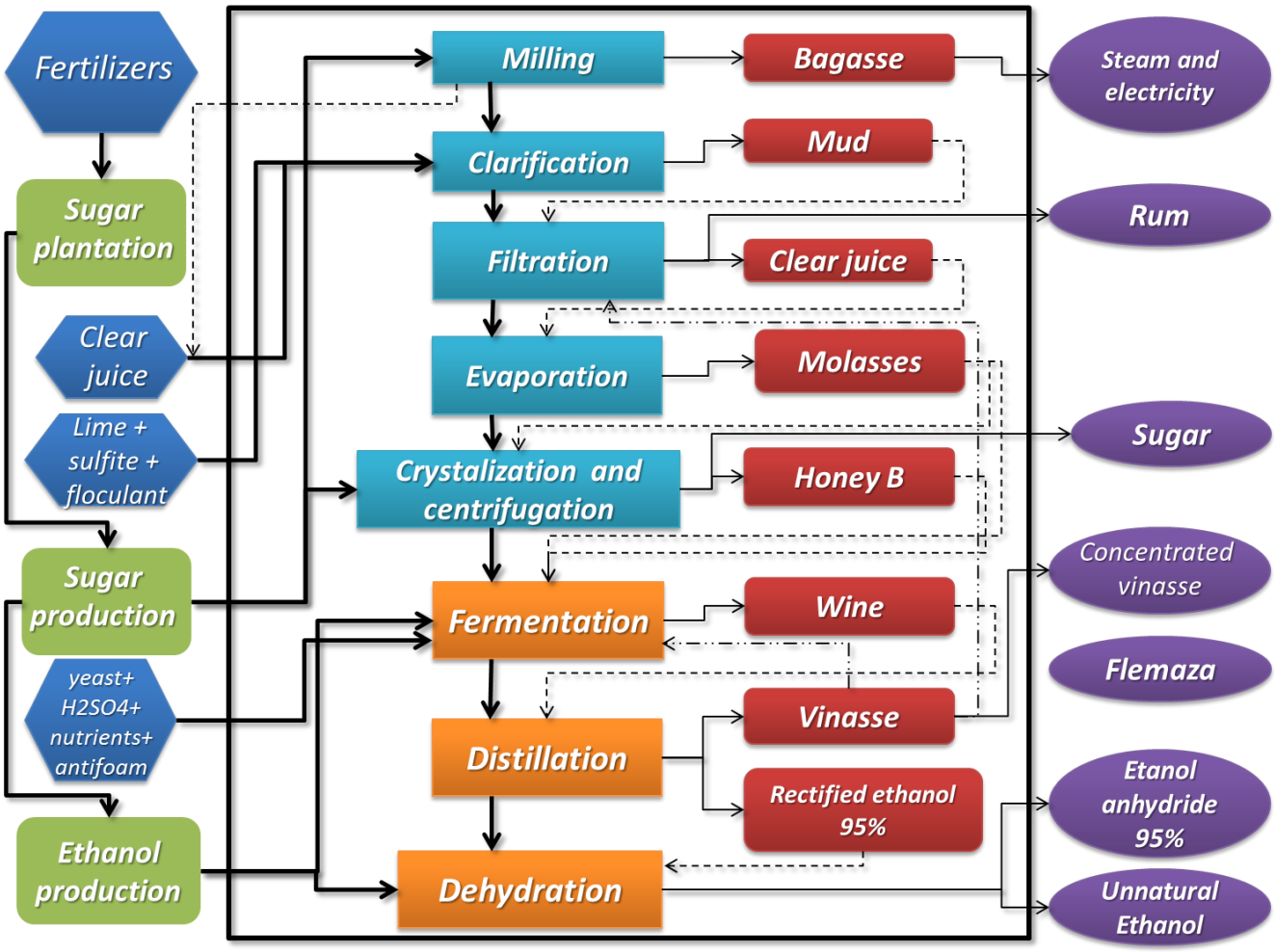


Figure 2: Flowchart of the supply chain of sugar cane in Costa Rica (2011).

The agricultural phase of sugarcane production includes:

Land preparation and adaptation: subsoiling, ploughing, land shaping, field layout (ridges and furrows, drainage channels), soil whitewashing and fertilizing.

Seed and seedling selection, planting and replanting.

Plantation maintenance: maintenance of furrows, pest and disease management, weeding, fertilizing, fastening maturation.

Harvesting: cutting (either manually or mechanically), loading (either manually or mechanically), transporting by trucks.

The industrial phase or sugarcane transformation to ethanol includes:

Sugarcane reception and evaluation of its sugar content

Sugarcane milling and juice extraction

Sugar and molasses production: Juice clarification, filtration, evaporation, crystallisation and centrifugation, yielding molasses

Fermentation of the molasses and alcohol distillation.

Dehydration or rectification of the alcohol.

The ethanol distribution and commercial phase includes:

- For international alcohol markets: transport to harbour terminal (in Morales, some 100 km from Guanacaste's main sugar plants, exportation through LAICA
- For national fuel market: transport to the main facilities (in Ochomogo, near the capital city San José, some 200 km from Guanacaste's main sugar plants) mixing ethanol with gasoline in the publicly managed refinery, in proportions up to 10% ethanol.

Between 1999 and 2007, while population has grown at an average rate of 1.85%, the number of vehicles has grown at the rate of 2.94% and gasoline sales at the rate of 7.43% (Blackman et al., 2009). Ethanol consumption was not properly measured. At current level of national gasoline consumption (www.mideplan.go.cr/sides/regional/03-07.htm) and accounting for the Biofuel law mentioning a 10% introduction of ethanol, we can assess the potential demand in the country somewhere between 75 and 100 million litre ethanol.

For the time being, only the Guanacaste region is consuming ethanol (produced out of imported ethanol from Brazil) in a proportion of 7% (varying between 5 and 8%). This local consumption represents 12% of national gasoline sales, around 8.4 Ml.

Current production and supply on national level is limited to the activity of three facilities:

- Punta Morales, dehydrating imported ethanol, with a capacity of 110 Ml, actually producing approximately 99 Ml
- Taboga, with a capacity of 30 Ml, actually producing 13 Ml ethanol
- CATSA, with a capacity of 25 Ml, actually producing around 13 Ml ethanol also

At current production levels, Taboga and CATSA are using approximately 40% of the molasses produced nationally. The two plants have the capacity to process almost all the molasses produced at current levels of sugarcane and sugar productions.

Average yields are:

Agricultural yield: 73.5 ton/ha sugar cane with an average sugar content of 93 kg sugar/t sugarcane

Industrial yield: 6 to 10 litres of ethanol anhydride per tonne of processed sugarcane for sugar (molasses ethanol)

- Key characteristics of the system (inputs, labour requirement):

Stage	Inputs	Labour
sugarcane production	fertilizers herbicides maturing agent fuel for agricultural machines	seed and seedling management, planting harvesting (50% of workforce) loading & transport (truck driving)
sugarcane transformation	water sulphite lime flocculants process heat and electricity (from bagasse)	process engineering and control machine cleaning and maintenance
ethanol production	yeast process heat and electricity (from bagasse) water	process engineering and control machine cleaning and maintenance
commercialization	fuel for trucks	truck drivers

- Detailed description of cropping system

  Sugarcane is planted for six years, harvested every year, five times before plantation renewal then.

  After six years, the land is left aside for a few months before being planted again.

  Seeds are generally selected on-site with a follow-up of performances. Technical assistance and information are provided by LAICA the national sugarcane league; see for instance its virtual library www.laica.co.cr/biblioteca.

  Before and during planting, herbicides and fertilizers (organic and inorganic) are applied, including vinasses from the sugar and ethanol production processes. Fertilizers are applied during the plant growth. Harvesting time is controlled by the use of maturing agents, allowing shortening the time required to reach the desired level of sugar content.

- Determining factors of the type of production system used

  Sugarcane plantations are mainly determined by the perception that this is the best land use option given soil conditions (clayey, liable to flooding...).

  Activities are partly mechanized. The level of mechanization depends mainly on how steep is the land and whether soil compaction might become a problem.

Mechanization does not necessarily exclude burning before harvesting. Decisions on burning are taken according to the existing possibilities in terms of green biomass use and to the burning authorizations by local authorities.

Ethanol production comes after sugar production, given relatively high sugar prices and guaranteed market access. Hence ethanol is produced out of molasses rather than sugarcane juice. However, juice is sometimes added to molasses so as to improve their brix.

The decision to invest in distillery facilities (some 20 million dollar worth) has been done by 2 of the 16 sugar plant only, located quite close from the harbor terminal where ethanol is exported. Molasses from the sugar plants is bought by these two. However, there are other market opportunities for molasses, in the food industry namely.

3.1.11 Actors of the supply chain of sugar cane in Costa Rica

A whole description of biofuel actors is available in deliverable 7.1 on public perception of biofuels in Costa Rica, second section of the document.

Amongst actors of the sugarcane to ethanol supply-chain

The public-private sugarcane producer association LAICA is the most influent, as an intermediary between public authorities and producers as well as between international markets and producers. LAICA negotiates production quotas and prices for sugar and ethanol, establishes quality standards, manages ethanol imports, dehydration and re-exports, provides research efforts and technical assistance all along the supply-chain, currently with a specific emphasis on vinasses. LAICA exports sugarcane material to various Latin American countries. It is well integrated in international research networks, for example the BIALEMA network on biofuels, see www.icidca.cu/Red/QueEs.htm.

- The public firm RECOPE must be reckoned with because of its monopoly on refinery and distribution
- The public tariff authority ARESEP influences production and distribution choices, for instance: use of molasses or juice, cogeneration out of bagasse for internal use only or also for the network, ethanol exports or sales to international markets.
- ACEC gathering owners of gas stations have a crucial role in determining the acceptability of biofuels by consumers nationally. ACEC has been pleading for better incentives at the distribution level arguing the need for specific adaptation of tanks and tubes to ethanol, hence drawing some doubts to the fuel consumers whether the product was safe for their motors.

PHASE	ACTOR	ROLE IN THE SUPPLY-CHAIN
sugarcane production	Independent farmers, appr.10,000 90% are smallholders Average area: 3.2 ha	Produce sugarcane and supply sugar plants Independent farmers produce 45% of the sugarcane processed in the country
	Farmer association	Gathers small producers, support commercialization
	Sugarcane Federation of chambers	Represents the sugarcane sector in general, LAICA in particular
Industrial production (sugar and ethanol)	Sugarplants, also non independent sugarcane producers	Receive sugarcane deliveries from smallholders, process to sugar and ethanol (en two plants in the country)
	Sugar cane chamber	Organization of sugar plants
	Industrial Sugarcane League (LAICA[1])	Regulates relationship between sugarcane producers and sugar plants to ensure fair deals
	Directorate of Research and Expertise on Sugarcane (DIECA)	Provides scientific and technological support to farmers and to the producers of sugar and of ethanol.
Commercialization	Oil Costa Rican Refinery (RECOPE[2])	Refine, transport and distribute oil and oil products, maintain and develop facilities to execute development plans of the Energy Sector in Costa Rica
Distribution	Gas stations	Sell fuel to general public
	Costa Rican Association of Fuel distributors (ACEC)	Organize owners and managers of gas stations
	Costa Rican Electricity Institute (ICE[3])	Develop existing sources of energy in the country and provide electricity and communication services
Regulation	Public Service Regulating Authority (ARESEP [4])	Determine prices and taxes on public services and basic goods including sugar and fuels
	Ministry of Agriculture and Livestock (MAG[5])	Promotes integration and development in the agricultural productive sector and related institutions
	Ministry of Environment, Energy and Telecommunications (MINAET[6])	Governing entity in the energy sector

[1] www.laica.co.cr

[2] www.recope.go.cr

[3] www.grupoice.com

[4] www.aresep.go.cr

[5] www.mag.go.cr

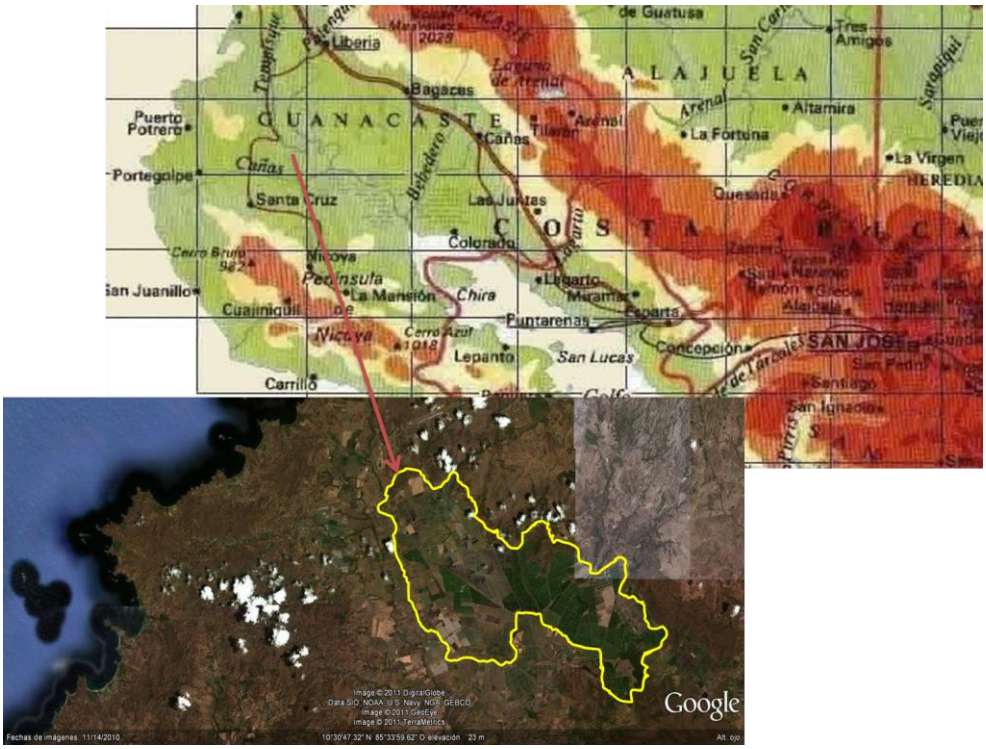
[6] www.minaet.go.cr

3.2 Case Study at the local level: Central Azucarera Tempisque S.A. CATSA

There are only two firms producing ethanol out locally grown sugarcane: Taboga and CATSA. We chose CATSA that appeared more open to provide detailed data.

Orders of magnitude are quite similar for CATSA and Taboga. On the basis of national data on land use and the sugar industry, we can estimate that with two additional plants of their size, Costa Rica would reach a level of ethanol production that could correspond both to a 10% gasoline substitution in the country, and a full exploitation of sugarcane production potential (current 53,000 ha, and additional 10 to 25 thousand hectares).

3.2.1 Location of the Case Study



Source: Instituto Geográfico de Costa Rica (2011)

CATSA is located in Guanacaste, with altitudes between 25 and 10 m.s.n.m., an average temperature of 28 °C and average rainfall of 1,600 mm/year.

Sugarcane areas represent 6,500 hectares, 90% of CATSA's farmland (7,285 ha). The rest is rice (785 ha).

Land occupied by industrial activities and other uses represent areas of respectively 70ha, and 45ha.

Figure 3: Location of the case study

3.2.2 Description of project/company

CATSA is an agroindustrial firm, conceived in the 70's. Founded in 1975, CATSA was first a subsidiary firm of CODESA, the Costa Rican development Corporation promoting the establishment of industries with public capital in sectors with little private initiatives. CATSA is now managed by Guatemalan entrepreneurs involved in the sugar and ethanol industry of various countries of Central America.

CATSA grows sugarcane and process it along with sugarcane independently produced in its neighbourhood. CATSA produces molasses and sugars of different qualities (crude, white, refined, for exports, white E-150), as well as alcohol of different types (for human consumption, ethylic neutral, ethylic anhydrous).

CATSA has four divisions:

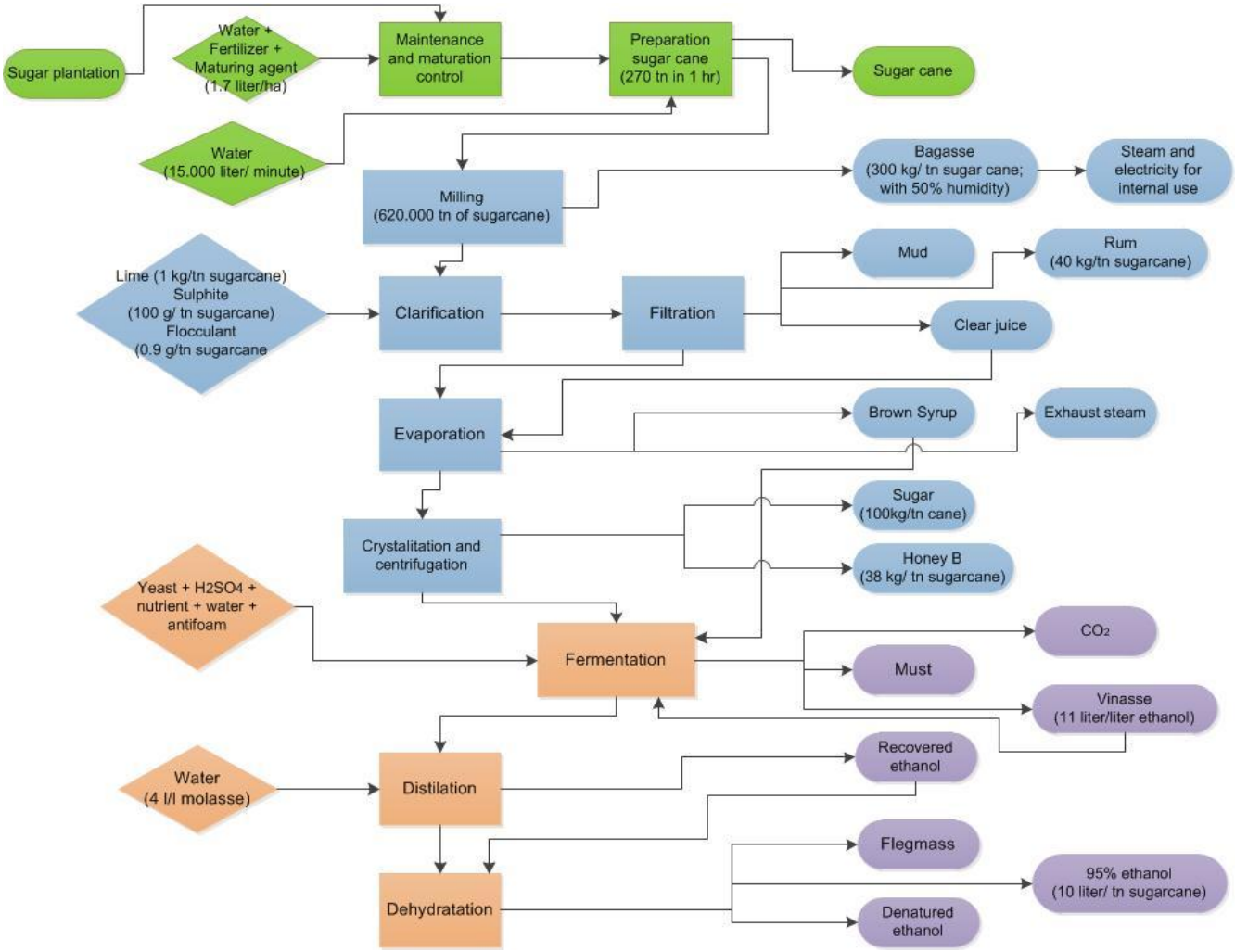
- Administrative, running the whole year
- Agricultural, including sugarcane crop establishment, maintenance and harvest
- Industrial producing sugar and ethanol during harvesting period
- Mechanical, with the workshop where machines are repaired and maintained.

CATSA's distillery was constructed in 1978-79 with Brazilian equipments. Commercial alcohol production started in 1980.

Its capacity is of 240,000 l/d or anhydrous alcohol and 120,000 l/d of neutral alcohol. Storage capacity is of 10.2 Ml, equivalent to 42 day production.

CATSA was ISO 9001 certified since 2001 and currently satisfy the requisites of ISO 9001:2008. Since December 2010, CATSA is also ISCC certified so as to keep its access to the German market and the other European markets.

3.2.3 Flowchart of the supply chain



Sugarcane is produced on CATSA's own land and additionally provided by 1049 independent producers, whose supply represents 27% of the sugarcane processed in CATSA. Prior to sugarcane plantations, the land was mainly for pastures.

Applied agrochemicals include: fertilizer: CaCO3; 10 – 30 – 10; Nutran 35.5% N; 15 – 3 – 31; Pesticides: Diuxon 80% SC; 2.4 D 60%; Hexazizona (active ingredient of SESAMO ® WG); Coadyudante / madurante: Roundup.

Without accounting for recent (2010-11) decline, the average sugarcane yield reaches 87.4 t/ha at CATSA's farm, 65 t/ha for independent farmers Sugarcane crops rotate every 5 to 6 years with rice or pasture kept for two years.

80% of sugarcane fields are burnt before harvest, even this harvest is mechanized.

5,500 t sugarcane/day were processed, 657,000 t sugarcane during the whole harvest season 2009-10. This represents 16% of national production.

Sugar yield at CATSA is 100.3 kg sugar per ton sugarcane.

Heat and power are generated to supply all needs of CATSA's facilities (including offices) during the four months of harvesting time when the sugar plant is functioning. There is no additional heat and power production since electricity tariffs do not make it financially wise.

During harvesting time, CATSA employs approximately 1,210 persons, including 300 temporary workers from Nicaragua and local workforce for technical tasks such as

transportation and machine maintenance. The agricultural division represents 66% of total employment during harvest time.

The rest of the year, employment is at 490 persons.

4 Socio-economic impacts of sugarcane ethanol production

4.1 Economics

4.1.1 Macroeconomic impacts of the sugarcane ethanol production

Feedstock production

Sugarcane production generates 1.1% of the PIB.

Costa Rica has a long history of sugarcane production, with continuously improved material and well developed technical assistance and international cooperation.

However the incomes from sugarcane production fluctuate with climate conditions and international prices.

Feedstock conversion

There are only two distilleries in the country so macroeconomic impacts are not very visible.

1) Number of $ invested in ethanol infrastructure
   Approximately 20 M$ were invested per distillery. Equipments were imported mainly from Brazil.
   The rest of investments in sugarcane production and transformation are not specific to ethanol production.

2) Number of people working in jobs directly related to ethanol
   Each distillery requires very limited personnel, approximately 6.

The added value mainly depends on the market opportunities for ethanol and special alcohols. For the time being, CATSA estimates its production costs at EUR 0.27 per litre. At this production cost level, oil price must rise above USD 90 per barrel for ethanol production to generate positive added value.

4.1.2 Microeconomics in the sugarcane to ethanol chain in Costa Rica

Given that CATSA staff was not in a position to provide us numbers for all the variables of interest for the Global Bio-Pact project, we proceeded in three steps:

- getting all possible data from CATSA during a visit where we met main engineers in charge of each phase of the production and visited the installations;

- deducting missing data on the agricultural phase by interviewing other sugarcane producers;

- sending our results to our interlocutors at CATSA so as to get their feedback;

Following costs data correspond to the 2010-11 sugarcane crop and ethanol production.

Feedstock production

Table 1: Estimated sugarcane production costs in Costa Rica (2011)

		Expenses per hectare (EURO/ha) (a)					
	Yield (tn /ha)	Field preparation and maintenance	Planting	Transplanting	Fertilizer application	Pesticides application	Transport
Year 0	-	171.43	494.29		352.14	-	9.56
Year 1	85	42.86			341.29	288.19	258.26
Year 2	95	77.74			366.61	282.99	288.21
Year 3	85	131.31			366.61	288.19	258.21
Year 4	75	131.31			366.61	288.19	228.21
Year 5	60	93.21			117.06	288.19	192.86
Total Yr 0 to 5	**-**	647.86	494.29	-	1910.32	1435.75	1235.31
Year 6 = Year 0	-	171.43	494.29		352.14	-	9.56
Year 7 = year 1	85	42.86			341.29	288.19	258.26
etc.				-			

Own elaboration with field data

(a) Production costs and profit per ton of cane in Costa Rica (Euro /ha)

Items		***CEPAL (2006)***		***Finca Turrialba (2011)***	
		Amount	***Euro[1]***	***Amount***	***Euro[2]***
reporting period (years)	establishment	1	-	1	-
	maintenance	1	-	1	-
	total Zocas[3]	4	-	4	-
total sugarcane cycle		6	-	6	-
yield (tn /ha)		85	-	74.00	-
sugar yield kg /tn sugarcane		100.52	-	113.25	-
kg sugar price		115	-	165.77	-
production cost (all cycles including)		-	5,612.37	-	8,304.79
production cost (excluging costo of establishment)		-	4,713.31	-	7,277.37
expenses /ha		-	942.66	-	1,455.47
expenses /tn		-	11.09	-	19.67
sugarcane value tn (€)		-	18.50	-	26.82
utility /tn sugarcane (€)		-	7.41	-	7.15
utility /ha sugarcane (€)		-	629.47		529.15

[1]Exchange rate CEPAL (2006): 625 colones/ euro
[2] Finca Turrialba (2011): 700 colones/ euro
[3]Zoca: renovation of plantation
Source: Alpizar 2008; Average yield and price of sugar kg recorded in Atirro mill (www.agriatirro.com) harvest 2010 /11, telephone interview Ing M. Solano (*Common per. 2011*)

Activities	***Labour***	***Description***
Field preparation	Semi-skilled	Machine use
Planting	Unskilled	Seed and seedling care and manipulation, by mainly feminine workforce
Irrigation	Unskilled	establishment and maintenance of irrigation and drainage canals
Fertilizer application	Unskilled	manual
Pesticides application	Unskilled	manual
Transport	Semi-skilled	driving machines and trucks

Own elaboration with field data

Table 2: Estimated labour requirements for sugarcane production in Costa Rica (2011)

		Labour requirements (person.hour/ha)[1]							
	Yield (t/ha)	Land clearing	Field preparation	Planting	Irrigation	Weed control	Fertilising	Harvesting (b)	Logistics (c)
Year 0	-	10	100	-	-	-	30	-	-
Year 1	85	-	-	2.50	-	64	14	148.75	5.27
Year 2	95	-	-	2.50	24	64	14	166.25	5.27
Year 3	85	-	2.50	2.50	24	64	14	148.75	5.27
Year 4	75	-	2.50	2.50	24	64	14	131.25	5.27
Year 5	60	-	2.50	2.50	24	64	18	105	5.27
Total 6yr rot.		10	100 + 7.5	12.5	96	320	104	700	26.35

Comments:

(a) Those numbers were calculated on the basis of data obtained from a sugarcane plantation of 110 ha in Costa Rica, for lack of access to CATSA's detailed data.

(b) The total of harvesting hours was obtained from producer data and own calculations: the number of cut sugarcane tons per hectare (for example 85 t/ha) was multiplied by the numbers of working hours in a day (7 h/day) and divided by the average daily volume of sugarcane cut by worker (4 t/day).

(c) Total time estimated, accounting for the following rates:

Activity			***Estimated time (in hours)***
Sugarcane loading into the harvester			3
From the harvester to the farm where sugarcane is loaded in a truck	Harvester capacity (TM)	3	0.5
	Speed of the harvester (km/h)	20	
	Average distance from the field to the farm platform (km)	2	
Harvester unloading and loading in the truck driving to the plant			0.33
From the farm platform to the sugar plant	Average distance from the farm to the plant (km)	20	0.66
	Total truck capacity (TM)	30	
	Truck average speed (km/h)	40	
Average time required to enter the plant area and pass quality control			0.25
Time to arrive to the yard where sugarcane is washed			0.33
Sugarcane unloading			0.20
Total			***5.27***

Table 3: Wage levels for sugarcane production in Costa Rica (2011)

Function	*Staff volumes*					*Average wage US $/month*
Agricultural division	Off-season	185	35	Executives	35	2,500 to 3,000
			150	Technicians		1,500 to 1,800
				Machine op.		700 to 1,000
				Field worker		600 to 700
	Harvest season	835	35	Executives	35	2,500 to 3,000
			800	Technicians		1,500 to 1,800
				Machine op.		700 to 1,000
				Harvester op.		500 to 600
Administrative and industrial division	Off-season	305	25	Executives	25	2,500 to 3,000
			280	Technicians		1,500 to 1,800
				Others		700 to 1,000
	Harvest season	375	25	Executives	25	2,500 to 3,000
			350	Technicians		1,500 to 1,800
				Others		700 to 1,000
Staff volumes	Off-season				490	
	Harvest season				1210	

Sugarcane to ethanol conversion

Table 4: Input costs of the sugarcane to etanol conversion at CATSA in Costa Rica (2011)

Input costs	Quantity (per unit end product)	Price (per unit end product)
Energy	1050 pounds of steam/ton sugarcane	obtained from bagasse
Sugarcane	657,000 ton sugarcane	EUR 18.7/t sugarcane
Water	Sugarcane mill: 15,000 l/minute for sugarcane washing Distillery: 4 liter per liter of processed molasses	s.d.

Source: in-depth interviews at CATSA

Comments: The price of sugarcane is set according to a nationally established price (EUR 0.186/kg sugar) [7] and the estimated content of the industrial sugar yield (100.3 kg of sugar / ton sugarcane).

4.2 Employment generation

Sugarcane production

Employment in the agricultural sector has various characteristics:

- It is not specific to the sugarcane to ethanol supply-chain (sugar and ethanol production), not even to sugarcane (other agricultural activities complement sugarcane production such as rice in Guanacaste, coffee in other zones…);
- It is mainly seasonal
  during 4 months, agricultural employment at CATSA rises from 430 to 1150. Given that CATSA cultivates around 6500 ha of sugarcane, one agricultural worker deals approximately with 15 ha sugarcane off-season, with 6 ha during harvest season. However these rates do not indicate how time is shared between sugarcane and other agricultural activities (CATSA cultivates rice on 785 ha)
- It depends on mechanization degree of activities. CATSA estimates that one harvester substitutes for 250 field workers. About 90% of its harvest is mechanized.
- It counts with the participation of Nicaraguan workers, namely to cut sugarcane.
  During the four months of the harvest season, CATSA brings about 300 workers from Nicaragua following legal procedures. Their monthly wage is about EUR 211. In other farms of the region, the participation of Nicaraguan workers is higher than for CATSA, where local workforce, i.e. belonging to Guanacaste population, is working on more technical tasks such as transportation, machine and equipment maintenance.

At CATSA, agricultural activities represent 66% of the employment. Remaining 34% combine industrial and administrative employment as table 5 shows below.

[7] Rodriguez, B. 2011. Prices paid to producers for purchase of sugar cane. Turrialba Chamber of Sugarcane. Costa Rica.

Table 5. Employment at C.A.T.S.A.

Division		Employment (number of persons)	
		off-season	harvest season
Agricultural	Executives	35	35
	Others	150	800
Industrial and administrative	Executives	25	25
	Others	280	350
Total		490	1210

Source: Interview E. Jenkins y C. Segura CATSA Mills.

Sugarcane to ethanol conversion

Given the high level of automation of the sugar and ethanol production processes, employment at this stage is mainly for maintenance, control and supervision.

Specifically for ethanol production, CATSA counts with 6 position:

- 2 in fermentation process
- 1 in dilution
- 1 in distillation
- 1 in alcohol production
- 1 coordinator

4.3 Working conditions

The fact that Nicaraguan workers come to work in the sugarcane fields of Costa Rica is commonly understood considering that working conditions are not attractive to Costa Rican workforce but that they still represent an opportunity for Nicaraguan workforce where wage levels are lower.

There is no trade union in the sugarcane sector and freedom of trade unionism is limited in Costa Rica. Instead there exist solidarity association controlled by the employer, providing multiple social benefits to the permanent employees.

When getting ISCC certified, CATSA had to provide evidence that the firm complied with the labour regulation. Two improvements were therefore necessary: the installation of mobile bathrooms in the fields and the provision of security equipment to workers.

Feedstock production

Working in sugarcane fields is harsh:

- because of exposure to heat and sun, as well as contact with inputs
- when sugarcane is burnt because of high temperatures, smoke and particle emissions;
- during harvest, for the heavy loads.

During harvest:

- flexibility and precariousness characterize contracts of occasional workers;
- workers are often contracted indirectly through an intermediary employer, which can dilute employer responsibilities (Cerdas Vega, 2007);
- wages are paid by ton or by linear meter of sugarcane harvested.

Feedstock conversion

The sugar plant is a quite hot and noisy place with strong sugary odours. Workers wear special protection equipment. The distillery is fresher and quieter.

During sugarcane to ethanol conversion, two activities are dangerous and specifically cared for:

- the handling of sulphuric acid;
- the loading of fuel.

Minor burnings and a crushed finger were reported ultimately.

4.4 Health issues

Feedstock production

Additionally to reported harsh working conditions, major health issue relate to sugarcane burning before harvesting, because of the smoke and particle emissions affecting the neighbourhood.

Feedstock conversion

River and other waterflows must be protected from the spreading of vinasses or water might be contaminated.

Other health issues have not been reported as such, they might include heavy truck traffic during harvest time and the handling of waste containers.

4.5 Food issues

Out of molasses, ethanol production is complementary to sugar production rather than in competition. Sometimes the brix of the molasses must be improved to better ferment; the resulting use of sugarcane juice does probably not affect much sugar production.

4.6 Land use competition and conflicts

For the time being, it seems that sugar prices rather than ethanol demand drives sugarcane extension. If sugarcane areas were to extend on the areas identified as favourable to this crop, this could be on extensive pastureland and this could compete with the extension of staple crops (rice, bean, maize...). Such possibilities are hypothetic.

Competition for water might be more actual if draught episodes lead to irrigation decisions of sugarcane field, possibly detrimental to rice and other staple crops, or to livestock.

4.7 Gender issues

There are few women working in the sugarcane-to-ethanol supply-chain in Costa Rica. CATSA staff is 10% women.

Feedstock production

Given harsh working conditions, the low percentage of women in the fields might not be an issue.

Feedstock conversion

Given the increasing number of women graduating as engineer, an indicator of gender equity could be how far is the percentage of women engineer in sugar and ethanol plants, from the percentage of women graduating as engineer in the country for instance. For the time being, women are underrepresented, which can also be explained by the low attractiveness of the Guanacaste province for young people who went to the Central Valley for their studies.

5 Environmental impacts

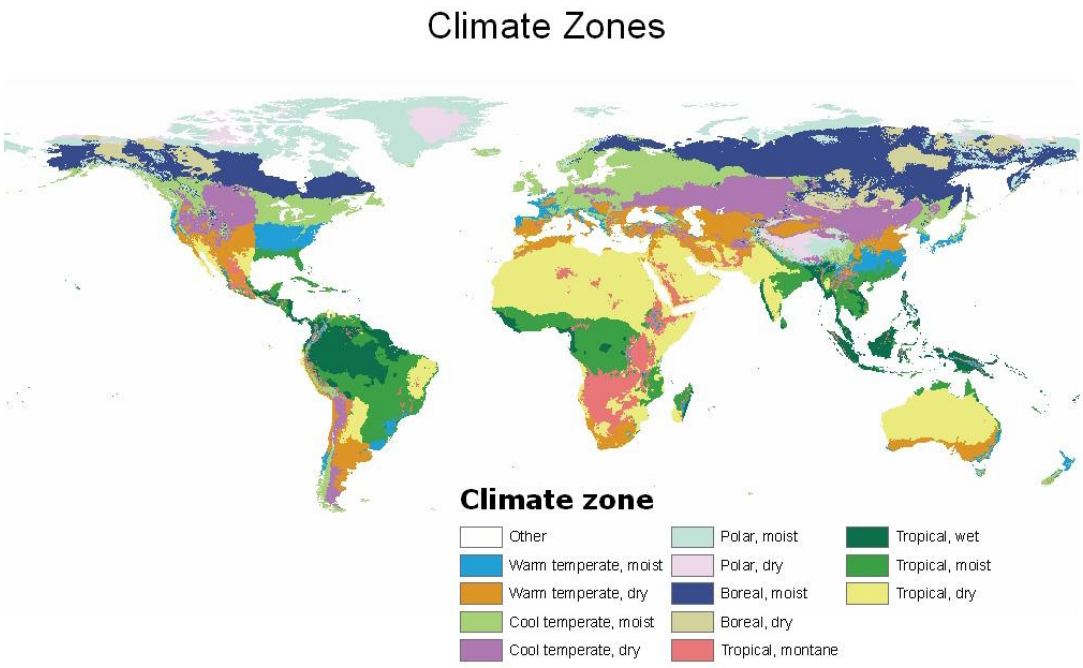
5.1 Greenhouse gas emissions

5.1.1 Greenhouse gas emissions in the sugar cane chain in CATSA (local case study 1)

Greenhouse gas emissions from carbon stock changes

- **Climate zone / region** of case study

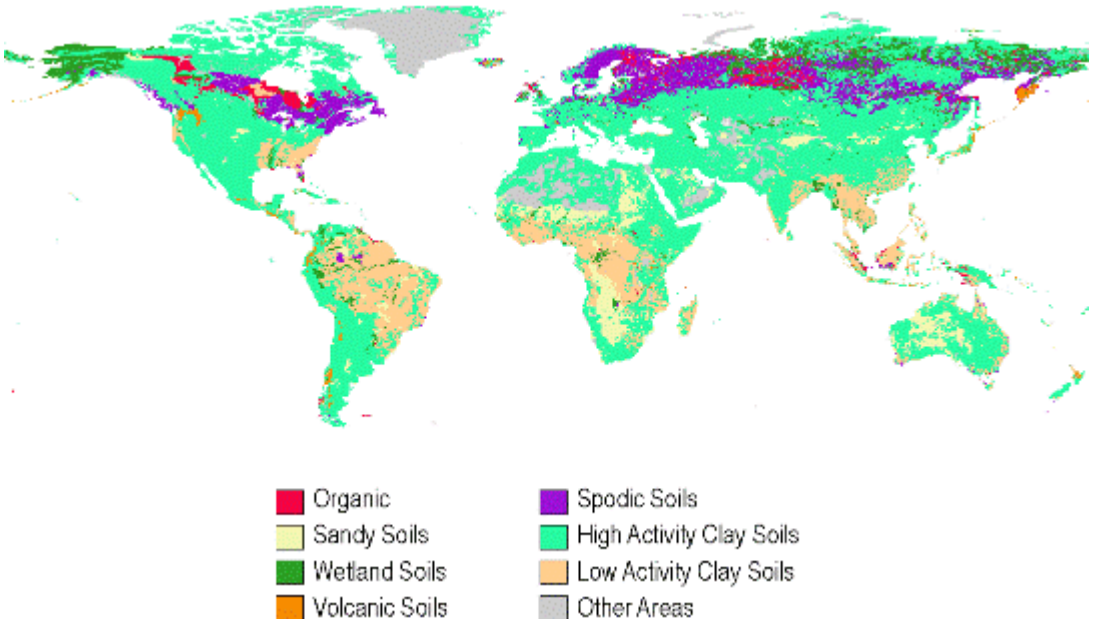
In the http://eusoils.jrc.ec.europa.eu/projects/RenewableEnergy/ Costa Rica is so small it appears to be entirely in the tropical wet climate zone. However CATSA case study belongs rather to the tropical moist climate zone, with an average temperature of 28 °C and average rainfall of 1,600 mm/year.



- **Soil type** of case study

  According to the map given by http://eusoils.jrc.ec.europa.eu/projects/RenewableEnergy/, it is not clear to which category CATSA's soils belong to.

However, knowing from CATSA manager, their soils are mainly inceptisols and vertisols, we can consider the the category "high activity clay soils" is the principal one.



- **Land use factor (F_{LU}), management factor (F_{MG}) and input factors (F_I)** for land use on 01/01/2008 and today

  Given http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:151:0019:0041:EN:PDF) and CATSA's situation (tropical moist, reduced tillage, medium level of input):

  FLU = 0.48

  FMG = 1.15

  FI = 1

- **Vegetation type** on 01/01/2008 and today: sugar cane
- **Ecological zone**, tropical moist deciduous forest
- **Continent:** America (Central)

Table 5: Greenhouse gas emissions from biomass cultivation

Yield per ha per year		
Yield	87,400	kg per ha per year
Size of the cultivation area		
Size	6,500	ha
Fertilizer applied per ha per year **Please enter the amount for each of the following fertilizers.**		
CaCO3	1,916	kg CaO per ha per year

	(a)	
10 - 30 - 10 (N-P-K)	360	kg P_2O_5 per ha per year
Nutran 35.5% N	262,5 (b)	kg N per ha per year
15 - 3 - 31 (N-P-K)	315	kg K_2O per ha per year
Pesticides applied per ha per year		
Diuxon 80% SC	5 liter/ha	Active ingredient Diuron. Class IV.
2.4 D 60%	4 liter/ha	Active ingredient Acid 2-4-Dicloro Fenoxiacético. Class II.
Hexazizona (active ingredient of *SESAMO ® WG)*	2 kg/ha	Class II.
Coadyudante / madurante: Roundup	1.7 liter/ha	Glifosato is the active ingredient of Roundup. Class III.
Diesel use per ha per year		
Diesel	s.d.	L per ha per year

Comments:

(a) Average between Y1 with 1500 kg and Y2 to Y5 with 2000 kg

(b) Average between Y1 with 225 kg and Y2 to Y5 with 270 kg

Table 6: Greenhouse gas emissions from biomass transport

Average distance from the energy crop plantation to the conversion facility		
	20	km
Type of vehicle used to transport the biomass		
	truck	
Fuel used by this vehicle		
	diesel	

Table 7: Greenhouse gas emissions from biomass conversion: CATSA local case study, Costa Rica

Tons of feedstock processed per year		
Processed sugarcane, from own fields and other fields	657,000	ton/year

Molasses bought from other sugar plants (estimated)	16,834,000	kg/year
Amounts of by-products produced per year.		
Ethanol (10 l ethanol per t sugarcane, 1 l ethanol per 3.8 kg molasses)	11,000,000	l
Sugar (100 kg/tn sugarcane)	65,897	tn
Rum (40 kg/tn sugarcane)	26,280	tn
Bagasse (300 Kg/tn sugarcane - produced and burnt)	197,100	tn
Vinasse (11 l/l ethanol)	121	Ml
Energy consumption of the sugar mill and ethanol distillery per production season (dec-april)		
Steam consumed in the sugar mill 1050 pounds per tn sugarcane per hour	283,500	Pounds per hour
Steam consumed in the distillery	85,000	Pounds per hour
Electricity capacity required during production season and entirely fed by bagasse	5	MW

Table 80: Greenhouse gas emissions from final product transport

Average distance from the final conversion facility to the end sales point		
	100	km
Type of vehicle used to transport the biomass		
	Truck	
Fuel used by this vehicle		
	diesel	

5.2 Biodiversity

Costa Rica and the whole Central American region is megadiverse and a biodiversity hotspot. Four cordilleras cross the country (Guanacaste, Tilarán, Central and Talamanca), bringing a variety of climates and microclimates, with climate and biological differences: 12 Holdridge lifezones and 12 lifezones in transition have been censed.

Costa Rica as an isthmus is a biological bridge where many flora and fauna species coexist:

- herpetofauna, about 360 species (150 amphibians y 210 reptiles),

- avifauna, about 850 species including 225 migratory,

- mastofauna, about 205 species, inluding bats and mammals

The country has 169 areas under protection as "wild protected area", covering 26.3% of its terrestrial extension, 17.2% of territorial seas and 0.9% of its sea-coastal waters (see table 11; Figure 11)

Table 11. Wild protected areas by type of management in Costa Rica (2009)

number	*Type of management*	*% national territory (51,100 km²)*	*% territorial sea waters (30,308 km²)*
28	National parks	12.33	15.69
8	Biological reserves	0.42	0.17
31	Protective zones	3.09	0.00
9	Forest reserves	4.24	0.00
75	National wildlife refuge	4.67	1.27
13	Wetlands, incl. mangroves	1.34	0.00
5	Other categories (national monuments, experimental station…)	0.17	0.05
169	***Total***	***26.28***	***17.19***

Source: SINAC 2009.

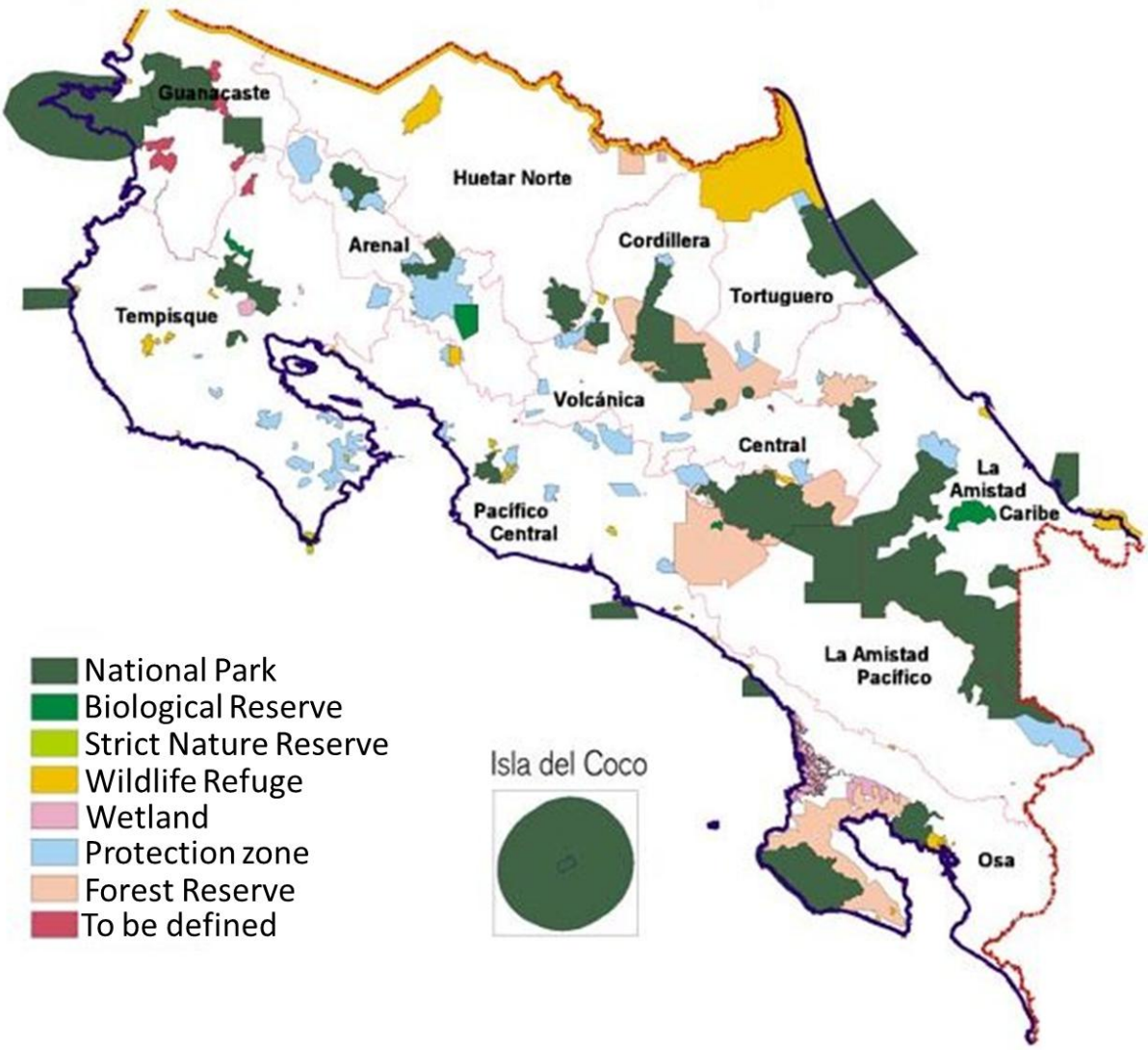


Figure 12. Management categories of Protected Areas

Source: INBIO
www.inbio.ac.cr/estrategia/Estudio_2004/Paginas/esfuerzos_conservar01.html

With SINAC (national system of conservation areas), the country developed the concept of integral conservation in matters of forests, wildlife and protected wild areas, under the 1998 Biodiversity law. SINAC aggregated 11 subsystems (see Figure 13).

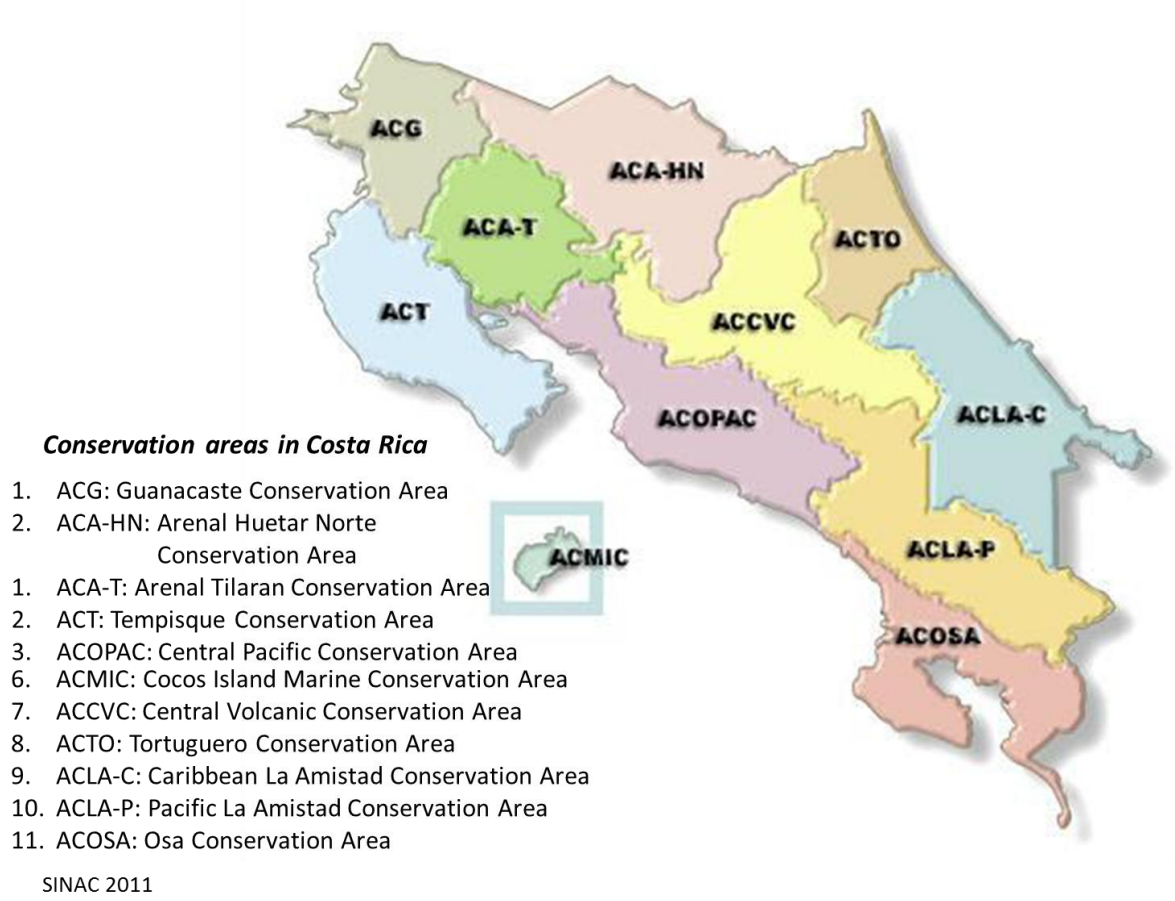


Figure 13. Conservation areas of Costa Rica

Source: SINAC 2011

As shown in figures 14, 15 and 16, CATSA case study is within or close to three conservation zones: Guanacaste, Tempisque and Arenal-Tempisque.

Figure 17 also helps locating the case study within the influence area of the three conservation zone.

With average distances of 15 to 20 km between sugarcane plantations and the sugar and ethanol plants, CATSA is located close to 7 protected areas at a distance of 11 to 95 linear kilometres.

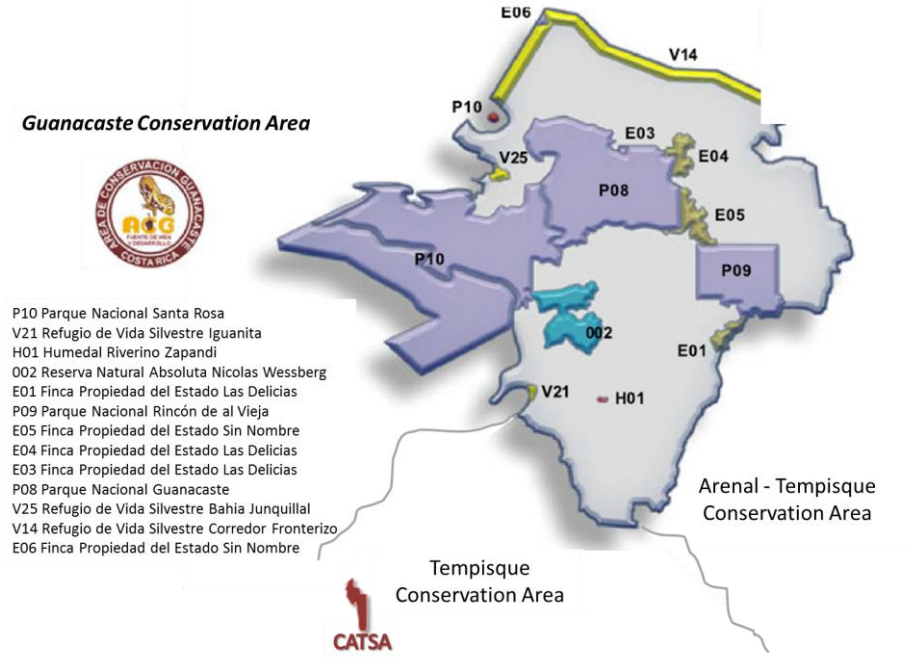


Figure 14. Guanacaste conservation area

Source: SINAC 2011

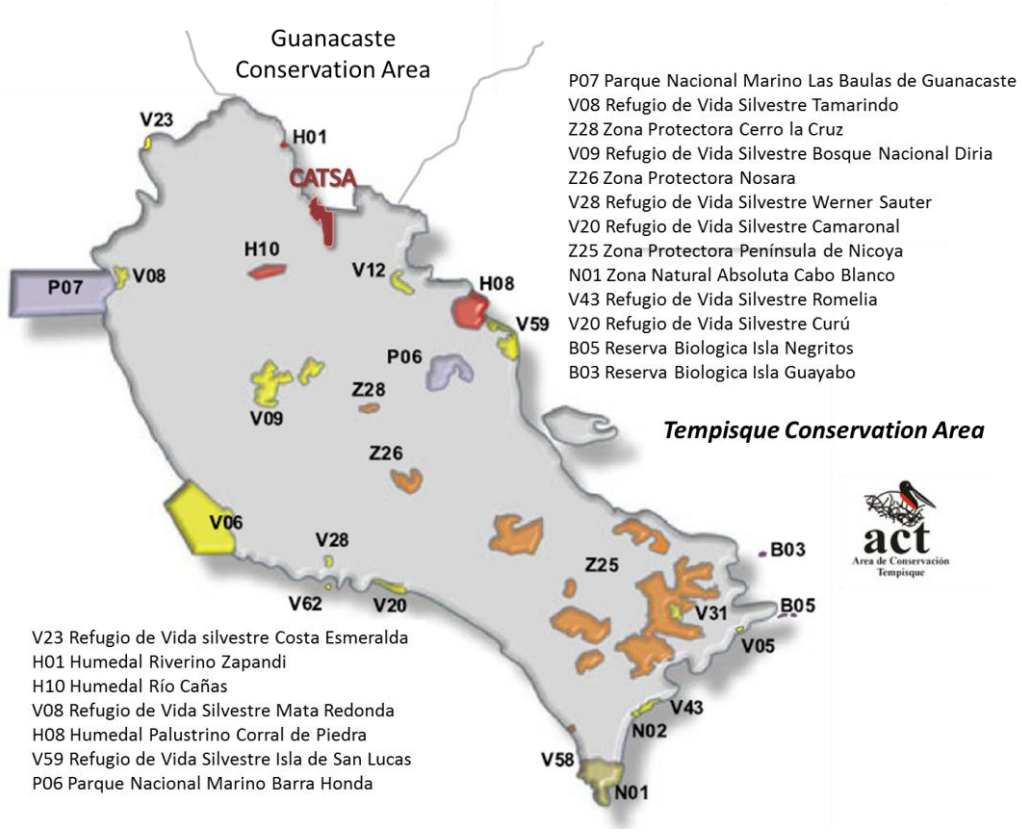


Figure 15. Tempisque conservation area

Source: SINAC 2011

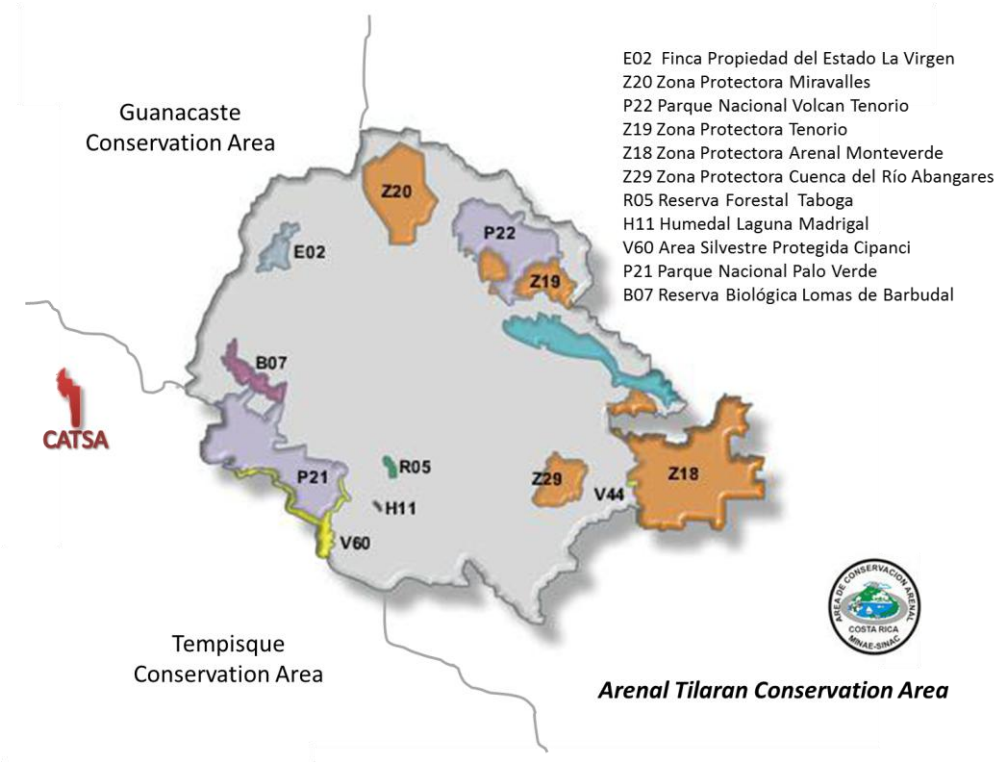


Figure 16. Arenal-Tempisque conservation area

Source: SINAC 2011

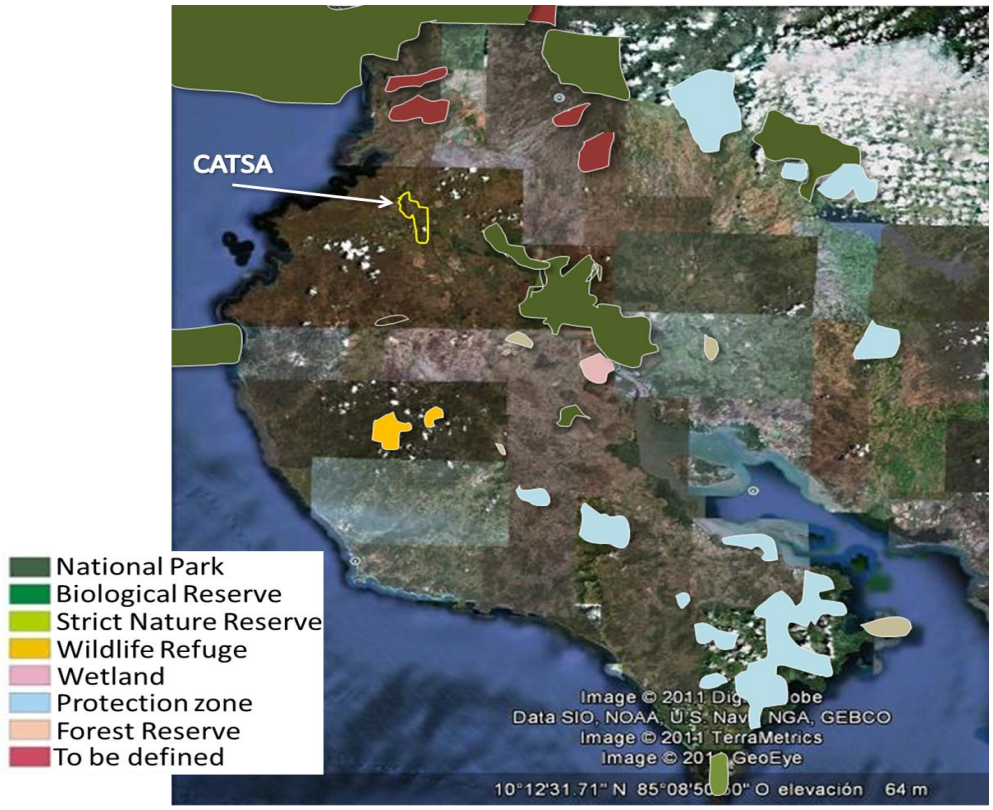


Figura 17. CATSA location and the wildlife protected areas in Costa Rica

Source: SINAC 2011

5.3 Water resources and water quality

General information on water availability and quality can be found in the national institute of aqueducts and sewer systems (Aya), specialized organism created by Law Nº 2726 of April 14th 1961.

According to Aya, Costa Rica do not have availability problems of water resources to meet its demand for drinkable water at the national level, but its distribution is not homogenous neither spatially nor on time scale. The lack of water infrastructure impedes satisfying demand generated by population growth, trade and industry, additionally to the unplanned tourism development that has been taking place for the last 10 years mainly on the Pacific coast (CFIA 2010).

Compared with the other countries of the region, Costa Rica has on average a better water availability, better total extraction and intensity of water use (see table 12).

Table 12. Water availability, extraction and use intensity in Central America

Country	Water availability		Total extraction	Use intensity index	Water use per sector (%)		
	Per capita m^3/year	Total million m^3/year	Million m^3/year	%	Agriculture	Municipal	Industrial
Costa Rica	16,859	72,900	2,680	3.67	54	17	29
El Salvador	1,752	10,600	1,270	12.01	54	46	0.3
Honduras	12,008	82,800	860	1.04	81	11	8
Guatemala	12,197	155,000	5,140	3.32	77	16.2	8.7
Nicaragua	23.486	128,000	1,300	1.02	83	3	14
Panamá	29,193	94,200	824	0.87	29	5	66
Belice	66,429	18,300	125	0.58	0	89	11
Average	*23,132*	*80,257*	*1,743*	*3.22*	*54*	*27*	*19*

Source: CEPAL 2011

In the country, 67% of the water is superficial, 33% is underground (Morales 2010); rainfall bring an estimated 170 km^3 yearly (OPS 2003). Hydroelectricity is the main use of water from the river (70%), then agriculture (23%). Water use for human consumption, tourism, industry and agroindustry represents less than 8% of total extraction (CEPAL 2011).

There are 17 main watersheds in the country, see Figure 18.

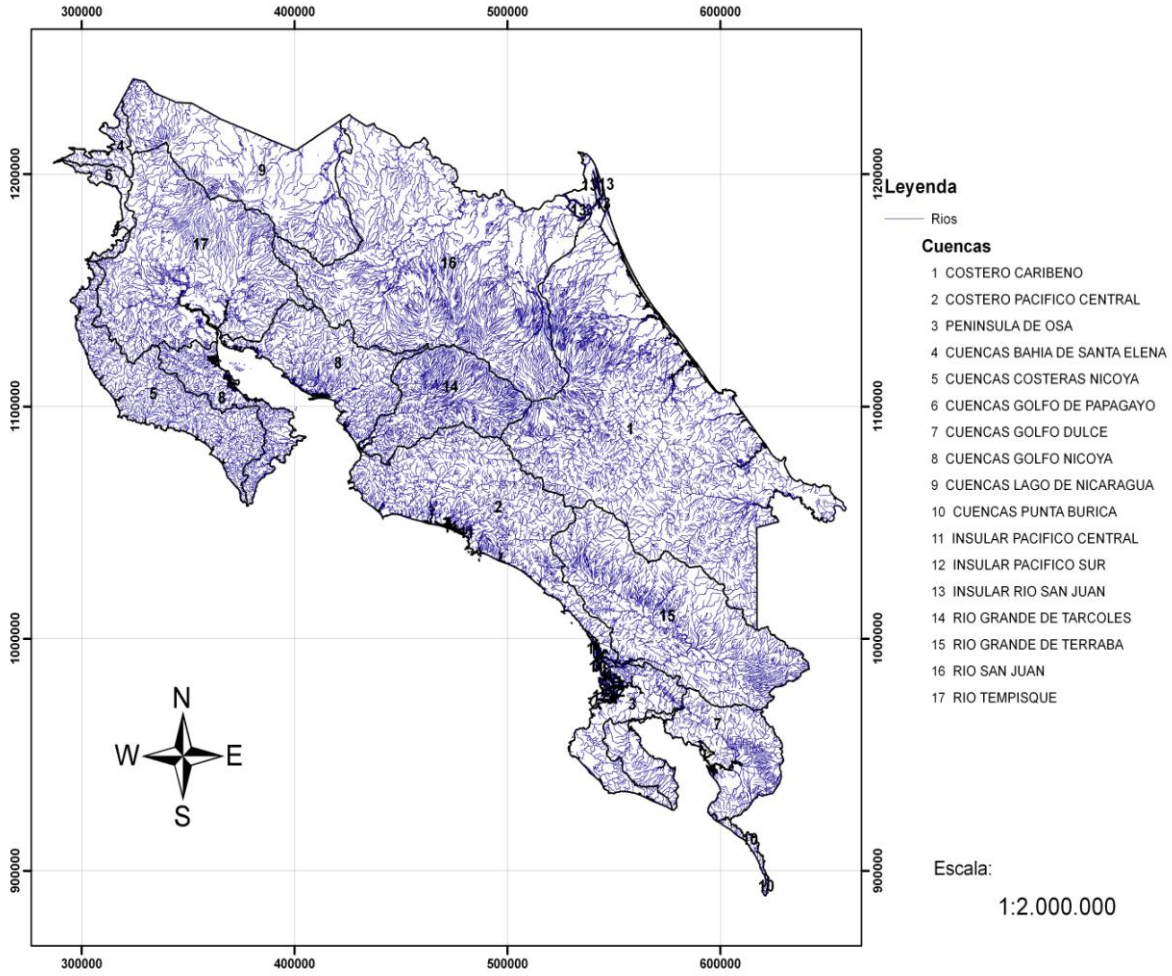


Figure 18. Costa Rica's watersheds

Source: MAPOTECA UNA 2008

The Arenal-Tempisque watershed hosts the Arenal dam, the largest hydroelectric project of the country. The same watershed is used downstream for irrigation in the Guanacaste province, aquaculture, recreation, inundation control and conservation of the waterland ecosystem.

The most important aquifers in the country are: Colima Superior, Colima Inferior, Barba, Liberia, Bagaces, Barranca, La Bomba (Limón), Zapandí y los acuíferos costeros: Jacó, Playas del Coco, Brasilito and Flamingo[8].

In Guanacaste, the coverage and quality of water for human consumption is 84.3%, percentage of the population receiving drinkable agua (Mora y Portuguez 2011) (see Figure 19). La provincia es la que cuenta con el mayor % de tratamiento de aguas residuales con 4 lagunas de estabilización (25 % de población), tanques sépticos y letrinas (75% población). El 71% de la población descarga sus aguas residuales domesticas por medio de pozos sépticos.

[8] Wikipedia: http://es.wikipedia.org/wiki/Geografía_de_Costa_Rica

CATSA uses the water from the Tempisque river for the production of sugarcane and its conversion to ethanol. The Tempisque river is one of the 9 most important rivers of the country, 138 km long and a 8.2 m^3/s volume of flow. It drains 60% of the Guanacaste province, one of the driest zone of the country. The Tempisque watershed represents a 3,405 km^2 area, an average (over a year) 27.4 m^3/s fall. Together with the Bebedero river, it is of great importance for agricultural use, both rivers represent 75% of total irrigation water.

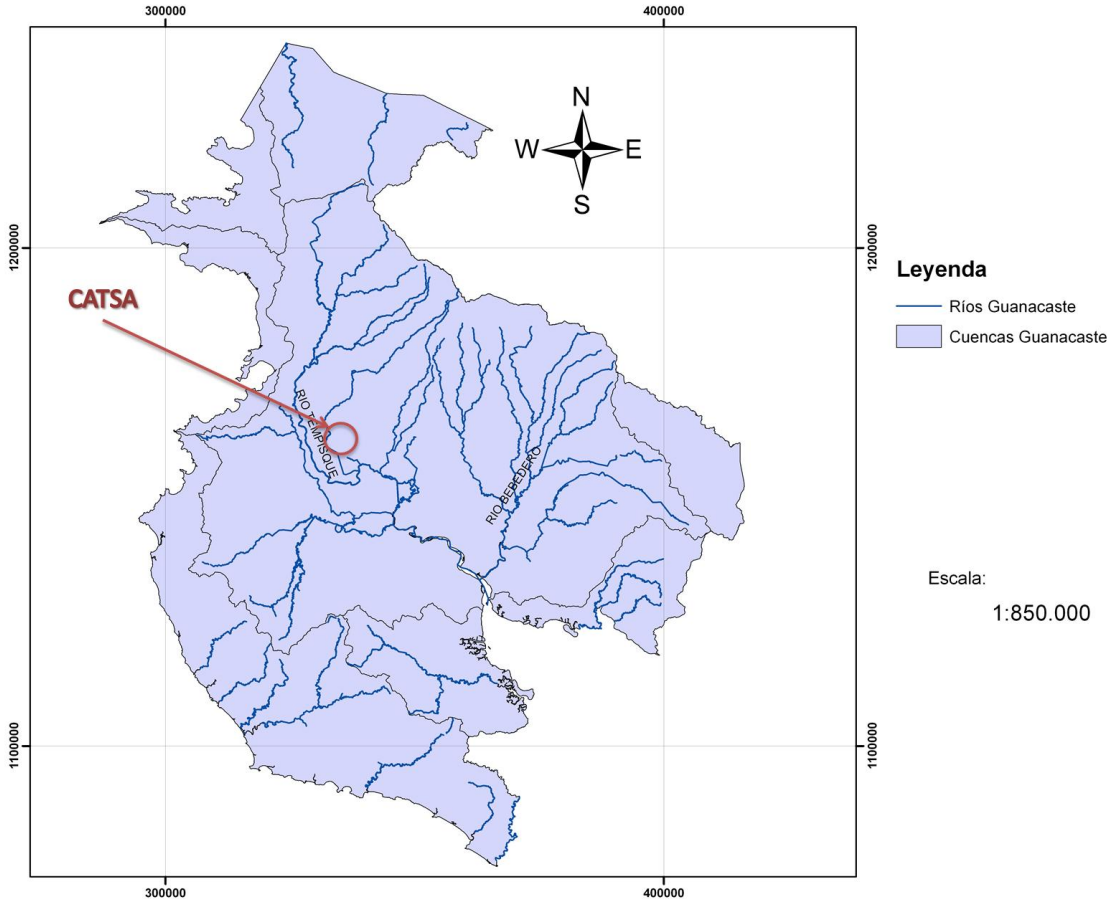


Figure 19. Main rivers in the Guanacaste province

Source: MAPOTECA UNA 2008

In the Tempisque watershed, available water has been estimated at approximately 2.43 km^3 per year (Oreamuno 2004), totaling 1.61 km^3 of superficial water and 0.82 km^3 underground water. The water from the river is subject to a concession (21 mil l/s) for its use in sugarcane, rice and melon especially (Mateo-Vega 2008) (see table 13). Agricultural activities have increased with the development of an irrigation project diverting about 90 m^3/s of water from the Caribbean slope towards the Tempisque watershed (OTS 2008).

Table 13. Concession pumped water in the Tempisque watershed (km^3)

Use	Superficial	Underground	**Total**
Agriculture	0.61	0.03	**0.64**
Industry	0.13	0.00	**0.13**
Human *	0.00	0.02	**0.02**
Turism	0.00	0.00	**0.00**
Total	**0.74**	**0.04**	**0.80**

*Estimates, considering an annual consumption of 500 l/person and demographic data from INEC 2004.

Source: Echeverria 2004

5.4 Soil

The soils of the Tempisque watershed belong to 5 groups: alfisols, entisols, inceptisols, molisols y vertisols (Mateo-Vega 2008). CATSA present great proportion of inceptisols containing various tipes of clay and primary minerals, making the zone subject to inundations.

6 Evaluation of the measurable units and indicators

Characteristics		Study data
Economic impacts	% of sugar cane contribution to GDP	1.1% (LAICA 2011)
	% of sugarcane contribution to agricultural GDP	14.4% (LAICA 2010; Gómez 2008; SEPSA 2008)
Social impacts through employment	Number of jobs at CATSA	1210 jobs in total 490 the whole year long 720 additionally during harvest
	Ratio of fixed contract : casual/daily workers	0.68
	Wage levels paid to workers, including casual workers	cf. Table 3 p 38
	Income earned by smallholders from the sale of sugarcane	according to sugar content of their supply, approximately EUR 16/tn sugarcane
Working conditions	Level of provision of OSH systems, training and protective equipment	good for permanent employees enhanced with ISCC certification process
	Extent to which legal requirements for social security payments and accident insurance are complied with	OK
	Extent to which trade union rights are respected	limited employer controlled solidarity association
Health impacts	Number of workers reporting health concerns related to agrochemical use	direct causality not established Costa Rica with high cancer rates
	Level of compliance with a given standard for waste treatment and disposal	internal use of vinasses, limited access to data
Risks for smallholders	The extent to which plantation companies and millers deal	regulated by LAICA where all affiliated sugarcane producers are equally

	transparently with smallholders	represented
Environmental impacts	particule emissions	
Environmental impacts	vinasse spreading	

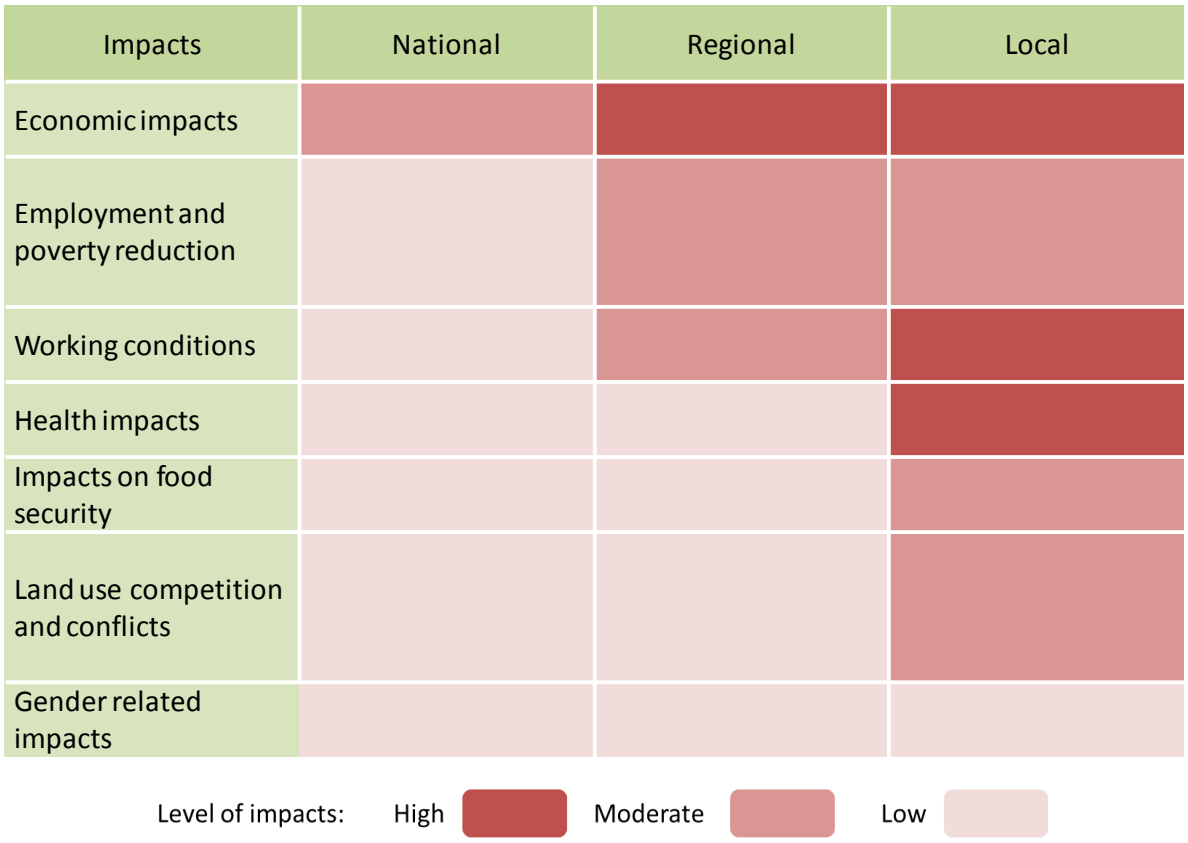


Figure 20. Relevance of impacts at different scales

Source: adapted from Wright 2011

Impact and biomass certification

ISCC is already in place, CATSA being certified since 2010. According to CATSA, the certification process implied mainly paperwork, only minor improvements were asked for.

7 Conclusion

The case of Costa Rica was studied separately from Brazil for the sugarcane-to-ethanol supply-chain.

Costa Rica has a long history of sugarcane plantations with sugar as a main product and alcohols produced out of the molasses.

However no sugarcane-to-ethanol production chain has been settled yet in spite of the 2008 biofuel law promoting the substitution of up to 10% of the gasoline consumed nationally by ethanol. Two firms in the country are growing sugarcane, producing sugar and molasses out of which they process ethanol exported to the European Union. The national ethanol

consumption limited to one region comes from hydrated ethanol imported from Brazil and dehydrated in Costa Rica.

Sugarcane production has only one zone favourable to relatively large-scale production and supply for ethanol production, this is the Guanacaste province where a few large farms coexists with smallholders.

In this province with relatively low population density and high poverty rates, sugarcane production has been offering since long the possibility to maintain part of the population. However it does not seem that the sector can take the province out of poverty. Opportunities offered by the sugarcane production are limited by land prices rising with tourism development and higher value-added crops. In the rest of the country, complementarity of sugarcane production with other agricultural production is key to the sustainability of sugarcane cultivation.

Regarding sugarcane transformation to ethanol, it comes after sugar production and using bagasse to provide process heat. However the context (electricity selling prices to the network) is not favourable to the optimization of yields in the conversion of sugarcane to ethanol.

Main issues on environmental impacts are related: upstream to the burning of sugarcane before harvesting even with mechanization given the low profitability of residue conversion for the time being; downstream to the spreading of vinasses given that some soils are saturated.

Further developments of the sugarcane-to-ethanol supply chain mainly rely on better incentives to optimise production and conversion processes.

The impacts of sugarcane production

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