Dominik Rutz · Rainer Janssen *Editors*

Socio-Economic Impacts of Bioenergy Production

Springer

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Preface

Many countries worldwide are increasingly engaging in the promotion of biomass production for industrial uses such as biofuels and bio-products (chemicals, bioplastics, etc.). Driven by the strong public debate on sustainability aspects, bioenergy is confronted with many environmental and socio-economic impacts. For instance, social impacts, which can be both positive and negative, include property rights, labor conditions, social welfare, economic wealth, poverty reduction, etc. Impacts are influenced by local and regional framework conditions under which bioenergy is produced. These include educational level, cultural aspects, history and economy of the producing countries, policies including environmental and social targets.

This book "Socio-Economic Impacts of Bioenergy Production" discusses impacts of the increasing global bioenergy demand from different perspectives. It illustrates the complexity of interrelated topics in the bioenergy value chain, ranging from agriculture to conversion processes, as well as from social implications to environmental effects. It furthermore gives an outlook on future challenges associated with the expected boom of a global bio-based economy, which contributes to the paradigm shift from a fossil based to a biomass and renewable energy based economy. Contributions to this book are based on the experience of selected authors from Europe, Africa, Asia, and Latin America, including researchers, investors, policy makers and other stakeholders such as representatives from NGOs.

The book is targeted towards policy makers, scientists, and NGOs in the fields of agriculture, forestry, biotechnology, and energy.

This publication builds upon the results of the Global-Bio-Pact project on "Global Assessment of Biomass and Bio-product Impacts on Socio-economics and Sustainability" which was supported by the European Commission in the 7th Framework Programme for Research and Technological Development from February 2012 to January 2013.

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We also thank our colleagues at WIP Renewable Energies for their continuous support of our international project activities. Finally, we thank our partners and families for their support.

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Editors’ Biography

Dominik Rutz graduated in Environmental Science (Dipl.-Ing.) and Consumer Science (M.Sc.) at the Technical University of Munich, Germany, and the Institut National d’Horticulture, France. He is Senior Expert at WIP Renewable Energies and his main field of experience includes market support and international cooperation on bioenergy in developing countries and emerging economies worldwide.

Mr. Rutz coordinated the European Union supported projects BioTop (Biofuels Assessment on Technical Opportunities and Research Needs for Latin America), Global-Bio-Pact (Global Assessment of Biomass and Bioproduct Impacts on Socio-economics and Sustainability), BiG>East (Biogas for Eastern Europe) and Urban-Biogas (Urban Waste for Biogas Production). He is author of several handbooks on biogas, heat use from biogas, liquid biofuels, and biomass heating systems. He is furthermore an invited expert and lecturer for several conferences and courses, e.g. for a course on 2nd generation biofuels at UNAM (Universidad Nacional Autónoma de México) and REMBIO (Red Mexicana de Bioenergía).

While travelling to more than 45 countries worldwide in all continents and stimulated by his diploma thesis on vegetation ecology in the Okavango Delta in Botswana in 2004, his main fascination is dedicated to the beauty of nature and cultural spirit of different countries. Nature conservation on the one hand and social equity on the other hand are the main drivers for his engagement in decentralized renewable energy supply. Thereby his interest goes far beyond the bioenergy field, towards holistic and sustainable energy systems.

The interest in nature, nature conservation and in the use of natural resources is also mirrored in his private life as his main hobby and interest is in self-subsistence systems, including the operation of his own small-scale apiculture, animal breeding, vegetable and fruit cultivation, and electricity production through a PV plant.

Rainer Janssen graduated in Physics (Dr. rer.nat.) at the Technical University of Munich, Walter Schottky Institute, Germany and performed studies at the University of Toronto, Canada. He is Head of the Biomass Department at WIP Renewable Energies and Senior Expert in the Biomass field. He is involved in the production, distribution and market penetration of bioenergy (solid biomass, biogas) and biofuels for transport (e.g. bioethanol, biodiesel, vegetable oil) with special emphasis on the development of supportive framework conditions and policy regulations in the EU, Latin America, Africa and other emerging economies.

Since 2000, Dr. Janssen is involved in the coordination of a variety of international and European projects. Recent projects include the FP7 project Global-Bio-Pact focusing on socio-economic impacts of biomass and bioproducts on a global level, the FP7 project BioTop on biofuels assessment on technical opportunities and research needs for Latin America, and the international competence platform COMPETE (FP6) on the sustainable use of energy crops and agro-forestry systems in Africa.

Based on the results of the COMPETE project Dr. Janssen co-edited (together with Dominik Rutz) the book "Bioenergy for Sustainable Development in Africa" which was published by Springer in 2012. This book specifically addresses biomass energy development opportunities and associated risks for Africa and covers biomass production and use, biomass technologies and markets in Africa, biomass policies, sustainability, and financial and socio-economic issues.

In recent years, Dr. Janssen was invited expert in the field of biomass energy for the European Commission (DG RTD, DG ENER), IEA (International Energy Agency) Bioenergy, and GIZ (German Technical Cooperation). Since 2009, Dr. Janssen is member of working group 4 on "Sustainability" of the European Biofuels Technology Platform and member of the Steering Committee of the Biomass Panel of the European Technology Platform on Renewable Heating and Cooling. Finally, since 2012 he is Vice-President of EUREC Agency, the European Renewable Energy Research Centres Agency, and Biomass Expert for the GIZ Programme "Sustainable Management of Resources in Agriculture" (NAREN).

List of Acronyms

ACCESS	local rural energy service company in Mali
AIDS	Acquired Immune Deficiency Syndrome
AD	anaerobic digestion
AAPRESID	Argentinian Association of Producers for No Tillage
AAPRESID	Asociación Argentina de Productores en Siembra Directa
AACREA	Asociación de Empresarios Agropecuarios
ACSOJA	Asociacion de la cadena de la soja Argentina
MAIZAR	Asociacion Maiz Argentino
ASAGA	Asociasion Argentina de Grasas y Aceites
BSI	Better Sugarcane Initiative
B5	Biodiesel 5%
BEFSCI	Bioenergy and Food Security Criteria and Indicators
BIAS	bioenergy environmental impact analysis
BTG	Biomass Technology Group BV
PNAD	Brazilian Survey by Household Sampling
BC	British Columbia
CARBIO	Cámara Argentina de Biocombustibles
CATSA	Central Azucarera Tempisque S.A.
CST	Certification for Sustainable *Tourism* Program
CDM	Clean Development Mechanism
CHP	combined heat and power
CBO	community based organization
CGE	computable general equilibrium
CPI	consumer price index
CSR	corporate social responsibility
CPO	crude palm oil
DET	differential export tax
dLUC	direct land-use changes
DDGS	distiller dried grains solubles
ESR	Ecosystem Services Review
ESP	energy service platform
ESMP	environmental and social management plan

EA	environmental assessment
EIA	environmental impact assessment
E5	ethanol 5%
EC	European Commission
EU	European Union
FP7	7th Framework Programme
FT	fair trade
FTO	fair trade organisation
FFV	flex-fuel vehicle
FW	food waste
FSC	Forest Stewardship Council
FFB	fresh fruit bunch
GDI	gender-related development index
GATT	General Agreement on Tariffs and Trade
GM	genetically modified
GMO	genetically modified organisms
GIS	geographic information system
GBEP	Global Bioenergy Energy Partnership
GPS	global position system
GMP	good manufacturing practice
GHG	greenhouse gas
GDP	gross domestic product
GRDP	gross regional domestic product
HCV	high conservation value
HLPE	High Level Panel of Experts
HDI	human development index
HIV	Humane Immundefizienz-Virus
iLUC	indirect land-use change
I/O	Input/Output
IFEU	Institut für Entsorgung und Umwelttechnik GmbH
INTA	Instituto Nacional de Tecnologia Agropecuaria
INTI	Instituto Naciondel de Tecnologia Industrial
IRR	internal rate of return
IEA	International Energy Agency
ILO	International Labour Organisation
ISEAL	International Social and Environmental Accreditation and Labelling Alliance
ISCC	International Sustainability and Carbon Certification
LUC	land use change
LCA	life cycle assessment
LAICA	Liga Agricola Industrial De La Cana de Azucar
LPG	liquefied petroleum gas
MBSA	Mali Biocarburant S.A.
MFC	Mali Folkecenter
AMADER	Malian Agency for Domestic Energy and Rural Electrification

ANADEB	Malian Biofuel Agency
MDG	Millennium Development Goals
MAGNET	Modular Applied GeNeral Equilibrium Tool
MFP	multifunctional platform
MSW	municipal solid waste
NGV	natural gas vehicle
NPV	net present value
NGO	non governmental organisation
NES	nucleus estate smallholder
OECD	Organisation for Economic Cooperation and Development
POME	palm oil mill effluent
PM	particulate matter
PIR	Perkebunan Inti Rakyat
PF	phenol-formaldehyde
PCW	post-consumer waste
PCF	product carbon footprint
PROSOJA	Profecionales Especialisados en Cultivo de Soja
PEFC	Program for Endorsement of Forest Certification
PPP	purchasing power parity
SAN	Rain Forest Alliance Sustainable Agriculture Network
RECOPE	Refinadora Costarricense de Petróleo
RAIS	Relaçao Anual de Informaçoes Sociais
RED	Renewable Energy Directive
RTRS	Roundtable on Responsible Soy
RSB	Roundtable on Sustainable Biofuels
RSPO	Roundtable on Sustainable Palm Oil
RR	Round-up Ready
SAI	Social Accountability International
SA	social assessment
SIA	social impact assessment
SEIA	socio-economic impact assessment
SOM	soil organic matter
FAOSTAT	Statistics Division of the FAO
SJO	straight jatropha oil
SVO	straight vegetable oil
SEA	Strategic environmental assessment
SEA	strategic environmental assessment
SWOT	strengths, weaknesses, opportunities, and threats
UNICA	Sugar Cane Industry Union
THLB	timber harvesting land base
UNIDO	United Nations Industrial Development Organization
WIP	WIP Renewable Energies
WTO	World Trade Organisation

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Chapter 1
Socio-Economic Impact Assessment Tools

Martijn Vis, Anne-Sophie Dörnbrack and Sébastien Haye

Abstract Impact assessments are used throughout different sectors to evaluate the potential damages and benefits to the environment and the society, which a given project or realization could cause. Impact assessments are applicable to all sectors from construction to agriculture, services and industry. In many countries, (environmental) impact assessments are part of the legal requirements for any new project beyond a certain size. Socio-economic impact assessments are relevant to many bioenergy, biofuel and bio-product production processes. These assessments consists of the following steps: (1) scoping and issues identification, (2) determination of the social and economic baseline, (3) predicting and analyzing impacts, (4) determination of significance (5) mitigation, management and monitoring. Socio-economic impact assessments can be used as an add-on to environmental impact assessment and to support biomass certification schemes. An example of the latter is the RSB scheme in which a screening tool is applied to determine if impact assessments are required as part of the biomass certification process.

Keywords Impact assessment tools · Socio-economic impact assessment · Social impact assessment · Bioenergy · Rapid appraisal

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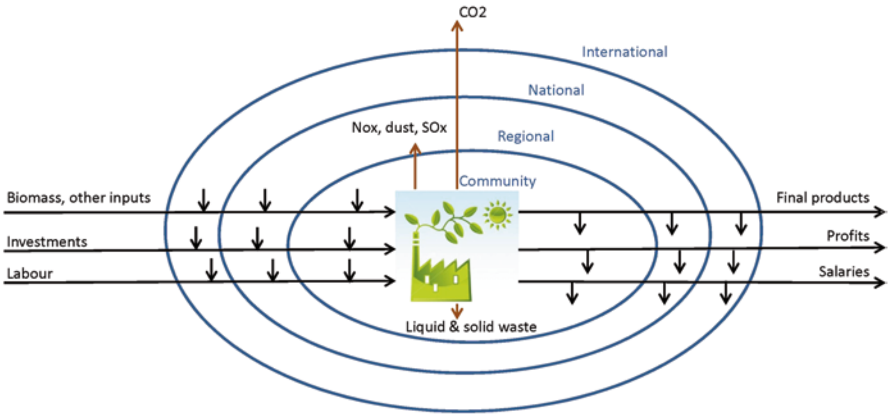

Fig. 1.1 Main inputs and outputs of a biomass conversion facility

1.1 Introduction

Each activity that takes place in a biomass conversion chain, as well as each input and output has impacts. Raw materials, labor and capital are the classic ingredients needed for a factory to operate. Technology could be added as a fourth factor that is materialized in capital goods (equipment/hardware, information technology, etc.) and embedded in humans (technical and organizational skills, etc.). The activities in the conversion chain result in various outputs such as final products, jobs, salaries, profits, but also emissions, waste, transport movements, etc. Figure 1.1 presents the main inputs and outputs of a biomass conversion facility.

The biomass conversion chain (its inputs, outputs and activities) will have various impacts such as socio-economic, fiscal, environmental, and traffic impacts. The impacts can take place at various levels:

- Production unit level
- Community level
- Regional level
- National level
- International level

Moreover, several types of impacts can be distinguished, such as direct and indirect impacts as well as in cumulative impacts.

Direct impacts are the direct consequences of a proposed project's location, construction or operation on the socio-economic environment. The direct socio-economic impacts of a large-scale development are often manifested as changes in socio-economic structures (e.g. increased employment opportunities, increased income levels, new or expanded social services, etc.).

Indirect impacts are the secondary consequences of direct impacts (e.g. altered consumption patterns, increased business opportunities and an increased need for particular services). The types of indirect impacts that the proposed development may cause, depend largely on an individual and community's priorities, and their ability to manage changes.

Cumulative impacts are repeated impacts on a valued component. The accumulation of insignificant impacts happening over time can cause one significant impact. An example of a cumulative impact is the effect on housing availability and the cost of living in a community that is experiencing an extended period of immigration of people employed by several consecutive developments in one region.

1.1.1 Types of Impact Assessments

Various methods have been developed to assess and quantify the impacts of planned interventions (policies, programs, plans, projects), such as:

- Socio-economic impact assessment (SEIA)
- Environmental impact assessment (EIA)
- Strategic environmental assessment (SEA)
- Social impact assessment (SIA)
- Development impact assessment/sustainable development
- Fiscal impact analysis
- Traffic impact analysis

These will be described in more detail in the subsequent sections.

1.1.1.1 Socio-Economic Impact Assessment

Different definitions for the **Socio-economic Impacts Assessment** (SEIA) exist. Mackenzie (2007) defines SEIA as the systematic analysis (used during EIA) to identify and evaluate the potential socio-economic and cultural impacts of a proposed development on the lives and circumstances of people, their families and their communities. After Edwards (2011), the SEIA examines how a proposed development will change the lives of current and future residents of a community.

The goals of SEIA may vary from simply reducing the negative effects of these actions on people to maximizing their positive benefits and to contribute to sustainable development.

The concepts used in SEIA are derived from a number of social disciplines, including economics, sociology, geography, anthropology and political science. The key issue and challenge in SEIA is to understand the nature of social or economic impacts. An impact is a change in conditions caused by a development, such as a road or a mine. Generally, socio-economic impacts are changes in the human condition. They are changes in the economic and social conditions of local communities, vulnerable groups (such as women, children, or poor), businesses and employees, districts, provinces or even the nation. Generally, health impacts and cultural impacts (e.g. language loss) are also subject of SEIA, but are not always covered in depth, as they may need special studies. Social and economic impacts may each require specific studies and analysis using different techniques.

Various other assessment methods have been developed in order to determine the impacts of projects, policies, programs and plans. Below a selection of these assessment methods are defined and related to the SEIA.

1.1.1.2 Environmental Impact Assessment and Strategic Environmental Assessment

Environmental Impact Assessment (EIA) is a systematic process to identify, predict and evaluate the environmental effects of proposed actions and projects. This process is applied prior to major decisions and commitments being made. A broad definition of environment is adopted. Whenever necessary, social, cultural and health effects are considered as an integral part of EIA (UNEP 2002).

Strategic Environmental Assessment (SEA) refers to a formal process of systematic analysis of the environmental effects of development policies, plans, programs and other proposed strategic actions. This process extends the aims and principles of EIA upstream in the decision-making process, beyond the project level and when major alternatives are still open (UNEP 2002).

Socio-economic impact assessments (SEIA) are often seen as additional to environmental impact assessments (EIA). Mackenzie (2007) states: *"In the past EIA focused on direct and indirect biophysical impacts of proposed developments (i.e. impacts of development activities on water, air, land, flora and fauna). In recent years the impacts of industrial development on society, culture and different forms economic activity have gained equal importance in EIA."* Especially when the social impacts are high, for instance when a big dam is planned, it is obvious that carrying out a SEIA, in addition to an EIA, is essential. EIA procedures and frameworks have been used as a base to develop SEIA.

1.1.1.3 Social Impact Assessment

The **Social Impact Assessment** (SIA) includes the process of analyzing, monitoring and managing the intended and unintended social consequences, both positive and negative of planned interventions (policies, programs, plans, projects) and any social change processes invoked by those interventions. Its primary purpose is to bring about a more sustainable and equitable biophysical and human environment (IAIA 2003). According to the definition of UNEP (2002, topic 13) the SIA identifies the consequences to people of any proposed action that changes the way they live, work, relate to one another, organize themselves and function as individuals and members of society, with particular attention to the mitigation of adverse or unintended aspects. This definition includes social-psychological changes, for example to people's values, attitudes and perceptions of themselves and their community and environment.

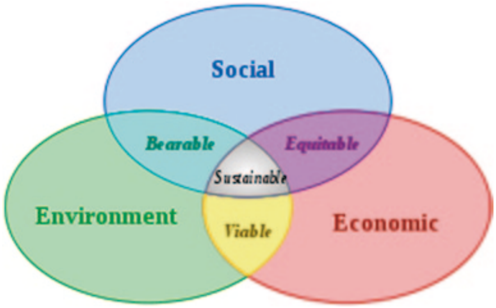

Fig. 1.2 Scheme of sustainable development: at the confluence of three constituent parts. (Source: Adams 2006)

The main types of social impact that occur as a result of these project-related changes can be grouped into five overlapping categories (UNEP 2002, topic 13):

- **Lifestyle impacts**—on the way people behave and relate to family, friends and cohorts on a day-to-day basis;
- **Cultural impacts**—on shared customs, obligations, values, language, religious belief and other elements which make a social or ethnic group distinct;
- **Community impacts**—on infrastructure, services, voluntary organizations, activity networks and cohesion;
- **Amenity/quality of life impacts**—on sense of place, aesthetics and heritage, perception of belonging, security and livability, and aspirations for the future;
- **Health impacts**—on mental, physical and social well-being, although these aspects are also the subject of health impact assessment.

The definitions of the SIA are very comparable to those of Socio-*economic* impact analysis (SEIA). These assessment types are sometimes mixed. However, it is clear that in a proper SEIA both social and economic impacts are studied.

1.1.1.4 Development Impact Assessment/Sustainable Development

The classic definition of sustainable development is *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (United Nations 1987). The United Nations 2005 World Summit Outcome Document refers to the "interdependent and mutually reinforcing pillars" of sustainable development as economic development, social development, and environmental protection (Fig. 1.2). By combining environmental impact assessment and socio-economic impact assessments the sustainable development impact can be assessed.

Development impact assessment involves a process to comprehensively evaluate the consequences of development on a community. The assessment process should be an integral part of the planning process as it provides extensive documentation of the anticipated economic, fiscal, environmental, social and transportation-related impacts of a particular development on a community (Edwards 2011).

Sustainable development assessment (SDA) is an overarching methodology (with many components), which is used in evaluating investment projects (as well as programs and policies), to ensure balanced analysis of both development and sustainability concerns. The 'economic' component of SDA is based on conventional economic and financial analysis (including cost benefit analysis). The other two key components are environmental and social assessment (EA and SA). However, many other more specialized types of assessments may be included within an integrated SDA.

1.1.1.5 Other Impact Assessments Analyses

The **Fiscal Impact Analysis** estimates the impact of a development or a land use change on the costs and revenues of governmental units serving the development. The analysis enables local governments to estimate the difference between the costs of providing services to a new development and the revenues, taxes and user fees, for example, that will be generated by the development. (Edwards 2011)

A **Traffic Impact Analysis** is a study which assesses the effects that a particular development's traffic will have on the transportation network in the community. Traffic impact studies should accompany developments which have the potential to impact the transportation network (Edwards 2011).

Fiscal impact analysis could be part of an economic impact assessment. A traffic impact analysis could typically be included in an environmental impact assessment.

1.2 Socio-Economic Impact Assessment

For the evaluation of socio-economic impacts of biofuel/bio-product conversion chains the *socio-economic impact assessment (SEIA)* is the most relevant assessment method. In the last decade, broad guidelines for the practice of the SEIA have been developed at the practitioner level. For example, principles for SEIA have been developed by the International Association for Impact Assessment (IAIA) (IAIA 2003). Mackenzie has published *socio-economic impact assessment guidelines* (MVEIRB 2007) and UNEP has published an *Environmental Impact Assessment Training Resource Manual*, that includes a chapter on social impact assessment (UNEP 2002). In this chapter the SEIA is described and related to the other impact assessment methods.

The following main steps are included in the SEIA process (Mackenzie 2007):

1. *Scoping and issues identification:* The proposed project must be well-defined. Social and economic issues must be identified as well as the geographic and temporal study boundaries.
2. *Determining the social and economic baseline*: There must be a good understanding of the impacted community or communities and the general socio-economic conditions in the project area.

3. *Predicting and analyzing impacts*: The assessment must be able to project what the social and economic impacts may be, including the effect of potential interactions between factors and over the lifetime of the development.
4. *Determining significance*: There must be an assessment of the importance of the social and economic impacts of the project.
5. *Mitigation, management and monitoring*: Once impacts and their significance are understood, decisions must be made about whether the project should proceed. If so, measures must be identified to avoid or lessen negative impacts (mitigation) and maximize positive impacts. Management of the mitigation needs to occur and on-going monitoring of the projects effects must be carried out to ensure thresholds are not crossed.

These steps are further explained in the next sections. More information can also be found in Mackenzie (2007).

1.2.1 Scoping and Issues Identification

Before starting an SEIA it is important to determine its scope consisting of:

- The scope of development
- The scope of issues
- The scope of assessment
- Level of detail of SEIA

The **scope of development** includes a description of the project to be studied in the SEIA, including the needed human resources, skills, goods and services and changes to the physical infrastructure.

In the **scope of issues**, potentially relevant impacts need to be identified. An initial selection can be made with the help of existing long lists of possible impacts. Initially or later in the process, also community members need to be involved to ensure that relevant impacts are included.

van Dam (2010) provides a list of socio-economic impacts relevant for biomass production, classified under the following themes:

- Working conditions and rights
- Economic aspects
- Competition and availability of natural resources
- Social aspects and welfare
- Health impacts
- Food security
- Smallholder aspects
- Policy and governance aspects
- Land tenure and rights
- Participatory aspects

Each theme consists of a number of potential impacts. The theme *working conditions and rights* includes for instance:

- Freedom of association and collective bargaining
- Forced labor
- Elimination of child labor and protection of children and young persons
- Equality of opportunity and treatment
- Minimum wages
- Working time
- Health and safety
- Social security
- Unemployment benefit
- Social security for migrant workers
- Maternity protection
- Migrant workers

Most of these themes and their underlying potential impacts could be relevant for both, biomass production (feedstock cultivation) and conversion.

If needed, other lists of potential impacts can be used to support the process of impact identification. An initial list of issues—mainly relevant on community level—is provided by Mackenzie (2007). Another extended list of potential impacts can be found in UNEP (2002). During the SEIA process some issues initially included might be found less relevant, and some new issues might be added to the selection.

The **scope of assessment** defines the spatial boundaries of the SEIA, depending on the type of the listed potential impacts. It is likely that many social impacts take place on company and community level; some impacts such as the contribution to the GDP can be assessed on national level. Furthermore, it should be defined which stages of the project are included in the SEIA. The following stages can be distinguished: planning, construction, operation, decommissioning, and post closure stage.

The **level of detail of the SEIA** can be different. It is reasonable to link this level to the size of the project and the expected level of concern related impacts. MVEIRB (2007) distinguished basic, moderate and comprehensive SEIAs and developed a test to determine which level is appropriate.

In a *basic SEIA* the following information should be included:

- A record and description of efforts to consult potentially affected communities and other parties.
- A development description, including the following socio-economic data:
  - Total estimated capital costs of the proposed development, including annual operating costs
  - Approximate number of workers including the developer's employees and contractors, and number of person days/years of work for the proposed development, including subcontracting
  - Identified archaeological resources within the footprint of the proposed development

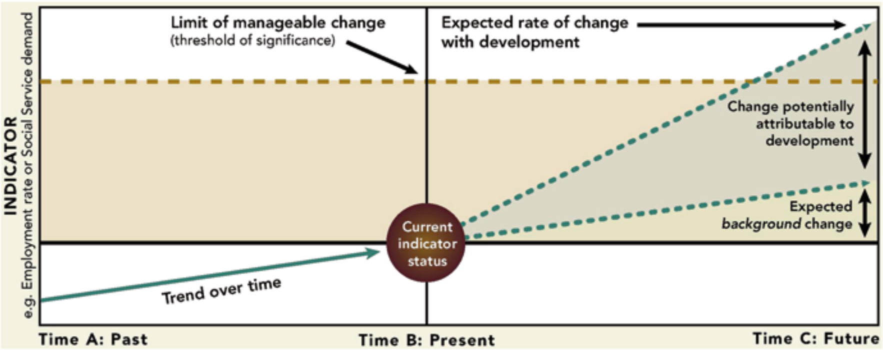

Fig. 1.3 Impact predictions. (Source: MVEIRB 2007)

- – A list of any extra regional infrastructure required for the proposed development to proceed

- Any identified potential impacts on the socio-economic environment, and suggestions for mitigating these impacts

In a *moderate SEIA* a distinction is made between the construction, operating, maintenance and decommissioning phase of the proposed project. Additional information requirements are described in MVEIRB (2007).

The *comprehensive SEIA* is required for complex large-scale and long-term developments such as large mines, oil and gas operations, pipelines, large new highways, hydroelectric dams, etc. The SEIA needs to be carried out well in advance of the proposed development (see MVEIRB 2007, pp. 28–29).

1.2.2 Determination of the Baseline

The developer should describe the current socio-economic and cultural environment and the context of the proposed project. It can be difficult to determine whether an impact is caused by the proposed project. The socio-economic environment will continue to evolve whether the project occurs or not. The occurrence of two simultaneous projects/developments can make it hard to attribute the impacts between the projects. Even the issue whether an impact is adverse or beneficial, depends on an individuals' personal choice. For example, increased disposable income can create stronger families, brighter futures for children and greater health; or it can fuel anti-social behavior (Fig. 1.3) (MVEIRB 2007).

The choice of methods and tools for characterizing and predicting social and cultural impacts is essential and described in the next sections.

1.2.3 Methods of Predicting and Determining Economic Impacts

Economic issues are given substantial emphasis in SEIA. Possible economic impact assessment tools include fiscal analysis, cost benefit analysis and input/output analysis.

The **Fiscal Impact Analysis** estimates the impact of a project or development on the costs and revenues of governmental units serving the project or development. It focuses on the inter-relationship between project viability and government costs and revenues. Government obtains revenues from a project through a variety of taxes, fees, and royalties. The government may also impose conditions on the developer that will raise the costs of government institutions managing and monitoring the environmental and socio-economic standards of a project. If the net cost of all of these elements is too high, the project will not proceed. A balance is required. Fiscal analysis also concerns intergovernmental relationships with respect to project revenues and costs (Mackenzie 2007).

A **Cost-Benefit Analysis** is a technique used to compare the various costs associated with an (investment) project with the benefits that it proposes to return. Most feasibility studies use cost-benefit analysis to determine the feasibility of a project. Typical indicators used are Net Present Value (NPV), Internal Rate of Return (IRR), Simple Payback Period and figures showing yearly cash flows. In order to make this calculation, traditionally the main inputs and outputs of the project need to be identified, including direct labor costs, use of intermediary products, quantities of waste, etc. *as far as they have a direct financial impact* on the proposed project. In addition, it is possible to quantify the costs and benefits of environmental impacts, cost effectiveness of mitigation and, where possible, environmental and social costs of intangibles (e.g. costs of pollution) in monetary units (e.g. dollars, euros). In some cases, the environmental and social cost/benefit estimates provided in the SEIA are then used to perform an overall economic analysis of the project. An overall economic analysis evaluates the total economic value of a project.

The **Input-output (I/O) Analysis** studies the interrelationships within and between economic sectors of a country and can be used to determine the impacts of an economic activity on the whole economy. The I/O method is based on a country's I/O table, which is available from national statistical bureaus and which generally concerns the country's economy for a time period of 1 year. There are two options by which a new industry can be introduced to the economy. The first method is based on creating a new final demand vector, while the second method is based on including the new industry in the technology matrix. Despite the first method's popularity, the second method has the advantage that it accounts for the impacts of the introduction of a new sector in a more complete manner. That is to say, the second way not only accounts for the inputs being bought by the new sector from the existing sectors, but can also account for its outputs being consumed by the existing sectors (Wicke 2006). The construction of an input-output table requires a large amount of data on inter-industry flows and other variables. Governments are often the only organizations with adequate resources for designing these models, and collecting and analyzing the required data. Other agencies using input/output models must usually rely on existing models developed by government (Mackenzie 2007). For more information and examples of input/output analysis applied to a biomass conversion chain see Wicke (2006), van den Broek et al. (2000), and Wicke et al. (2006).

1.2.4 Methods of Predicting and Determining Social Impacts

Many consultative techniques are used in SEIA to identify issues, predict impacts and plan for mitigation. These include surveys, public meetings, workshops, focus groups, networks, and checklists. Table 1.1 gives an overview of commonly used tools.

The techniques described in Table 1.1 are effective for identifying present vulnerability and future developments, and to involve stakeholders in the identification of issues and concerns. Once issues and concerns are identified, the social analyst normally consults case studies of similar projects to compare impacts. If time permits, focused ethnographic research may be carried out. Otherwise rapid cultural appraisal techniques can be used. An example of the design of a rapid appraisal method is given in Box 1.1. The case study partners determine their approach based on the particular situation of the case.

Box 1.1: Rapid Appraisal

Rapid appraisal firstly involves collecting data from existing written sources. Secondly, 'key informants' are recruited to help obtain the views of local people. Key informants are local people who have a good knowledge of the local area. Their opinions are sought and they are asked to identify further informants, and if willing can join the research team to assist in interviewing other local people. The final stage of the process is a validation workshop, which provides an opportunity to feedback on findings and identifies any remaining gaps.

1.2.5 Determining Significance and Mitigation

After analysis of impacts it is important to evaluate whether the (negative) impacts are acceptable. If negative impacts are below an acceptable threshold, proper mitigation measures must be taken or ultimately the project should be terminated. The acceptable threshold can be determined using traditional and local knowledge, community based knowledge, standards, guidelines, policy statements, and biomass sustainability certification systems. In many cases mitigation measures can be identified and discussed with impacted communities, governments and other stakeholders. From the positive view, measures can be taken to benefit optimally from the positive impacts of the project. Management of the mitigation needs to occur and on-going monitoring of the projects effects must be carried out to ensure that thresholds are not crossed.

Table 1.1 Tools for the determination of social impacts. (Mackenzie 2007)

Techniques for social analysis	Description	Evaluation
Surveys/Questionnaires	Continuous or one-time. Targeted at impacted individuals (e.g. those employed during projects, workers spouses, etc.)	If a carefully designed survey keeps turning up a particular answer, causality is suggested. Poor design can yield inadequate responses
Focus Groups/Workshops	Held in groups of 6 or less (the smaller the group, the more productive the session) of individuals well informed on a particular topic. Collaborate to move towards consensus on key issues	A well-conducted focus group/workshop can yield a great deal of very useful information and insight. Moderate disagreement would normally suggest that there should be no attribution until more evidence of causality has been obtained
Community Meetings	Held in public to identify community based concerns. Provides opportunity for open dialogue	Effective when identifying broad issues regarding impacts (e.g. do you think what is happening is good or bad?). Good indicator of public support/unhappiness. A poorly organized public hearing can be counterproductive, leading to polarization of views, to unfounded fears about the socio-economic impacts of the project, or to unfounded confidence in the project
Networks/Technical Advisory Committees	Experts on particular issues relevant to the assessment process who lend advice on an on-going basis (community leaders/policy analysts)	Difficult to establish. Development can take time and energy
Checklists	Matrices are useful in ensuring that relevant impacts are identified. Design requires giving consideration to key component impacts of a project	Useful in making inter-community comparisons—identifying how various communities may see things differently
Ethnographic/ethno-historic studies	Focused study of the impacts of development on indigenous communities on social organization. Carried out by trained community or academic researchers at the community level	Difficult to carry out in the timeframe of an SEIA. Alternative is the Rapid Ethnographic Assessment Procedures (REAP) of cultural mapping, in-depth interviewing, focus groups supplemented with limited survey research

1.3 Socio-Economic Impact Assessment and Biomass Certification

1.3.1 The Relevance of Impact Assessment in Biomass Certification

Certification schemes and impact assessments can also complement each other. An interesting example is the certification scheme of the Roundtable on Sustainable Biofuels (see www.rsb.org). It requests participating operators to perform a screening exercise to determine whether assessments like an Environmental and Social Impact Assessment are required. A special RSB Screening Tool (RSB 2011) is developed for this purpose. In case biofuel operations will have significant impacts, as measured during the screening exercise, a social impact assessment process shall be carried out. RSB provides further guidance on how to carry out these impact assessments. This could be an interesting way to address the relevant socio-economic issues in more depth while using a biomass certification scheme.

Impact assessments are used throughout different sectors to evaluate the potential damages to the environment and the society, which a given project could cause. Impact assessments are applicable to all sectors from construction to agriculture, services and industry. In many countries, impact assessments are part of the legal requirements for any new project beyond a certain size.

Standard and certification systems are designed to offer economic operators the possibility to obtain a neutral and credible mean to demonstrate compliance with sustainability criteria. Some certification systems prove to be more stringent and comprehensive in the way they address social and environmental impacts and are more robust in their implementation. Some schemes dedicated to biomass/biofuel certification, such as the Roundtable on Sustainable Biofuels (RSB, see next chapter), address a large number of potential impacts, including complex topics such as land rights violation and local food insecurity.

Certification in general and certification of biomass/biofuel in particular can greatly benefit from the use of impact assessment processes to support economic operators towards compliance with standard requirements and sustainable practices. Understanding and evaluating the intensity of potential impacts is the logical prerequisite to any mitigation or corrective action. In the example of the RSB (see next chapter), the accomplishment of an impact assessment process is not only a recommendation towards compliance, but a specific requirement, which needs to be complied with to receive certification.

Conducting an impact assessment can prove to be extremely relevant for the adaptation of the implemented design and practices in the early stage of a project. Thus, potential impacts of the biofuel project can be sufficiently understood, mitigated upfront and monitored over the further development.

Whether or not an impact assessment is required *per se* for certification, the data collected by an operator during an impact assessment process provide important information on the local context, implemented practices and potential impacts of operations. These data can be used by an auditor during the certification process to evaluate compliance of operations. Therefore, by conducting a proper impact assessment, an operator may as well save time and costs in anticipation of a certification process. Additional benefits include improved management systems and practices, decreased likelihood of dispute with local communities, risk mitigation regarding payment of penalties for environmental damages, improved reputation, etc.

1.3.2 An Example of Use of Impact Assessment Tools in Biomass Certification: The Roundtable on Sustainable Biofuels (RSB)

Certification schemes can include impact assessments as part of the requirements for compliance, although this remains rare. As an example, the Roundtable on Sustainable Biofuels (RSB) requires operators to conduct an impact assessment process, which can be adjusted to the needs and specific context of each operator. Through this impact assessment process, operators evaluate the potential or existing impacts of their operations on all the environmental and social aspects included in the RSB Standard. These are: stakeholder consultation, human and workers' rights, impacts on local communities, food security, land rights, conservation (biodiversity), soil, water and air.

For each of these topics, operators may be required to conduct an in-depth impact assessment. Whether or not this is the case is being determined through a preliminary step called a **Screening Exercise** (RSB 2011). The screening exercise is a compulsory step for all operators to carry out. It includes different sections, which relate to the environmental and social criteria covered by the RSB Standard. For each section, the operator needs to answer simple questions, which determine whether a more detailed investigation is mandatory. As an example, an operator located in an industrialized country will not be required to evaluate the impact of operations on local food security or an operator using rain fed agriculture does not have to assess the impact of operations on the depletion of water resources.

Such differentiation and flexibility is extremely important, as each of these in-depth impact assessments involve additional costs and efforts for producers. The aim of the RSB is to have an efficient, cost-effective and practical certification process; hence the need to avoid triggering additional unnecessary studies. As an important safeguard, the results of the screening exercise are verified by the auditor during the certification process. It is also important to note that, regardless of the content of the impact assessment process and the Environmental and Social Management Plan (ESMP), operators will still be evaluated against each and every RSB requirements.

The RSB developed specific guidelines for in-depth impact assessments, which are available for operators and auditors to use. They cover the following topics:

- Rural and Social Development
- Food Security
- Conservation (Biodiversity)

- Soil
- Water, including water-use rights
- Land Rights

At the end of the impact assessment process, operators shall compile all the results and the mitigation practices implemented to address the impacts of biofuel operations in a document called an **Environmental and Social Management Plan (ESMP)**. The content and length of the ESMP will vary according to the number of impact assessments triggered by the operator. For an operator with low risk of impacts, as determined through the screening, the ESMP will be rather succinct, while operators with high risk of impacts will produce a substantial ESMP to cover all topics sufficiently.

By including Impact Assessments into their standard, the RSB assures that potential and existing impacts of certified biofuel projects are adequately addressed, mitigated and monitored.

1.4 Conclusion

Impact assessments are used throughout different sectors to evaluate the potential damages and benefits to the environment and the society, which a given project or realization could cause. In many countries, environmental impact assessments are part of the legal requirements for any new project beyond a certain size. In addition several impact assessment methods have been developed to assess relevant non-environmental impacts like socio-economic impact assessment (SEIA), Strategic environmental assessment (SEA), Social impact assessment (SIA), Development impact assessment/sustainable development, Fiscal impact analysis and Traffic impact analysis. Especially socio-economic impact assessments are relevant to many bioenergy, biofuel and bio-product production processes. These assessments consist of the following steps: (1) scoping and issues identification, (2) determination of the social and economic baseline, (3) predicting and analyzing impacts, (4) determination of significance (5) mitigation, management and monitoring. Socio-economic impact assessments can be used as an add-on to environmental impact assessment and/or to support biomass certification schemes. An example of the latter is the RSB scheme in which a screening tool is applied to determine if and what impact assessments are required as part of the biomass certification process.

Biomass certification schemes measure whether the normative sustainability criteria are met by the use of indicators for compliance, and are usually applied after project implementation. Impact assessments are systematic processes to identify, predict and evaluate the effects of proposed actions and projects. Both certification schemes and impact assessment are recommended tools for ex ante and ex post evaluation of biofuel and bio-product projects.

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Chapter 2
Indicators for Socio-Economic Sustainability Assessment

Rocio Diaz-Chavez

Abstract Indicators have been used to organize, monitor and assess information in different contexts. During the last twenty years indicators have gained more importance, being used to assess sustainability performance of different activities through the implementation of standards. This chapter explores the evolution of the use of socio-economic indicators and their applicability in a relatively new production area, that of biofuels. The use of indicators has been more focused on environmental issues and compliance with voluntary schemes. Socio-economic indicators have gained more attention as a result of concerns with production of biofuels in developing countries. A set of indicators is proposed to monitor the possible impacts (both negative and positive). It is suggested that monitoring may help initiatives at national, regional and local level and may be combined with voluntary performance schemes in order to promote a sustainable production of biofuels.

Keywords Indicators · Socio-economic sustainability assessment · Criteria · Biofuels · Certification

2.1 Introduction

Many efforts for the development of sustainability schemes, dedicated or related to bioenergy crops have focused on environmental impacts, such as deforestation, biodiversity loss, water availability and quality, soils, and greenhouse gas (GHG) emissions. However, the increased use of biomass for biofuel production may generate conflicts along with synergies between socio-economic and environmental impacts, particularly in the context of developing countries. The last two years have seen an increment in the number of standards that have been developed for bioenergy purposes. In 2012, the European Commission had recognized twelve voluntary schemes (EC 2012). These standards have also improved the balance between environmental and social issues, although they largely rely on compliance indicators.

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The chapter contextualizes the growing importance of indicators in the wider agenda of sustainable development, which highlights the need for balancing the social, economic and environmental objectives and impacts of development initiatives. It reviews existing standards that include socio-economic indicators in bioenergy production, discussing the role and challenges involved in creating and using indicators, before it presents a specific set of indicators developed for application in the biofuel sector.

2.2 Indicators and Sustainable Development

The last twenty years have seen a growing interest in use and selection of indicators in the context of sustainable development and in debates on sustainability, although there is no universal consensus on the theory, methodology and use of indicators. Yet, international protocols and agreements, have contributed greatly to the development and use of sustainability indicators, on economic, social and environmental issues (Diaz-Chavez 2003). Since the 1992 Rio Summit, many initiatives have been undertaken to promote sustainable development as well as to measure progress towards it, with chapter 40 of Agenda 21 calling for the development of indicators for sustainable development specifically (UN 1992).

Indicators have since gained much greater importance and have been used for a wide range of purposes (Siniscalo 2000), particularly for monitoring trends and changes in any particular process, and for identifying challenges. Yet, indicators and indices are only useful for describing or helping to describe a given situation, rather than explaining it. International and national institutions (e.g. GBEP 2011, OECD 2000a, b; UN 2007) have been using indicators to assess performance and change on a number of dimensions, such as income, education, health and welfare, both at the regional and national levels (Diaz-Chavez 2006).

In the context of sustainable development and sustainability, there has been a tendency for emphasis to be placed on the economic and environmental dimensions, to the relative detriment of social and cultural dimensions. Nevertheless, as established in Agenda 21 (UN 2012), the functions of indicators is to provide a solid basis for planning and decision-making on all dimensions so as to contribute to the sustainability of integrated environment and development systems.

Sustainability indicators can be useful in showing how changes in the economy, the environment and society interrelate. The key function is to simplify information, so that there is a balance between accuracy and concision. The applicability of indicators at the local level is crucial in helping both the public and decision-makers to identify and solve problems of sustainable development (Diaz-Chavez 2003).

Most of the attention paid to indicators has focused on environmental issues and indicators, which have been used largely for ecological purposes for quite some time (e.g. water quality indicators). Less attention has been paid to social and economic indicators (Diaz-Chavez 2006).

Growing interest on biomass for biofuel and bioenergy production has evidenced the need for standards that address sustainability goals. This requires ensuring that any particular production system is environmentally, socially and economically sustainable. In addition, this entails contributing to a reduction of greenhouse gases (GHG) emissions, creating no negative impacts (environmental or socio-economic), as well as contributing to positive social outcomes.

In the discussion on sustainability indicators, key concepts are often used interchangeably, although there is often conflation. Here, a 'standard' refers to a set of principles and criteria to be used consistently as rules and guidelines to ensure that materials, products, processes and services meet their purpose. A standard will also define indicators and methods used to gauge compliance with principles and criteria. A standard incorporates:

- **principles**: defined as 'general tenets of sustainable production'
- **criteria**: the conditions needed to achieve these tenets and which help to define the indicators to be answered
- **indicators**: the individual questions that demonstrates how a producer meets a particular criterion (Woods and Diaz-Chavez 2007).

An index in turn is a composite indicator derived from individual indicators that are compiled into a single index, on the basis of an underlying model of the multi-dimensional concept that is being measured (OECD 2012).

2.3 Indicators: Role, Choice and Challenges

It must always be born in mind that the ideal indicator does not exist. A second-best proxy is often used to develop an indicator, a practice that is thought to be both acceptable and effective (Segnestam 1999).

After selecting and measuring indicators, it is necessary to interpret them. The absolute level of the indicator can serve as a diagnostic tool to be compared with future trends. In some cases, control groups can be used to measure conditions in areas not affected by a project or the activity. In other cases, modeling techniques should be used to predict what would have happened had the project not been implemented.

There is also interest in concise and balanced sets of indicators that provide meaningful information on the key dimensions of sustainable development to policy-makers and the general public. Sets of indicators reflecting key trends and policy variables are useful instruments to respond to common policy goals. Core sets are useful for comparison and can be adapted for different purposes, including tracking performance against plans and budgetary information (Siniscalo 2000).

Indicators are generally meant to be used for decision-making processes at the national level and so not all indicators will be applicable in every situation. Countries will choose from potential indicators those which are relevant to national priorities and goals (UN 1992).

Some of the key limitations of indicators include the fact that they may simply constitute parameters, the fact that a methodology needs to be fine-tuned to better reflect the requirements of sustainable development, and the lack of indicators that mesh together environmental, social, economic and institutional aspects (Hens 1996). Also, for the most part, indicators are quantitative measures, whilst environmental and social indicators are often not suited to economic evaluation. In particular, the value of ecological functions is often underestimated in traditional economic and accounting models. For this reason, indicators of sustainability are not always quantifiable, and at times, may also be subjective (WTO 1996). In addition, it has been noted (Briassoulis 2001) that indicators still need to be developed to address critical dimensions (e.g. social, cultural, institutional and political), and so are indicators that integrate all the dimensions of sustainability and track progress towards sustainability, or indicators that account for spatial relationships (e.g. horizontal and vertical).

2.4 Socio-Economic Indicators of Sustainability

Social impacts tend to be more difficult to monitor and quantify as they require more in-depth studies, such as household surveys, which are time consuming and expensive to conduct. Thus, the implementation of standards might provide an effective means of bringing together organizations that are already monitoring impacts and certifying activities. Still, a key difficulty is that in most standards the monitoring refers more to compliance than to the actual impacts.

A further issue is the need to consider the interactions between environmental and socio-economic indicators when examining impacts (for instance, the link between the use of water for the feedstock production and the use of water by the community).

Socio-economic indicators are used to analyze a particular social phenomenon or society as whole. They are useful for monitoring developments over a period of time; they are appropriate for including within a standard or certification scheme; they may be derived from qualitative and quantitative data; and they can be applied on a supply chain (e.g. feedstock production and conversion).

Indicators are expressed in real values, or they can be expressed in binary units, such as zero or one. This mode is often used to depict the presence or absence of a circumstance or event. Often, several indicators are used together. When their combined values are expressed as a single value, these indicators are said to form an index or an aggregated indicator. Indices can be further manipulated by ascribing weights to their components (Webber and Alexander 1997).

Quantitative indicators are useful as they may provide additional information rather than just describing the state of the environment (Segnestam 1999). Also, information that can be collected and presented as a ratio or percentage is of more value than presenting absolute numbers in isolation. The choice of an indicator or index requires consideration of the methods to be employed for collecting, analyzing and disseminating data. Seasonality is also important as it will impact on trends and changes over time. Another important factor for the choice and use of indicators is whether an indicator or index can be ascribed targets, which can be long or short-term (Webber and Alexander 1997).

The measurability of indicators can be placed along a continuum. At one end, there are indicators that cannot be measured at all, whilst at the other end, there are indicators that comprise an inherent measure. In other words, some components may be of more importance than others and should therefore be weighted more heavily (Hart 1999). However, it is also extremely difficult to determine a weighting which is reliable and valid (Webber and Alexander 1997).

In particular, indicators are needed that describe the social-environment interface and address issues of social sustainability. There is still a gap between the demand for sustainable development indicators, the measurability of underlying data sets and the actual use of such indicators (Diaz-Chavez 2011). The interactions between social and environmental dimensions are also complex and many of their links need to be examined (e.g. environmental degradation and social impacts). Similarly, economic and social relationships may have environmental consequences, but their links may be difficult to ascertain with precision (OECD 2000a; Diaz-Chavez 2009).

A further issue is the need to consider the interactions between the environmental and socio-economic indicators when examining impacts. For instance, the link between the use of water for the feedstock production and the use of water by the community has to be investigated (Rettenmaier et al. 2012).

International and national institutions have been using indicators to assess the regional and national performance and development in social issues: income, education, health and welfare. Table 2.1 provides some examples of socio-economic indicators.

Socio-economic indicators are used for statistics to analyze a particular social phenomenon or a society as whole. They are useful to:

- monitor developments over a period of time (against a baseline)
- be considered along a standard or certification scheme
- employ with qualitative and quantitative data
- apply on a supply chain (feedstock production and conversion)
- employ with certification schemes

Given the diversity of environmental problems and of projects, either causing them or designed to address them, arriving at a set of "universal" indicators (e.g. applicable to all situations) is not feasible. Nor is it practical to develop an exhaustive list of all possible indicators.

2.5 Socio-Economic Indicators in Current Voluntary Schemes

A comparison of different international certification systems for general management, environment and supply chain, forest production and agriculture activities, has been carried out by different authors, in order to identify whether these systems

Table 2.1 Selected social indicators. (modified from Jannuzzi 2001)

Theme	Indicator
Demographic and health	Birth rate
	Demographic increase rate
	Child mortality rate
	Life expectancy at birth
	Rate of death per causes
	Morbidity and health attendance
	Under nutrition
	Malnutrition rate
Educational and cultural	Illiteracy rate
	Average schooling
	Information and culture access
Employment (Labor market)	Unemployment rate
	Average income
Income and poverty	GDP per capita
	Average familiar income
	Gini Index
	Theil Index
	Poverty rate
Housing and urban infrastructure	House condition
	Urban services accessibility
	Transport infrastructure
Quality of life and Environment	Satisfaction with house, neighborhood, city and basic infrastructure
	Crime and homicides
	Environment (air condition, water, waste treatment, garbage collection)
Development	Human Development Index

Table 2.2 Selected standards or systems. (Diaz-Chavez 2010)

Sector/crop	Operational	Early implementation
Forestry	FSC, PEFC	GBEP
Oil Palm	RSPO, SAN, ISCC	RSB, GBEP
Soy	AAPRESID, SAN, ISCC	RTRS, RSB, GBEP
Sugar cane	BSI, SAN, ISCC	RSB, GBEP
Other	Fair trade, ISEAL, SAI	

might be of relevance to biofuel production and supply chain environmental assurance (see Diaz-Chavez 2007, Diaz-Chavez and Rosillo-Calle 2009, van Dam 2010).

Considering the extensive number of possible applications (van Dam 2010), twelve standards and systems (ISEAL and GBEP are not standards) were assessed that were considered directly relevant to bioenergy and bio-products and that also include social and economic issues (Diaz-Chavez 2010). Table 2.2 shows those that were selected.

The selected standards or systems were assessed according to the following criteria:

- Description of the initiative (organization, geographical coverage, feedstock/raw material)
- Description of system (biofuels, co-products, technologies)
- Standards description (principles, criteria, indicators) including number of each one and categories (e.g. social, legal)
- Compliance: legal, voluntary, international/national/regional approach

The review of standards and systems focused on the social and economic issues addressed by them. The review aimed at identifying the key topics of the schemes. Table 2.3 shows some of the general characteristics of the systems.

Most of the standards reviewed focus on qualitative indicators or information to be monitored. Only GBEP has indicators that measure both forms qualitative and quantitative.

Most of the standards include principles related to the working conditions, health and community benefits (including Corporate Social Responsibility). Table 2.4 shows the comparison of the different principles in most of the standards. ISEAL is not included as it provides guidelines for the development of schemes. GBEP was also not included because it is not a standard. Some points to consider from this overview include:

- Some standards call for national interpretation (e.g. RSB) and others such as PEFC already have national interpretations.
- Most standards consider the feedstock or the final product and few of them look at different parts of the supply chain.
- Very few have a specific principle or criteria for gender inclusion, although most call for community participation.
- There is little differentiation between the different parts of the supply chain except where the certification specifies chain of custody.

From the standards and systems reviewed it is apparent that ISEAL Impact Code and GBEP offer the possibility of developing and/or using available indicators that refer to the whole supply chain of bioenergy feedstock and their co-products as well as the possibility for monitoring impacts.

Social impacts tend to be more difficult to monitor and quantify as they require more in depth studies, normally household surveys which are time consuming and expensive. Therefore the link with the impacts from the application of the standards could be a good possibility to link with organizations that are already monitoring and certifying activities. Nevertheless, one of the main issues is that the monitoring refers more to compliance than to actual impacts.

Table 2.3 General characteristics of the standards and systems. (modified from Diaz-Chavez 2010)

Acronym	Standard's Name	Year	Region	Level	Type	Certification	Social	Econ
RSB	Roundtable on Sustainable Biofuels	2007	Global	Project	Standard	Y	√	√
RSPO	Roundtable on Sustainable Palm Oil	2006	Global	Project	Standard	Y	√	√
RTRS	Roundtable on Responsible Soya	2004	Global	Project	Standard	Y	√	√
Bonsucro	Previously BSI Better sugar Initiative	2011	Global	Project	Standard	Y	√	√
SAN	Rain Forest Alliance Sustainable Agriculture Network	2002	Global		Standard	Y	√	√
FSC	Forest Stewardship Council	2000	Global	Project	Standard	Y	√	√
PEFC	Program for Endorsement of Forest Certification	1999	Global	Project	Standards at National level	Y	√	√
SAI	Social Accountability International	2004	Global	Project	Guidelines (standard in development)	No	√	√
ISEAL	International Social and Environmental Accreditation and Labelling Alliance	2006	Global		Code of Practice	No	√	√
FLO	Fair Trade Organisation	2008 (FLO-cert)	Global	Project	Standard	Y	√	√
AAPRESID	Argentinian Association of Producers for No Tillage	1989	Argentina	Project	Standard	Yes	√	√
GBEP	Global Bioenergy Energy Partnership	2008	Global	National	Indicators	N	√	√
ISCC	International Sustainability and Carbon Certification	2006	Global	Project	Indicators	Yes	√	√

Table 2.4 Comparison of principles of selected standards. (Diaz-Chavez 2010)

Standard	Principles
SAN	Social and Environmental Management System
	Fair Treatment and Good Working Conditions for Workers
	Occupational Health and Safety
	Community Relations
SAI	Child labor
	No Forced labor
	Health and safety
	Freedom of association and the right of collective bargaining
	Discrimination
	Disciplinary practices
	Working hours
	Remuneration
	Management systems
RTRS	Legal Compliance and Good Business Practice
	Responsible Labor Conditions
	Responsible Community Relations
	Environmental responsibility
	Good Agricultural Practice
RSPO	Commitment to transparency
	Compliance with applicable laws and regulations
	Commitment to long-term economic and financial viability
	Use of appropriate best practices by growers and millers
	Responsible consideration of employees and of individuals and communities affected by growers and mills
	Responsible development of new plantings
	Commitment to continuous improvement in key areas of activity
FSC	Compliance with laws and FSC principles
	Tenure and use rights and responsibilities
	Indigenous peoples' rights
	Community relations and worker's rights
	Benefits from the forests: ensure economic viability and a wide range of environmental and social benefits
	Management plan
	Monitoring and assessment: to asses activities and social and environmental impacts
	Maintenance of high conservation value forests
	Plantations shall be planned and managed
RSB	Planning with impact assessment and management process and an economic viability analysis
	Not violate human rights or labor rights, and shall promote decent work and the well-being of workers
	Contribute to the social and economic development of local, rural and indigenous people and communities
	Biofuel operations shall ensure the human right to adequate food and improve food security in food insecure regions
	Maximize production efficiency and social and environmental performance, and minimize the risk of damages to the environment and people
	Biofuel operations shall respect land rights and land use rights

Table 2.4 (continued)

Standard	Principles
BSI	Obey the law
	Respect human rights and labor standards
	Manage input, production and processing efficiencies to enhance sustainability
	Actively manage biodiversity and ecosystem services
	Continuously improve key areas of the business
Aapresid	Legal Obligations (including land property)
	Labor Obligations (labor conditions and ILO compliance)
	Social Obligations (consideration of traditional communities)
Fairtrade	Social development: Fairtrade adds to Development
	Socio-economic Development and environmentally-sustainable development
	Environmental Development
	Labor conditions: ILO Conventions organizations to meet the ILO requirements as far as possible
ISCC	Good social practice regarding human rights/ labor rights compliance
	Land rights compliance
	Priority for food supply/food security

2.6 Developing a Set of Indicators

The set of indicators reported here were derived from information obtained through a number of steps. They included benchmarking of standards for environmental and social indicators; identification of impacts from relevant case studies (in the Global-Bio-Pact project); identification of socio-economic impacts in supply chains; examining the links between environmental and social impacts; and analysis of macro and micro indicators from relevant case studies (Diaz-Chavez et al. 2012). The development of impact indicators also took into account two timescales. Firstly, a comparison was carried out between the conditions of the area prior to the establishment of the production unit (e.g. plantation) and the situation after establishment, with a view to comparing the overall impact of operations. The standards under consideration generally assume the need for Environmental Impact Assessment to be conducted before the start of operations, although this will not apply to operations that are long-established. Secondly, monitoring of operations and their impacts should be on-going, and this is a requirement in the standards examined. The criteria and indicators proposed here are meant to provide a clear and balanced set, rather than comprising a certification or verification system. Nevertheless, it is expected that the set of indicators will be used by different stakeholders for a number of different purposes, such as assessing a bioenergy proposal or project; assessing the sustainability of feasibility studies for specific bioenergy projects; monitoring impacts at the local and regional level; employing it alongside a standard. Assessment of the effectiveness of the indicators was based on four key characteristics. Indicators were chosen according to measurability (e.g. how easy to use in measuring the impact); easiness of gathering data (e.g. how easy and cost-effective the requisite data can be gathered); usefulness for assessing socio-economic impacts

Table 2.5 Impacts and examples of indicators. (Diaz-Chavez et al. 2012)

Impact	Examples of indicators
Basic Information	
Framework conditions	Location, average yield
Socio-Economic Impacts	
Contribution to local economy	Value added, employment
Working conditions and rights	Employment benefits
Health and safety	Work related accidents
Gender	Benefits
Land rights	Land rights and conflicts
Food security	Land converted from staple crops
Environmental Impacts	
Air	Open burning
Soil	Soil erosion
Water	Availability of water
Biodiversity	Conservation measures
Ecosystem Services	Access to ecosystem services

(e.g. whether they actually assess the impact); and temporality (e.g. whether time-frame for usefulness of indicator is set out).

The indicators were selected bearing in mind that they can measure an impact over a period of time. For this reason a baseline was suggested for the field test work.

The indicators were classified in basic or background information, socio-economic indicators and environmental indicators (Table 2.5):

- **Basic information**: data that provides background information from the selected case study
- **Socio-economic indicators**: these include the impacts caused by bioenergy crops production and the different stages of the supply chain to produce biofuels
- **Environmental indicators**: in the context of the Global-Bio-Pact project refer to the environmental impacts that affect the socio-economic characteristics of the communities

Each indicator is linked to a measurement, monitoring process or unit depending of its nature. For instance, the "Average yield of the feedstock" is measured in t/ha/yr. The set includes further guidance on how to measure or monitor the indicator. Tables 2.6–2.8 present the indicators developed within the Global-Bio-Project. Furthermore it is indicated from where the data could be accessed: Processing company or plantation (P); Government (G); Community (C); Non-Governmental Organisation (N); Worker (W).

The set of indicators proposed by the Global-Bio-Pact project is balanced and includes the main topics of impacts selected by a clear process with the aid of expert partners of the project. Furthermore, the topics reflect the main identified socio-economic and environmental areas which can be measured in order to monitor and if possible to eliminate negative impacts and to promote the benefits if a sustainable production is in place.

Table 2.6 Global-Bio-Pact set of impact indicators: Basic information. (Diaz-Chavez et al. 2012)

No	Indicator	Measurement/ Monitoring Process/ Unit	Guidance	Data access
1.1	Name and location	Name and geographical location of the operation	Location map	P
1.2	Land area under cultivation	The total area of land cultivated by the operation (ha)	Breakdown of land under different feedstock and under different tenure (own land, rented land, smallholders, outgrower)	P
1.3	Expansion of land area	Additional land area under production (ha/year)	Additional land under feedstock production within the last 5 years. Previous land use of the land area.	P, G
1.4	Average yield	Average yield of the feedstock (t/ha/yr)	Annual average yields of the feedstock within the last 5 years	P
1.5	Annual production	Annual production of feedstock and subsequent products (t)	Annual production of the feedstock and the subsequent products and by-products within the last 5 years	P
1.6	Certification	Is the operation certified? If so, which certification(s)?	Type of certificate	P, N
1.7	Sectorial associations	Is the operation involved in sectorial associations, if so which association(s)?	Registered membership of associations	P, N

2.7 Conclusion

Any sustainability standard must include the three key components: economic, social and environmental aspects. Furthermore, a political and institutional new pillar has to be included as many of the issues implied in sustainability are regarded of political nature (e.g. targets) (see Diaz-Chavez 2003).

Most of the research on standards works on a monitoring and compliance basis but few have indicators which can actually be monitored under quantitative or clear qualitative parameters. The set of indicators of the Global-Bio-Pact project was created to be able to indicate the state of the impact and to be able to monitor it over time. It is expected that these indicators can be useful for different users from project developers, government and standards.

There is still a need to include other socio-economic indicators that can contribute to avoid some negative impacts of biofuel production. The use of these indicators will help the different users in promoting the sustainable production of biofuels.

Table 2.7 Global-Bio-Pact set of impact indicators: Socio-economic indicators. (Diaz-Chavez et al. 2012)

No	Indicator	Measurement/ Monitoring Process/ Unit	Guidance	Data access
Contribution to local economy				
2.1	Production cost	Breakdown of yearly production costs of the facility (incl. labor, raw material, energy, services, etc.) (EUR/t of feedstock)	Annual production costs within a 5-year period	P
2.2	Value added	Value added by the operation. Annual value of sales less the price of goods, raw materials (including energy) and services purchased. (EUR/t of feedstock)	Annual value added within a 5-year period	P
2.3	Taxes/ royalties paid to the government	Breakdown of payments made to the government/year (EUR)	Payments made to the government per year within 5 years	P, G
2.4	Contributions made by the operation to allied industries in the local economy	Percentage of total production cost paid to contractors, suppliers per annum	Percentage of total production cost paid annually to contractors and suppliers of raw materials (excluding suppliers of feedstock) within a 5-year period	P
2.5	Involvement of smallholders or small suppliers	Percentage of feedstock that originates from associated smallholders and outgrowers	Percentage of feedstock that originates from associated smallholders outgrowers within a 5-year period. Number of associated smallholders or outgrowers.	P, C, W
2.6	Amount paid to smallholders and suppliers of feedstock	Annual amount paid to smallholders and suppliers of feedstock (EUR)	Annual value paid to associated smallholders and outgrowers per unit of product within a 5 year period.	P, C, W
2.7	Employment	Total number of employees and person days of employment per year	Total number of people employed each year and total number of person days per year within a 5 year period. Breakdown should be given for categories of employment for operation (management/office/processor/field labor, male/female, contract/no contract)	P, W
2.8	Ratio between local and migrant workers	Ratio of employment from local area/ outside local area per category of employment (management/office/processor/ field labor)	Local area is defined as state or province (however, the assessor can further adapt this to local context). Absolute annual number of workers per employment category (including temporary/ permanent) within a 5-year period	P, G

Table 2.7 (continued)

No	Indicator	Measurement/ Monitoring Process/ Unit	Guidance	Data access
2.9	Percentage of permanent workers	Percentage of workers that have a fixed contract employment per category of employment	Annual percentage permanent vs. temporary workers within a 5-year period	P, G
2.10	Provision of worker training	Number of workers that have received training (for skills development, education etc.) each year, number of working days spent in training provided by the operation each year, type of training	Annual numbers should be given for a 5-year period	P, W
2.11	Community investment	Amount invested in community investment projects (e.g. CSR) (% of annual revenue) and qualitative description of investments including any projects specific for women	Annual values should be given for a 5-year period. This should be calculated as percentage of annual revenue.	P, C
Working conditions and rights				
2.12	Employee income	Average income of employees by category of employment (EUR)	Annual average income per employment category for a five-year period	P, W
2.13	Employment benefits	Employment benefits (e.g. housing, health care, holidays) provided by operation (description of benefits per employee per year)	Breakdown of average benefits given per employment category. Distinction should be made between the benefits that are mandated by law and those that are not.	P, W
2.14	Income spent in basic needs	Percentage of worker disposable income (by category of employment) spent on fulfilling basic needs (food, accommodation and transport)	To be estimated based on average salary per employment category, amount spent in food per day, accommodation per month and transport per day	W, C
2.15	Hours of work	Average daily hours of work per employee per employment category (h)	Average daily working hours per category of employment. This should be verified from employment records and worker interviews with questions addressing number of working hours/day.	P, W

Table 2.7 (continued)

No	Indicator	Measurement/ Monitoring Process/ Unit	Guidance	Data access
2.16	Freedom of association	Existence of labor unions	Existence of labor unions and whether workers have the right to join them. This should be verified by interviewing the management and the workers: Do workers belong to a union or other type of working association?	P, W, C
Health and safety				
2.17	Work related accidents and diseases	Number of work-related accidents per person days of employment per year, number of work related diseases/ person days of employment per year	Records of any work-related accidents or diseases.	P, W
2.18	Personal protective equipment	Percentage of workers that use appropriate personal protective equipment	To be calculated as a percentage of sample in a site visit	P
2.19	OSH training	Percentage of employees that have received OSH (Occupational Safety and Health) training	Training records and worker interviews	P, W
Gender				
2.20	Benefits created for women	Employment benefits that are specific for women	List any employment benefits that are specific for women (i.e. maternity leave, others)	P, W
Land rights and conflicts				
2.21	Legal title of land right	Operation has a legal title/ concession for the land that is not challenged.	Document of legal title	P, G
2.22	Communal/ public land	Area of land cultivated by the operation that is customary, public or community land (ha)	Report on public or community land within the project which would affect people living from subsistence agricultures, nomads, etc. Cross-check this information with the land categories listed under 'basic information'	P, C (N)

Table 2.7 (continued)

No	Indicator	Measurement/ Monitoring Process/ Unit	Guidance	Data access
2.23	Land conflicts	Area of land currently under dispute, land conflict. (ha) Did the operation have any land use conflicts, if so, what caused them, how were they resolved?	Land area currently under dispute. Qualitative description of any current or previous land use conflicts. If they were resolved, how this happened.	P, C, G (N)
Food security				
2.24	Land that is converted from staple crops	Land that has been converted from staple crops (ha)	Hectares of land that has been converted from staple crops to the feedstock production (assessor should define staple crops for the country) within the last five years	P, (G, N)
2.25	Edible feedstock diverted from food chain to bioenergy	Amount of edible raw material diverted into bioenergy production (t)	Annual amount of edible feedstock that was used in bioenergy production (5-year period)	P
2.26	Availability of food	Perceived change in availability of food after the beginning of bioenergy operations	Check (survey) at community level about perceived change	C, W
2.27	Time spent in subsistence agriculture	Change in time spent working in subsistence agriculture in the household	Check (survey) at community level about perceived change	C, W

Table 2.8 Global-Bio-Pact set of impact indicators: Environmental indicators. (Diaz-Chavez et al. 2012)

No	Indicator	Measurement/ Monitoring Process/ Unit	Guidance	Data access
Air				
3.1	Open burning on company level	Days open burning used in operations/year	Annual days open burning used in operations, 5-year period	P
3.2	Open burning area	Percentage of surface under open burning regime	% surface under open burning regime	P
3.3	Use of Best Available Technologies for reducing emissions	List of best available technologies in place	Review technologies used at company	P
Soil				
3.4	Implemented Practices	Percentage of surface under no or reduced tillage	Check practices on the fields	P
3.5		Fertilizer applied (type) (kg/ha/yr)	List types of fertilizer and the annual amounts applied per hectare (5-year period)	P
3.6		Herbicides and pesticides applied (type) (kg/ha/yr)	List types of fertilizer and the annual amounts applied per hectare (5-year period)	P
3.7	Soil Erosion	Feedstock cultivation area in flood prone region (ha)	Maps and data from company	P
3.8		Feedstock cultivation area in wind prone region (ha)	Maps and data from company	P
3.9		Feedstock cultivation area in slopes above 25° surface gradient	Maps and data from company	P
3.10		Implemented measures to control soil erosion	List measures implemented	P
3.11	Soil analysis	Frequency of carrying out soil analysis in the operation	How often is soil analysis carried out in the operation?	P

Table 2.8 (continued)

No	Indicator	Measurement/ Monitoring Process/ Unit	Guidance	Data access
Water				
3.12	Water consumption (irrigation)	Net non-recycled water consumed through irrigation per unit mass of product (l/t of feedstock)	Check water balances at the company level	P
3.13	Water Management Plan	Implementing a water management plan	Is there a water management plan, is it implemented?	P
3.14	Availability of water	Perceived change in availability of water by local communities (amount consumed)	Questions addressed to local community representatives, NGO or local authority	C, N, G
3.15	Quality of water	Perceived change in quality of water by local communities	Questions addressed to local community representatives, NGO or local authority	C, N, G
Biodiversity				
3.16	Reduction of biodiversity	Non-agricultural land or pasture that has been converted towards feedstock operation within a 5- year period (ha), type of previous vegetation of converted land	This can be check with the operation and cross checked with local or national authorities or environmental NGOs	P (G, N)
3.17	Impacts on fisheries/other aquatic fauna	Local perceptions on impacts on fisheries/other aquatic fauna	Questions addressed to local community representatives, NGO or local authority	C, N, G
3.18	Impacts on local fauna/ flora perceived by community	Local perceptions on impacts on local fauna and flora	Questions addressed to local community, NGO or local authority	C, N, G

Table 2.8 (continued)

No	Indicator	Measurement/ Monitoring Process/ Unit	Guidance	Data access
3.19	Conservation Measures	% of surface set-aside for conservation purposes	e.g. protected habitat, buffer zones, ecological corridors, riparian vegetation, etc.	P
Ecosystem services				
3.20	Access to ecosystem services	Reduction in local communities' access to hunting, fishing	Qualitative questions to local community representatives, and NGO(s)	C, N
3.21		Reduction in local communities' access to non-timber forest products	Qualitative questions to local community representatives, and NGO(s)	C, N
3.22		Reduction in local communities' access to cultural ecosystem services such as sacred and recreational sites	Qualitative questions to local community representatives, and NGO(s)	C, N

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Chapter 3
Test Auditing of Socio-Economic Indicators for Biofuel Production

Rocio Diaz-Chavez and Anni Vuohelainen

Abstract The EU funded Global-Bio-Pact project developed a set of socio-economic impact indicators. The purpose was not to create a new standard or scheme for bioenergy production, but to compile a set of socio-economic sustainability criteria and indicators for biomass production and conversion which could be used by developers, governments, nongovernmental organizations or as an aid to existing standards. The set of indicators was tested in two locations in South America, which comprise the two case studies reported in the chapter. The selected indicators are introduced and discussed here, along with an assessment of the results from their application in the field.

Keywords Sustainability audit · Field test · Indicators · Case studies

3.1 Introduction

A number of socio-economic sustainability criteria and indicators were identified in the EU funded project Global-Bio-Pact (see Chap. 2). These indicators aim to measure socio-economic impacts of biomass production and cover a wide range of aspects related to socio-economic sustainability, including contribution to local economy, working rights and conditions, health and safety, gender, land rights and conflicts, food security and a range of environmental impacts that could affect local communities.

The general methodology used to select the indicators is presented in Fig. 3.1.

The general steps to develop the set of indicators included:

- Benchmarking of standards for environmental and social indicators
- Identification of impacts mentioned in selected Global-Bio-Pact case studies

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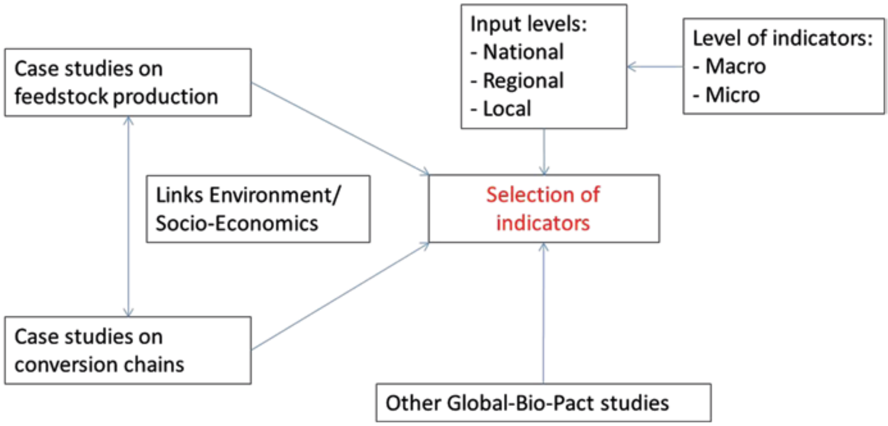

Fig. 3.1 Methodology for the selection of indicators

- Identification of socio-economic impacts in supply chains
- Links between environmental and social impacts
- Preselection of criteria and indicators
- Workshop with experts from the Global-Bio-Pact project
- Final selection of indicators

To further develop and improve these indicators, it was considered essential to field test the set of indicators for different feedstock, production models and geographical contexts. To this end, two case studies were selected for the field test of the Global-Bio-Pact set of socio-economic indicators. The field tests were carried out in two operations and surrounding communities. J. Pilon S/A—Açúcar e Álcool is a Brazilian sugar cane producer company in the town Cerquilho, in the state of São Paulo. J. Pilon S/A uses sugar cane to produce sugar and ethanol in its processing mill. Viluco S.A. is an Argentinean agro-industrial company that produces a number of crops, including soy that it uses for the production of soymeal and biodiesel in its processing plant. Viluco S.A. cultivates fields in the provinces of Tucumán, Salta, Santiago del Estero and Catamarca and has a processing plant in Santiago del Estero.

As a part of the field tests, both of the operations were asked to fill in a questionnaire that covered different aspects of the indicators. This was followed up with a visit to the facilities and selected agricultural fields of the two operations, during which key staff and a sample of employees were interviewed. The assessment team also visited surrounding communities and carried out community surveys to capture community perceptions of the impacts of the operations.

This chapter presents a selection of results obtained from two field tests, comprising a summary, for each indicator, of the data collected, followed by an assessment of the clarity, availability, relevance, measurability and temporal availability. The report does not aim to compare the results obtained in the two different countries or subject the data into further analysis of the impacts of the specific operations.

Table 3.1 Surveys applied in each case study

Type of survey	J. Pilon S/A (Brazil)	Viluco S.A. (Argentina)
Workers	31	30
Community	40	32
Outgrower	9	4
Contractor companies	0	1
Associations and government representatives	3	1

3.2 Methodology of the Field Tests

The two operations were visited as a part of the field tests, the first visit was to J. Pilon S/A and the town of Cerquilho, Brazil on 27–29 July 2012. The second visit was to Viluco S.A. and the fields and communities in the province of Tucumán, as well as the industrial operations and community in the town of Frias, Santiago del Estero on 10–12 September 2012.

In the field assessments, the data from each operation was collected in four ways:

- A questionnaire was sent to both operations prior to the field visit. The questionnaire included different aspects related to the indicators. Staff in charge of different areas of the operation filled in the questionnaire and sent it to the assessment team.
- A visit to the operations was carried out. During this visit, the assessment team completed the information sent by the operation via interviews with staff in charge of different areas of the operation (e.g. agricultural manager, human resources, quality manager).
- Fields, offices and processing facilities of the company were visited and questionnaires were applied to employees of the operations.
- Questionnaires were applied to outgrower and contractor companies of the operations where possible. In some cases other stakeholders such as representatives of government or associations were also interviewed.
- Communities located in the vicinity of the operations were visited and community surveys were carried out.

The number of surveys applied per case study is presented in Table 3.1.

The selection of indicators must be based on sound criteria, the availability of information, or human and economic resources for collecting data. As Webber and Alexander (1997) note, it is necessary to use real, available or easily calculated data. Some of the factors for selecting indicators, as noted by a number of authors (Avérous 1997; Webber and Alexander 1997; Hart 1999; Segnestam 1999; OECD 2000; Stanner et al. 2009; Dahl 2009) are summarized in Table 3.2.

The following chapter presents a summary for the information collected via different methods. The summary of the results is followed by an assessment of each indicator. The assessment is based on two sources: some of the interviewees were asked to evaluate the indicators they had been interviewed on and the assessment team evaluated each of the indicators based on their experience of the field test. Following criteria were used to assess the indicators:

Table 3.2 Synthesis of factors to consider when selecting indicators. (Source: Diaz-Chavez 2003, 2006)

Factors	Description
Reliability and quality	The accuracy of the data; a measure of the information collected. Based on theory and science when possible
Validity	Whether the indicator truly measures what it is supposed to measure
Realistic and practical	The collection of the data or information should be accurate and easily collectable, assuming the costs of collection
Spatial and temporality	Consider temporal and spatial scale as well as changes over time
Simplicity and clarity	Clarity in design and simple in format; understandable for any person
Comparability	To allow comparisons at the adequate level
Consensus	Among different actors (local, national, international, sound groups)
Measurability	According to the data they are interpreting (qualitative/quantitative)
Reviewability	Considerations to update the information
Limitation and balance	In number. Extensive sets of indicators are not in use any more. They should be short in number and balanced in the three dimensions of sustainability
Links	To show casual links among indicators or relevant data (even processes) and to strengthen links among institutions
Relevance	Direct relevance to the goal or objectives of the set of indicators
Cost/benefit	To show a relationship

- *Clarity*—Is the indicator clear in design and simple in format, is it easy to understand what is being measured?
- *Availability*—Is the data readily available from the source of the information?
- *Relevance*—Is the indicator relevant for the socio-economic impact that it aims to measure?
- *Measurability*—Can the indicator be easily measured?
- *Temporal availability*—Is the information readily available from the specified time period?

Each indicator was graded on the scale of 1–5, where 1 = poor, 2 = fair, 3 = good, 4 = very good and 5 = excellent.

3.3 Case Studies

J. Pilon S/A is a Brazilian sugar cane producer company that owns sugar cane plantations and a sugar/ethanol mill in the town of Cerquilho, in the state of São Paulo. The company was founded in 1953. The company currently has 5,070 ha of own land under sugar cane production and also produces sugar cane on 5,206 ha of rented land. It also has a processing mill that is used to produce both sugar and ethanol. As a by-product of the processing, the company also produces electricity and

Fig. 3.2 Map of Cerquilho. (Source: Wikipedia 2012a)

is energy self-sufficient. Between 40 and 50 % of sugar cane processed in their mill originates from the lands of independent outgrower. Cerquilho, São Paulo, Brazil (Fig. 3.2) is a municipality with a population of about 35,000 inhabitants and an area of 128.86 km^2. It has three small distilleries producers of *cachaça* (‘firewater’) and one mill that produces sugar and ethanol.

The case study in Argentina was conducted at Viluco S.A., an Argentinean agro-industrial company that produces soy, corn, wheat, sorghum and chick peas. The company produces crops on 22 fields located in north-eastern Argentina, in the provinces of Tucumán, Salta, Santiago del Estero and Catamarca (Fig. 3.3). The company has 25,170 ha of own land and 10,000 ha of rented land. In addition to the agricultural fields, Viluco S.A. has a soy crushing and biodiesel plant in the town of Frias, Santiago del Estero. The plant started its operation in 2010 and 2011 was the first full year of operation for the plant. The soybean crushing and biodiesel plants produce soy flour, husks and biodiesel. Over 70 % of the soybeans crushed in the plant are sourced from independent outgrower. The plant also sources soy oil from other suppliers. Viluco S.A. is a part of a business group called Grupo Lucci. Apart from Viluco S.A. the group includes three other companies that focus on the production of lemon and lemon derivatives, livestock and sugar cane.

3.4 Selected Indicators and Assessment

This chapter presents a selection of indicators from the set presented in Chap. 2 and in Diaz-Chavez et al. (2012). The indicators of the set include three main topics: background information, socio-economic indicators and environmental indicators. These last indicators are focused on the impact on the social issues within the region or the community. The indicators are presented by chapter, number and name.

Fig. 3.3 Map of Argentina with the province of Tucuman. (Wikipedia 2012b)

3.4.1 Land Area Under Cultivation

While information about the operations' own and rented land area was readily available for both operations, in the case of Viluco S.A. the operation purchased 70 % of the soybeans it used from independent outgrowers (Table 3.3). Since soybeans can be readily stored and transported for long distances before they reach the processing plant, the plants often have limited information and control over their outgrowers, which makes it difficult to obtain information about the agricultural operations of the outgrowers. It would be also important to make a distinction between the total area under production and the area that is harvested annually, as the total area harvested yearly typically varies, due to crop rotation and replanting (in the case of sugar cane). It was not possible to obtain exact information about the previous

Table 3.3 Land area under cultivation in both case studies

J. Pilon S/A (Brazil)	Viluco S.A. (Argentina)
Own land: 5,070.79 ha Rented land: 5,206.07 ha Of this around 8,000 ha is harvested annually Independent outgrowers: 6,553.35 ha (harvested), total area cultivated by them ~ 8,000 ha Total area harvested in the year 2011/2012 = 16,830.21 ha	Own land: 2,5170 ha Rented land: 10,000 ha 72.58 % of the soybeans processed in the bio-diesel plant are purchased from independent producers, there is no information about the exact land area farmed by them. The plant also purchases crude soy oil from others, but the information on the quantity of this was not available at the time of the visit

Table 3.4 Expansion of land area in ha at the J. Pilon S/A plant

Year	Own land	Outgrower	Total
2007	216.56	372.10	588.66
2008	0	22.49	22.49
2009	60.55	0	60.55
2010	195.22	112.02	307.24
2011	209.66	214.30	423.96

5 years in the case of J. Pilon S/A. The biodiesel plant of Viluco S.A. has only been in operation since 2010, so information was only collected from year 2011, as this was the first complete year of operation.

3.4.2 Expansion of Land Area

J. Pilon S/A reported the expansion of area in the last 5 years for both, their own land and the outgrowers' land (Table 3.4).

Viluco S.A. reported there has not been expansion of own or rented fields. Information from the independent producers was not available. While information about the operations' own and rented land area was readily available for both operations, in the case of Viluco S.A., the operation purchased 90 % of the soybeans it used from independent outgrowers. Since soybeans can be readily stored and transported for long distances before they reach the processing plant, the plants often have limited information and control over their outgrowers, which makes it difficult to obtain information about the agricultural operations of the outgrowers. For soybean (and other annual crops) it would also be important to assess the total area of the farm under crop production, as soybean is generally produced in crop rotation and the land area under soy production typically varies annually. This indicator was deemed particularly relevant, as many negative socio-economic or environmental impacts can increase with expansion of land area under production.

3.4.3 Certification

This information about certification was readily available from both of the operations. J. Pilon S/A reported that they do not have any certification at the moment. Viluco S.A. reported that for their own and rented fields, they are certified by the Roundtable on Responsible Soy (RTRS). The soy suppliers for Viluco S.A. are also RTRS certified. The plant for flour production is certified with the Good Manufacturing Practice (GMP) and for the production of biodiesel they are certified by the International Sustainability and Carbon Certification scheme (ISCC). This indicator is relevant, as the indicators of the schemes could be used to assess impacts of certification in the future.

3.4.4 Production Cost

Information on production costs was not available at J. Pilon S/A. Viluco S.A. was able to provide this information for both, processing plant and its own agricultural production. They reported 255.79 €/t of soy (processing plant, including cost of soy purchased from outgrowers) and 24.93 €/t of soy from their own agricultural production. It is advisable to further refine this indicator to account for feedstock produced on own, rented and outgrowers land. Furthermore, it would be more useful to assess this value for a liter of biofuel, instead of quantity of feedstock. This value would account for the whole chain from agricultural production to processing. This indicator is relevant mainly in relation to the following indicator (value added), as the production cost alone does not give an indication of the economic profitability of the feedstock production.

3.4.5 Contributions Made by the Operation to Allied Industries in the Local Economy

Both operations provided information on costs of feedstock, which was not requested for this indicator. The information from J. Pilon S/A also included labor costs, but information could not be obtained on the percentage paid to allied industries. They reported an average of 65 % for sugar cane allied industries and 35 % for other costs (inputs, maintenance, labor).

In Viluco S.A. the soy production and biodiesel plant are managed by two different entities, which is why the information for the soy production was often not integrated with the information from the biodiesel plant. Therefore, information on this indicator was only available from the biodiesel plant. The estimated production inputs were of 7,944,541 € while the services from contractors were estimated at 822,270 €. Viluco S.A. did not provide information about labor costs, so the percentage of production costs could not be calculated.

Further guidance should be given on the calculation of production costs and allied industries should be defined more clearly, in order to obtain more useful information from this indicator.

3.4.6 Feedstock Production Farmed by Smallholders or Suppliers

Information on the feedstock production by smallholders or suppliers was readily available from both companies. J. Pilon S/A reported an average of half of the production every year produced by the outgrowers with an average of 150 suppliers per year as follows:

- 2007 = 48.9 %
- 2008 = 50.9 %
- 2009 = 40.6 %
- 2010 = 45.9 %
- 2011 = 47.6 %

Viluco S.A. reported that around 72.85 % of the soy processed in their mill was produced by 242 independent producers in 2010/2011. Additional information was gathered through the survey applied to outgrowers (see Vuohelainen and Diaz-Chavez 2012). The indicator was clear, measurable and relevant for estimating the contribution of outgrowers to the biofuel production.

3.4.7 Employment

Both companies provided information on the number of employees and the categories within each company. In 2011 J. Pilon S/A reported around 1,000 employees in the following categories: Administration: 30; Agricultural sector: 731 (381 permanent workers and 350 temporary workers); Industrial sector: 263 (238 permanent workers and 25 temporary workers). Temporary workers work 6 months per year.

Viluco S.A. reported for the industrial sector 230 permanent employees and in the agricultural sector 50 permanent employees. Viluco S.A. also works with 27 contractor companies for agricultural operations by Grupo Lucci (approximately 20 of them for crop production). Nevertheless, the quantity of companies used for soy production was not available.

This indicator requires both, information about the number of employees and of man-days worked per year. While the information about the number of employees was readily available for both of the companies, the concept of man days was not clear to the respondents and neither of the operations had easily accessible records on total man-days worked. Therefore, it would be easier to use the number of employees and the average number of months worked by temporary workers.

It is also important to consider that most of the agricultural work in the Argentinean soy sector is carried out by independent contractors. The contractor companies work in different regions of Argentina and are not under direct control of the producer companies. This makes it difficult to obtain accurate information about the total impact each producer company has on employment creation. This indicator is considered relevant, as job creation can be one of the most significant socio-economic impacts of biofuel production.

3.4.8 Ratio Between Local and Migrant Workers

Information on the ratio between local and migrant workers was easily obtainable from both operations and it was also easy to obtain this information from the workers interviewed. J. Pilon S/A reported that 20 % of workers are temporary migrant workers during the harvest period, while Viluco S.A. reported that 85 % of employees are from the local area (Tucumán and Santiago del Estero).

Additional information was gathered through the survey applied to workers where they reported on their birth place, as shown in Fig. 3.3.

3.4.9 Community Investment

J. Pilon S/A reported for the last 3 years an average investment of 7,000 €. These are monetary contributions to different community and educational projects and events. In addition to these, the company has contributed to community projects with in-kind contributions, including among others, land, labor and other donations. Viluco S.A. reported that through their main company Grupo Lucci, it carries out community investment via the 'Vicente Lucci foundation' that had an annual budget of 725,336.74 € in 2011. The budget included operational and personnel costs, volunteer program, communication and community relations program, organized visits to the biodiesel plant, educational projects and donations to community organizations

While the concept of community investment was clear to all of the interviewees, there are some problems with this indicator. In the case of J. Pilon S/A, the indicator only accurately captured the monetary value of investment, although a qualitative description of in-kind contributions for community investment was also provided. Thus the monetary value does not necessarily accurately capture all of the community investment activities of the company. For Viluco S.A., the total budget of the Vicente Lucci foundation was given. While the amount that the company spends in community investment is indicative, it also included personnel and operational costs of the foundation. Furthermore, the Vicente Lucci foundation is ran by the Grupo Lucci, which owns a number of companies and agricultural operations. Thus it would be impossible to differentiate which amount of this budget originates from soy and biodiesel production.

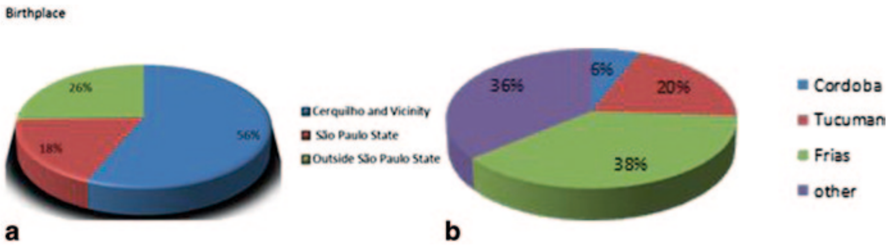

Fig. 3.4 Birthplace of workers at J. Pilon S/A (*left*) and at Viluco S.A. (*right*)

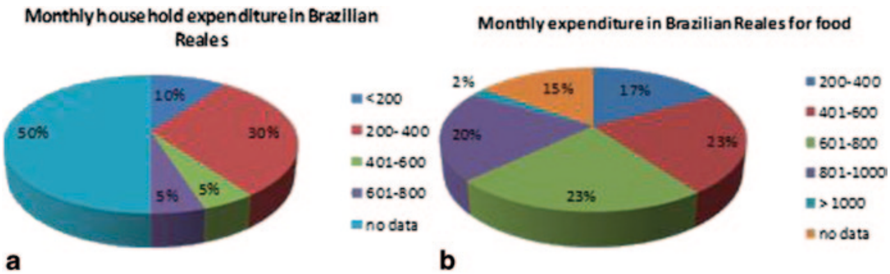

Fig. 3.5 Monthly household and food expenditure in Brazilian Reales

3.4.10 Income Spent on Basic Needs

The survey applied to workers provided information on the amount spent on food, but it was not possible to statistically correlate this information with the salaries of the workers. However, the survey included a question to enquire about the monthly household income, the amount varied according to the salary. The workers estimated the distribution of the income in food, transport and accommodation or household expenses (depending if they owned the property or lived with relatives). The data gathered for both case studies is presented in Figs. 3.4 and 3.5.

The indicator is important to understand the economic situation and well-being of the workers. It is possible to gather the data through the survey, but it should be better incorporated in the questionnaire with a higher level of clarity and detail. It was difficult for the workers to estimate the amount spent on the basic needs (food, transport, household expenses) in a monthly basis and some expressed the information per day or per week. These differences were also more evident according to the salary received by the worker. To be statistically valid a larger survey needs to be applied.

Table 3.5 Land converted for J. Pilon S/A production

Year	Pasture	Orange	Others (e.g. maize)
2007	470.93	88.30	29.43
2008	17.99	3.37	1.12
2009	48.44	9.08	3.03
2010	245.79	46.09	15.36
2011	339.17	63.59	21.20
2012	459.46	86.15	28.72

3.4.11 Benefits Created for Women

It was not clear to the interviewees whether this indicator referred to legally mandated benefits or additional benefits. As both of the operations only reported legally mandated benefits (i.e. maternity leave), no additional benefits for women obtained from biofuel production could be observed. In the case of the two field tests this indicator was not considered very relevant in terms of measuring socio-economic sustainability. In fact, this indicator more accurately reports on women's reproductive rights and so the indicator could be modified to relate to reproductive rights, as opposed to employment benefits for women.

3.4.12 Legal Title of Land Right

Both companies informed they hold legal title for all of their own lands and this is not challenged. Viluco S.A. reported that only one farm is rented and there is a rental contract for this. This indicator was clear to all of the respondents. Both of the operations were located in an area with very established land use and no evidence of unclear land rights could be encountered in the interviews with the company employees or communities. It was not possible to view the documents of legal titles during the field assessment.

3.4.13 Land Converted from Staple Crops

J. Pilon S/A reported the conversion of land mainly from pastureland, orange production and others. There is no information about land converted to sugar cane from crops considered staples by the local population (e.g. rice or beans) (Table 3.5).

Viluco S.A. reported that soy is currently farmed in rotation, whereby during summer 70 % of land area is cultivated with soy and 30 % with other crops (corn or sorghum) and if hydrological conditions of the field permit, wheat, chick peas, lentils and green peas are cultivated during winter.

For the purposes of the field assessments, it would be important to define what crops are considered staple in each country. Accurate information of exact quantities

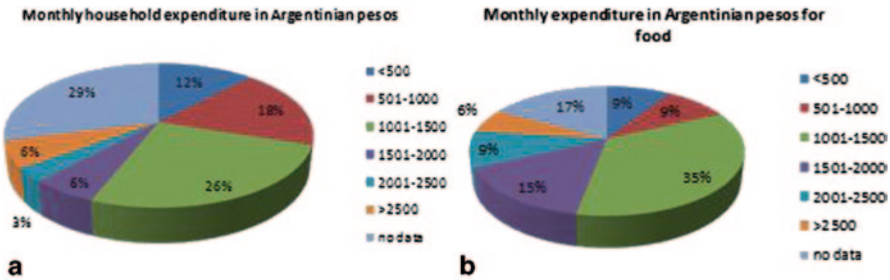

Fig. 3.6 Monthly household and food expenditure in Argentinian Pesos

of land converted from staple crops was not available for J. Pilon S/A. According to the operation, no land had been converted from other crops during the first years of operation of Viluco S.A. However, this indicator may not be entirely applicable for soy production, as soy is often cultivated in rotation with staple crops such as wheat. Information about conversion by outgrowers was not available for the assessment.

3.4.14 Open Burning on Company Level

Information about days of open burning was readily available from J. Pilon S/A and Viluco S.A. J. Pilon S/A reported the following days per year for open burning:

- 2007 = 207 days
- 2008 = 222 days
- 2009 = 228 days
- 2010 = 173 days
- 2011 = 182 days

In addition to this indicator, information about community perceptions on air quality was collected in community surveys. The results showed that the community had concerns related to the air quality related to the open burning practices of Cerquilho sugar cane farmers (Fig. 3.6).

In the case of Viluco S.A., open field burning is not used. The community surveys showed that the community members interviewed had some concerns related to air quality in the region, in relation to aerial fumigation of pesticides and bad smell from the soy processing mill (Fig. 3.7).

In addition to this indicator, some additional information related to air quality was collected in community surveys. The results showed that the indicator is very relevant in relation to sugar cane production, as concerns on air quality, due to burning practices, were mentioned by most of the community members interviewed for the survey. It would be useful to include an indicator that specifically relates to environmental impacts observed by community members.

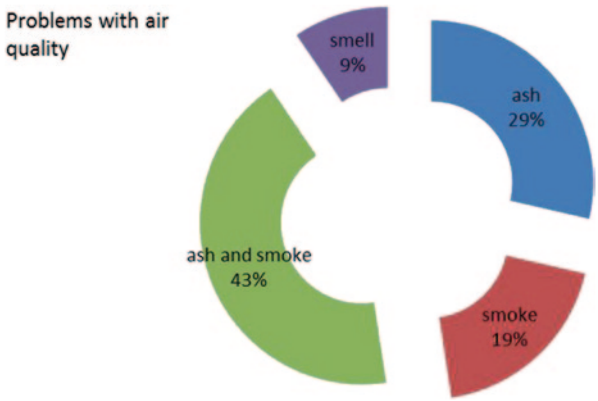

Fig. 3.7 Surveys result from local community in Cerquilho regarding air quality

3.4.15 Availability of Water

Surveys were applied to the communities of both case studies regarding their perception on the local environment. The problems nevertheless, could not be directly attributed to the biofuel production. This indicator is important and can be assessed qualitatively or quantitatively. The availability of water data can be obtained through other methods, for instance geographic information systems (GIS) calculations for a whole basin, data from the local authorities, or from the company. Nevertheless, this survey was based on the perception of the community which in some cases can provide information when they notice changes in the local availability of water for basic needs (drinking water, agricultural cultivation, washing). The data is difficult to assess in a qualitative form and the temporality can be an issue as it needs to be frequently monitored. It can be easily tracked to the consumption of the biofuel company.

3.4.16 Quality of Water

This indicator was also included in the survey applied to the communities to gather additional information regarding their perception on the local environment. The problems reported on water quality could not be directly related to the biofuel production. This indicator can be assessed qualitatively or quantitatively. However, the data are difficult to assess in a qualitative form and the temporality can be an issue as it needs to be frequently monitored. It can be monitored by the biofuels company through a water emissions assessment in the region. It can be also assessed through data from local authorities.

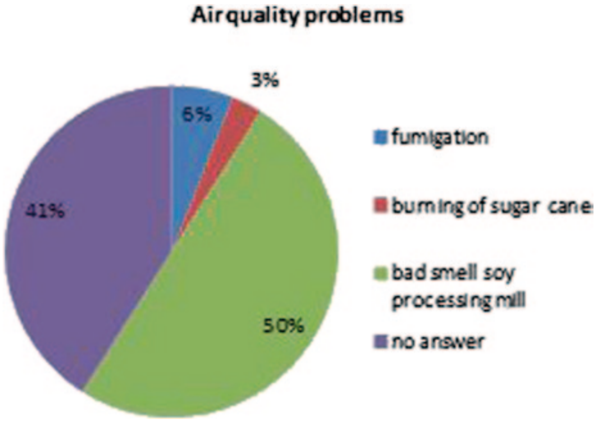

Fig. 3.8 Surveys results from local community in Santiago del Estero regarding air quality

3.4.17 Impacts on Local Fauna/Flora Perceived by the Community

The impact on local fauna/flora perceived by the community is a qualitative indicator based on the perception of the local population with information gathered through surveys. Figure 3.8 presents the results for the case of J. Pilon S/A (Cerquilho) and Fig. 3.9 for the case of Viluco S.A (Santiago del Estero) (Fig. 3.10).

Data are difficult to gather as it depends on the number of years that the interviewee has lived in the region or even the age of the interviewee. Nevertheless, with larger surveys and including several communities it is possible to assess the changes perceived by the population in a qualitative form. Another issue to consider is how to relate the changes directly to the biofuel production. It is very difficult to separate the general impact of agriculture from those derived from biofuels production, especially in cases were coproducts of food crops are being used.

3.4.18 Access to Ecosystem Services

The indicator related to ecosystem services includes the reduction of hunting and fishing opportunities.

Surveys applied to the local community provided the information for both case studies. In Cerquilho only 6% of the interviewees replied that they noticed changes in the last 5 years on fishing. They explained it with the quality of water. There were no changes reported in these activities in the regions of Tucuman and Santiago del Estero. This is due to the fact that these activities are not practiced in the region. This is a qualitative indicator based on the perception of the local population. Data may be difficult to gather because it will depend on the number of years that the interviewee has lived in the region or even the age of the interviewee. The concept of ecosystem services is not very much recognized and this may create confusion with

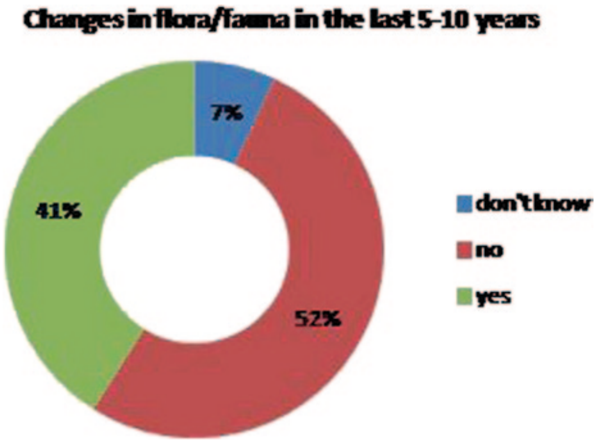

Fig. 3.9 Surveys results from local community in Cerquilho regarding changes in flora and fauna

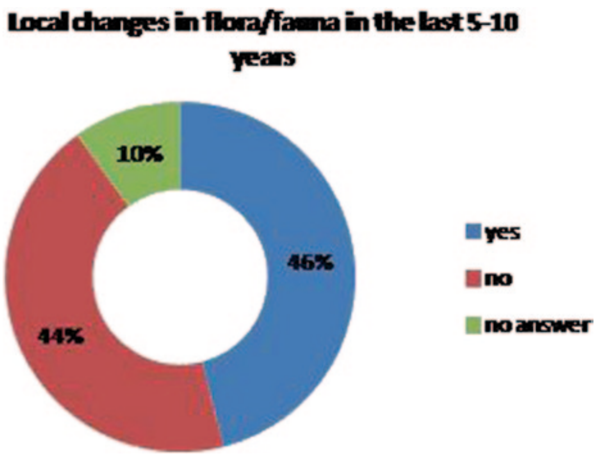

Fig. 3.10 Surveys results from local community in Santiago del Estero regarding changes in flora and fauna

general environmental knowledge or perception in the local population. Another issue to consider is how to relate the changes directly to the biofuel production.

3.5 Discussion

The selected indicators are summarized in Table 3.6. This is the assessment on the key criteria of indicators for both case studies on a scale 1–5 as explained in Chap. 3.2. There is no comparison between the cases, nor between the crops or the conversion process. The assessment was qualitative in nature, and should provide future guidelines to improving some of the indicators that had a score of three or lower.

Table 3.6 Selected indicators assessment for the two case studies

Number	Indicator/assessment criteria	Clarity	Availability	Relevance	Measurability	Temporal availability
Background information						
1.3	Expansion of land area	5	3	5	3	3
1.6	Certification	5	5	5	5	5
Socio-economic indicators						
2.1	Production cost	3	3	5	5	5
2.4	Contribution made by the operation to allied industries in the local economy	3	3	5	5	3
2.5	Production farmed by smallholders or suppliers	5	5	5	5	5
2.7	Employment	3	3	5	4	5
2.8	Ratio between local and migrant workers	5	5	5	5	3
2.11	Community investment	5	5	5	3	3
2.14	Income spent in basic needs	5	4	5	3	4
2.20	Benefits created for women	3	5	2	5	3
2.21	Legal title of land right	5	3	5	5	
2.24	Land that is converted from staple crops	3	3	4	3	3
Environmental indicators						
3.1	Open burning on company level	5	5	5	5	5
3.14	Availability of water	5	5	5	3	4
3.15	Quality of water	5	5	5	4	3
3.18	Impacts on local fauna/flora perceived by community	5	3	5	3	3
3.20	Access to ecosystem services (Reduction in hunting/fishing)	2	3	5	2	2

1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent

The indicators that require information from the community through surveys require a larger number of interviewees (e.g. indicators 3.18 and 3.20). Other indicators that applied directly to the operator or industry also require further development, such as for instance indicator 2.20 on benefits created for women, as most of the benefits are required to comply with the National Law.

Indicators 2.20, 3.20 and 3.24 have scored 3 and less for more than one criteria. Indicator 2.20 on benefits created for women, as previously explained, will need to be reviewed to see if additional criteria from the legal framework at national level should be included. Indicator 2.24 will need to be linked to background information on staple crops at national, regional and local level. Indicator 3.20 on access to ecosystem services (hunting and fishing) will need to be reviewed and the surveys applied will need to reword the question in order to define if the activity already existed or has not been practiced in the region.

3.6 Conclusions and Recommendations

The two field tests provided important information on the practical application of the Global-Bio-Pact set of socio-economic indicators and allowed for an assessment of the indicators using the predefined criteria.

The assessment showed that most of the indicators were clear and easily understandable for the respondents. Some of the indicators could, however, be further refined to make it clear what information is being requested. This was particularly the case for the indicators where parameters had not been clearly defined (e.g. wind-prone region). Particular attention should be given to specific concepts that may not be used in all countries and may thus be unclear for the respondents (e.g. man-day). This should also be taken into account when translating the indicators in different languages. For the two field tests the indicators were translated in Spanish and Portuguese and some terminology and concepts were difficult to translate to these languages.

Most of the information was readily available from both of the operations. For those that were not, the problem was that the company was not able to provide the data in the requested format. Most of the respondents did, however, agree that keeping records of the information would be useful for monitoring the socio-economic impacts of the operation. The field test also showed that companies had different ways of monitoring and managing data, which makes it difficult to collect standardized information across different companies. The issue of availability of data would probably be solved if the indicators were applied in a more formalized way, e.g. as a part of a certification scheme, and the companies would have systems in place to routinely collect the information from their operations.

The operational staff interviewed agreed that most of the indicators were very relevant for monitoring socio-economic performance of the companies. Overall, it would be useful to relate the collected information to some general parameters (e.g. average salary in the agricultural sector in the country) for a meaningful analysis of the performance of the companies. Alternatively, the indicators could be used to measure the change over time (e.g. before and after certification). Those indicators that were currently not considered as very relevant (e.g. water management plan), could be modified to increase their relevance by, for example, asking about management of waste water or measures to reduce water consumption.

Most of the indicators are quantitative in nature and thus easily measured. Not all socio-economic impacts can be, however, measured quantitatively, which is why some of the indicators are qualitative and thus somewhat more difficult to measure. While incorporation of qualitative indicators is considered important, the assessment team considered that some of the qualitative indicators could be further standardized in terms of the information requested, thus making them easier to measure and compare across time scales.

Overall, there was a very low temporal availability of the requested information. For most indicators, the respondents were requested to provide information from 5 years prior to the assessment, but this information had often not been collected, or it was not easily accessible for the purposes of the assessment. Viluco S.A. had only been producing soy biodiesel since 2010, so it was not possible to collect information prior to 2010. Considering the low availability of information from previous years, it would be probably the best to collect information from operations only from the year of the assessment. This information could then be collected annually so as to monitor changes in the indicators.

The combination of company interviews with employee, community and outgrower questionnaires was considered to be a good method for collecting the information necessary for the monitoring of the indicators. The application of community questionnaires was particularly useful to be able to gain an indication of community perceptions of impacts. Due to time constraints, it was not possible to apply the questionnaires to a statistically significant sample of respondents, but the information obtained was, nevertheless, considered to be useful supportive evidence for monitoring the indicators. While community questionnaires provided a range of useful information about impacts, the clear limitation of this method was that it was often difficult to link the impacts mentioned to biofuel production. Thus the questionnaire data should be evaluated as supportive data to the information obtained with other methods.

In the practical application of the indicators it may not always be possible to use similar amount of time and resources for field assessments as it was employed in these two field tests (3 days with three assessors). One possible use of the indicators would be to ask operations to report annually on a subset of the indicators. Where possible, the reports could then be verified annually, for example, as a part of a certification audit.

An overall recommendation on the application of the indicators is that if the main objective is to measure socio-economic impacts in a region, this should be a joint effort of local authorities and the company. This will help to have a better use of economic, time and human resources. Furthermore, the information provided to the local community regarding the activities of the biofuel sector in the region not only will be complying with sustainability aims for both the company and the government, but will also help to strength links between the stakeholders in the region.

The results presented regarding the feedstock, are related to the agricultural and agro-industrial activities in the region as a whole and it is very difficult to differentiate the impact of the biofuels production area from those of the whole system. This is especially challenging for mixed food/fuel crops such as for example the investigated soy and sugarcane value chains.

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Chapter 4
Linkages Between Socio-Economic and Environmental Impacts of Bioenergy

Nils Rettenmaier and Gunnar Hienz

Abstract In the light of a controversial discussion on the net benefit of biofuels and bioenergy, the European Renewable Energy Directive (2009/28/EC, RED)—which sets out a mandatory target for the share of renewable energy in the transport sector (10 % by 2020)—has established a number of mandatory sustainability criteria, which biofuels and bioliquids have to meet to be able to be counted towards the target. However, these mandatory sustainability criteria so far only address selected environmental impacts (greenhouse gas (GHG) emissions and biodiversity) and omit impacts on soil, water, and air as well as GHG emissions due to indirect land-use change (iLUC). Social and socio-economic impacts are not covered at all. The latter gap was addressed by the EU-FP7-funded Global-Bio-Pact project. The project's main aim was to improve and harmonize global sustainability certification systems for biomass production, conversion systems and trade in order to prevent negative socio-economic impacts. Within the project, linkages between socio-economic and environmental impacts of biofuels/bioenergy and bio-based products were analyzed in order to avoid an increase of negative environmental impacts while trying to prevent negative socio-economic impacts. After an introduction and some insights into the environmental impacts of biofuels/bioenergy and bio-based products, this chapter presents the results of a SWOT analysis (analysis of strengths, weaknesses, opportunities, and threats), revealing trade-offs as well as positive and negative correlations between socio-economic and environmental impacts. These linkages are subsequently interpreted using the concept of ecosystem services. Finally, conclusions are drawn and a recommendation is made how the current list of mandatory sustainability criteria in the RED could be amended.

Keywords Environmental impacts · Socio-economic impacts · Bioenergy · Biofuel · SWOT analysis · Positive correlations · Negative correlations · Trade-offs · Ecosystem services · Sustainability criteria

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4.1 Introduction

In many parts of the world, climate change and concerns of security of supply are the main drivers for the promotion of the use of renewable resources. One of the main pillars of most strategies to mitigate climate change and save nonrenewable resources is the use of biomass for energy. In several countries, strong incentives have been put in place to increase the use of biomass for energy both in the transport as well as in the energy supply sector (heat and/or power generation), mainly in the form of mandatory targets (U.S. Congress 2007), (EP and CEC 2009). Many countries have successfully implemented policies to foster biofuels and bioenergy, including tax exemptions or relief, feed-in tariffs, or quotas. On the contrary, much less attention has been paid to the use of biomass for bio-based products, despite considerable potentials to mitigate greenhouse gas emissions and to save nonrenewable resources (Rettenmaier et al. 2010a, b). Nevertheless, the demand for industrial crops for biochemicals and biomaterials is expected to increase in the future since biomass is the only renewable source of carbon.

Taken together, these nonfood biomass crops will put additional pressure on global agricultural land (Bringezu et al. 2009). At the same time, world population growth (projected to reach 9.3 billion people by 2050 according to UN (2011)) and changing diets due to economic development lead to an additional demand for land for food and feed production. As a consequence, the already existing competition for land for the production of food, feed, fiber (bio-based products), fuel (biofuels and bioenergy), and ecosystem services[1] might even aggravate over the next decades. Concerns have been raised both in terms of social and environmental impacts because land use competition might i) jeopardize food security (Eickhout et al. 2007) and give rise to social conflicts, ii) result in an intensified use of existing agricultural land, or iii) lead to an expansion of agricultural land, most likely at the cost of (semi)natural ecosystems being converted into cropland. Several studies have pointed out the negative implications of such direct and indirect land-use changes, among others in terms of biodiversity loss and greenhouse gas emissions (Searchinger et al. 2008; Fargione et al. 2008; Gibbs et al. 2008; Gallagher 2008; Melillo et al. 2009; Ravidranath et al. 2009).

In the light of a controversial discussion on the net benefit of biofuels and bioenergy, the European Renewable Energy Directive (2009/28/EC, RED) (EP and CEC 2009)—which sets out a mandatory target for the share of renewable energy in the transport sector (10 % by 2020)—has established a number of mandatory sustainability criteria, which biofuels and bioliquids have to meet to be able to be counted towards the target (Articles 17(2) to 17(6)):

- **Climate change-related criteria**: The greenhouse gas emission (GHG) saving from the use of biofuels and bioliquids—including emission from direct land-use

[1] Ecosystem services are the benefits people obtain from ecosystems. These include provisioning, regulating, and cultural services that directly affect people and supporting services needed to maintain the other services (see Sect. 4.3).

changes (dLUC)—shall be at least 35 % compared to the fossil fuel comparator (Article 17(2)). From 2017 and 2018, the GHG emission saving shall be at least 50 % and 60 %, respectively. Further details are found in Article 19 and Annex V (rules for calculating the GHG impact).
- **Land cover-related criteria**: Biofuels and bioliquids shall not be made from raw material obtained from land that in or after January 2008 had the status of i) land with high biodiversity value such as primary forest, protected areas, or highly biodiverse grassland[2] (Article 17(3)), ii). land with high carbon stock such as wetlands or continuously forested areas (Article 17 (4)), or iii). peatland (Article 17(5)).
- **Cultivation-related criteria**: Agricultural raw materials cultivated in the Community shall be obtained in accordance with the common rules for direct support schemes for farmers (Cross Compliance) under the common agricultural policy and in accordance with the minimum requirements for good agricultural and environmental condition (Article 17(6)).

The mandatory sustainability criteria listed above—which so far only have to be met by liquid biofuels and bioliquids (but not by solid and gaseous biofuels or bio-based products)—only address selected environmental impacts (GHG emissions and biodiversity) and omit impacts on soil, water, and air as well as GHG emissions due to indirect land-use change (iLUC). Social/socio-economic impacts are not covered at all by the list of mandatory sustainability criteria.

In addition, the RED sets out a number of reporting obligations by the European Commission to the European Parliament, but these are no mandatory criteria to be met by biofuels and bioliquids. The Commission shall, every two years from 2012 onwards, report (Article 17(7)):

- On national measures taken to respect the sustainability criteria set out in Articles 17(2) to 17(5) and for soil, water, and air protection
- On the impact on social sustainability in the Community and in third countries
- On the impact on the availability of foodstuffs at affordable prices, in particular for people living in developing countries
- On the respect of land-use rights
- Whether the countries that are a significant source of raw material have ratified and implemented the core Conventions of the International Labour Organization (ILO)
- Whether these countries have ratified and implemented the Cartagena Protocol on Biosafety and the Convention on International Trade in Endangered Species (CITES)

The aim of this chapter is to reveal trade-offs as well as positive and negative correlations between socio-economic and environmental impacts. This way,

[2] Protected areas and nonnatural highly biodiverse grassland may be used provided that the raw material production does not interfere with nature protection purposes and that the harvesting of the raw material is necessary to preserve its grassland status, respectively. Primary forests and natural highly biodiverse grassland, however, may not be used at all.

opportunities to minimize negative and optimize positive impacts on both the environment as well as social and economic situations are identified. Moreover, the aim is to explore whether and how the current list of sustainability criteria in the RED can be amended by mandatory socio-economic sustainability criteria and how this would impact on the environmental sustainability criteria.

4.2 Environmental Impacts of Biofuels and Bio-Based Products

4.2.1 General Environmental Impacts of Biofuels and Bio-Based Products

Biofuels, bioenergy, and bio-products are generally considered to be environmentally friendly since they save nonrenewable energy resources, are biodegradable and—at least at first glance—CO_2 neutral. The latter is of course only true for the direct combustion of biofuels which releases the same amount of CO_2 into the atmosphere that earlier has been taken up by the plants. However, when looking at the entire life cycle of biofuels it becomes clear that biofuels are neither CO_2 neutral nor environmentally friendly per se.

Like with any other product, a number of environmental impacts are usually associated with the production and use of biomass for bioenergy or biomaterial purposes. These include impacts on human health (release of toxic substances, emission of photo-oxidants and ozone-depleting gases), on the natural environment (release of toxic substances, emission of acidifying and eutrophying gases, land-use impacts), on natural resources (nonrenewable energy carriers and minerals), and on man-made environment.

Different techniques exist to assess the environmental impacts associated with a product or an activity. In general, environmental assessment techniques have been developed since the 1970s to ensure the identification, analysis, and consideration of environmental impacts before the regarded product or activity is launched (ex ante analysis). Environmental assessment therefore represents an integrative tool combining the consideration of potential environmental impacts and public concern and allows comprehensive decision-making.

There are several environmental management techniques such as product carbon footprint (PCF), life cycle assessment (LCA), eco-audit, environmental impact assessment (EIA), and strategic environmental assessment (SEA). Each of these techniques is appropriate for specific situations. Not only do they differ in the subject of study (product, production site, project, or law), but also in their ability to address environmental impacts occurring at different spatial levels.

Life cycle assessment (LCA), for example, addresses the environmental aspects and potential environmental impacts (e.g. use of resources and the environmental consequences of releases) of a product throughout its life cycle.

Although methodological developments are under way, LCA is still considered weak regarding local environmental impacts which are not yet covered in standard LCA studies.

Environmental impact assessment (EIA), on the contrary, is specifically designed to assess projects. It typically addresses the following environmental impact categories: soil, water, air, biological resources, landscapes, and visual impacts, as well as the physical factor of the impact (e.g. noise). Regarding bioenergy and bio-based products, studies focusing on local environmental impacts use elements of EIA and cover aspects connected to the cultivation of the respective feedstock. The considered impact categories are therefore mainly biodiversity, soil, and water (e.g., Fernando et al. 2010).

Within the Global-Bio-Pact project a review of existing studies on environmental impacts of bioenergy and bio-based products was performed (Rettenmaier et al. 2011). For this purpose, two assessment techniques were selected: life cycle assessment (LCA) and elements of environmental impact assessment (EIA). The latter were preferred over strategic environmental assessment (SEA) (EP and CEC 2001), since the case studies within the Global-Bio-Pact project are focussing on specific examples of biomass production and conversion (i.e. projects) rather than on (biofuel) policies, plans, or programs. For more information regarding SEA of biofuels, the reader is referred to a recent OECD publication (OECD 2011).

The main conclusion derived from this review (Rettenmaier et al. 2011) is that biofuels/bioenergy and bio-based products are mainly associated with land use impacts and related impacts on the natural environment and resources. A short summary of the most important aspects is given in the following list:

- **Greenhouse gas emissions**: In recent years, several studies have pointed out that the greenhouse gas balance (carbon footprint) of biofuels/bioenergy is only positive as long as no major changes in land carbon stocks occur, e.g. caused by direct and indirect land-use changes.
- **Biodiversity**: Biodiversity is threatened by two different mechanisms: intensification of production on existing agricultural land (high inputs, monocultures etc.) and expansion of agricultural land (i.e. land use changes) at the cost of (semi)natural ecosystems. The impacts strongly depend on location, agricultural practices, and previous land use.
- **Water**: Two aspects related to water are discussed in the context of biofuels/bioenergy and bio-based products: water quality and water quantity. Biomass cultivation and conversion may lead to water pollution/contamination and depletion of (scarce) water resources.
- **Soil**: Biomass cultivation—like other agricultural activities—may have negative impacts on soil physical, chemical, and biological properties, including soil erosion (by water and wind), soil organic matter (SOM) decline, soil compaction, and salinization.

These most important aspects are mentioned by the FAO-funded Bioenergy Environmental Impact Analysis (BIAS) project (Fritsche et al. 2010) and classified according to the spatial level (global/ regional/ local) at which they are occurring

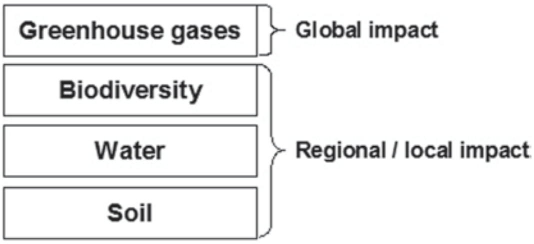

Fig. 4.1 Key modules of the BIAS framework (Adapted from Fritsche et al. 2010)

(Fig. 4.1). The BIAS project provides a framework for assisting decision-makers and stakeholders in comparing the environmental impacts of competing bioenergy development options. These main areas of concern are also reflected in the European Renewable Energy Directive (2009/28/EC, RED) (EP and CEC 2009). Article 23(1) of the RED specifically mentions the impacts on global warming (greenhouse gas emissions), biodiversity, water resources quality, and soil quality (EP and CEC 2009).

4.2.2 Environmental Impacts Associated with the Global-Bio-Pact Case Studies

Within the Global-Bio-Pact project seven in-depth case studies investigated the cultivation and conversion of five different feedstock types for biofuels/bioenergy and bio-based products. The following list gives an overview of the case studies. Further information about the case studies can be found in Chaps. 8–14 of this book.

- Argentina (soybean oil, biodiesel)
- Indonesia (palm oil, biodiesel)
- Tanzania (*Jatropha* oil, biodiesel)
- Mali (*Jatropha* oil, biodiesel)
- Costa Rica (sugar cane, bioethanol)
- Brazil (sugar cane, bioethanol)
- Canada (lignocellulosic biomass, 2nd generation conversion technologies)

For the assessment of environmental impacts associated with the case studies, it was decided to focus on the four environmental impacts mentioned in Sect. 4.2.1. Due to differences regarding the ability to address environmental impacts occurring at different spatial levels, a combination of the two techniques described above was used for the assessment of environmental impacts for the case studies: life cycle assessment (LCA) methodology for greenhouse gas emissions and elements of environmental impact assessment (EIA) for biodiversity, water, and soil. Greenhouse gas (GHG) emissions were quantified by IFEU, whereas the impacts on biodiversity, water, and soil were reported by the project partners in a qualitative manner.

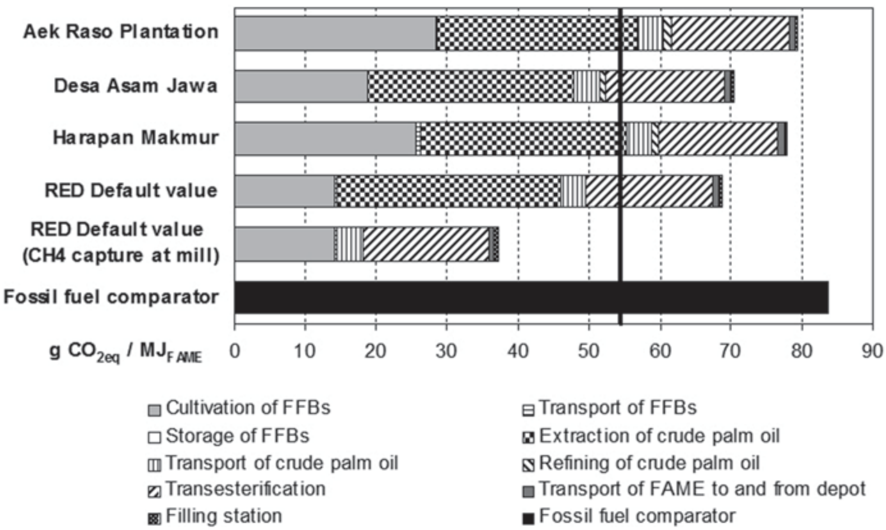

Fig. 4.2 GHG emissions from palm oil biodiesel in Indonesia compared to its fossil fuel comparator. (IFEU based on Wright 2011)

IFEU calculated the GHG balances based on case study-specific data provided by the project partners. The GHG calculations were performed according to the rules laid down in Annex V of the European Renewable Energy Directive (2009/28/EC, RED) (EP and CEC 2009), since the Global-Bio-Pact project was initiated in order to explore whether and how the current list of (environmental) sustainability criteria in the RED can be amended by mandatory socio-economic sustainability criteria. Three tools were used: the BioGrace GHG calculation tool (for sugar cane ethanol, soybean oil biodiesel, palm oil biodiesel) (BioGrace 2011), the ENZO2 Greenhouse gas calculator (for molasses ethanol) (IFEU 2012), and the GEF Biofuel GreenHouse Gas Calculator (for *Jatropha* oil biodiesel) (IFEU 2011).

In the following, the results of only one case study are shown, namely the environmental impacts associated with palm oil biodiesel production in Indonesia. The results for all other case studies can be found in Rettenmaier et al. (2012a).

Example: Palm oil biodiesel from Indonesia Palm oil biodiesel from Indonesia shows negative implications regarding greenhouse gas (GHG) emissions, water resources and quality, biodiversity, and soil. Both feedstock production and conversion contribute to the negative implications (Wright 2011; Chap. 9 of this book).

The most important problem is that palm oil biodiesel production in Indonesia—at least in case of the plantations and mills regarded in the case study—leads to high GHG emissions (Fig. 4.2). None of the investigated three cases reaches the 35 % minimum threshold of the RED (vertical line at 54.47 g CO_2eq / MJ in Fig. 4.2). This is mainly due to, i). the fact that the methane emissions from the palm oil mill effluent (POME) treatment are not captured and ii). the relatively high amount of fertilizers. Only the Desa Asam Jawa case (16 %) is getting somewhat close to the RED default value (for mills without methane capture). This highlights the great potential for process optimization in the palm oil industry, not only in terms of methane capture at the palm oil mill but also in terms of increased use of oil palm biomass residues.

In terms of biodiversity, it was found that all three cases lie within or next to areas of high biodiversity and high soil carbon stocks (Wright 2011). The increasing demand for palm oil is a threat to these neighboring areas, which could be converted to agricultural land, too. If rainforests are cleared and/or peatland is drained, there is a risk that high conservation value (HCV) areas are permanently lost, GHG emissions increased, and soil fertility decreased. Soil compaction and application of fertilizer and chemical pesticides are further weaknesses (Wright 2011). The application of the latter is potentially harmful for adjacent ecosystems and their water bodies and also results in increased greenhouse gas emissions. POME discharge into nearby water bodies creates another problem which can result in water contamination of the surrounding area, if not treated and handled appropriately. The palm oil mill needs to be located in the immediate vicinity of the plantation to ensure the quality of the fresh fruit bunches (FFBs) which are pressed to obtain the crude palm oil (CPO). Therefore, the negative impacts of the palm oil mill can also affect surrounding rainforests or other areas of high conservation value.

4.3 Linkage Between Socio-Economic and Environmental Impacts

4.3.1 Methodology

The overall aim was to reveal hotspots of trade-offs and correlations between socio-economic and environmental impacts of biomass production in developing countries. Based upon the assessment of existing studies, both regarding environmental and socio-economic impacts, the linkages between major environmental and socio-economic impacts of biofuel and bio-based product life cycles are investigated. This is important since positive social impacts are not necessarily associated with positive environmental impacts, and vice versa.

This task was carried out by combining the approach of a SWOT analysis[3] with a classification of various combinations of environmental and socio-economic impacts (see below). First, a SWOT analysis was performed on each Global-Bio-Pact case study which was entirely based on data provided by the respective partners. This way, differences in the biomass production and conversion into the biofuels and bio-based products depending on specific environmental, social, and economic conditions are revealed. The general structure of a SWOT matrix is shown in Table 4.1.

[3] A SWOT analysis is a tool to assess the performance of a project, a product, or a company. It originates from business management and it is a strategic planning tool to identify and assess the Strengths (S), Weaknesses (W), Opportunities (O), and Threats (T) of the surveyed project, product, or company. Internal factors are determined by the project/ product itself. All others are external.

Table 4.1 Example of a SWOT matrix: strengths (S) and weaknesses (W) are internal factors (determined by the project/product itself) whereas opportunities (O) and threats (T) are external factors (determined by the outside world)

	Favorable	Unfavorable
Internal factors	Strengths	Weaknesses
External factors	Opportunities	Threats

Table 4.2 Matrix used for the classification of linkages between socio-economic and environmental impacts. Example: A positive correlation results if both environmental and socio-economic impacts are positive

	Positive correlation	Trade-off
Environmental impacts	+	–
Socio-economic impacts	+	+
Environmental impacts	+	–
Socio-economic impacts	–	–
	Trade-off	Negative correlation

Regarding the identification of linkages between socio-economic and environmental impacts the classification depicted in Table 4.2 was applied.

Through the combination of SWOT analyses and classification of the assessed impacts regarding the Global-Bio-Pact case studies, all types of linkages between socio-economic and environmental impacts could be identified: positive correlations, trade-offs, as well as negative correlations.

4.3.2 Results

This chapter presents the results of the analysis of linkages. First, the results of a single SWOT analysis are shown, taking the Indonesian case study as an example. Subsequently, a summary of results of all SWOT analyses is presented, followed by remarks regarding the limitations of the analysis. The SWOT analysis results for all other case studies can be found in Rettenmaier et al. (2012a).

Example: Palm oil biodiesel from Indonesia All information regarding environmental and socio-economic impacts used for this SWOT analysis was entirely obtained from the Indonesian case study performed within the Global-Bio-Pact project, but condensed and interpreted by IFEU and Imperial College. For in-depth insights and a more comprehensive picture on the situation in Indonesia, the reader is referred to the original case study report (Wright 2011; Chap. 9).

Environmental impacts Table 4.3 shows the SWOT matrix about the environmental impacts of palm oil production in Indonesia. While containing several weaknesses, no strengths were mentioned in the case study report.

The weaknesses observed affect all assessed environmental aspects, namely GHG emissions, water resources and quality, biodiversity, and soil. Both the feedstock production and the conversion have negative impacts on the environment. The

Table 4.3 SWOT matrix for the environmental impacts of the production of palm oil and biodiesel in Indonesia (IFEU and IC based on Wright 2011)

S n/a	*W* greenhouse gas emission savings of less than 35 % (5 %–16 %) compared to the fossil reference fuel *W* all three case studies lie next to or within regions of high biodiversity and high soil carbon stocks respectively *W* incidences of water contamination by POME and agrochemicals were reported *W* decline in soil's organic matter, fertility, and soil moisture and increase in soil compaction were reported
O n/a	*T* potential of occupation of protected areas and/or regions of high biodiversity and soil carbon stock

POME palm oil mill effluent

most important weakness is that palm oil biodiesel produced from crude palm oil (CPO) from the mill assessed in this case study does not meet the minimum GHG emission savings stipulated in the European Renewable Energy Directive (>35 % as compared to the fossil fuel reference). This is merely due to the fact that the mill does not capture the methane emitted from the open ponds in which the so-called palm oil mill effluent (POME) is treated anaerobically. All three case studies lie within or next to areas of high biodiversity and high soil carbon stocks. This shows the general problem associated with the implementation of oil palm plantations in Indonesia: the clearing of rain forests or drain of peatland for the implementation of palm oil (Wright 2011). The danger to high conservation value areas, the increase of greenhouse gas emissions, as well as the decrease of the quality of the soil through loss of fertility are direct impacts of such a conversion. Soil compaction and application of fertilizer and chemical pesticides are further weaknesses (Wright 2011). The application of the latter is potentially harmful for adjacent ecosystems and their water bodies and also results in increased greenhouse gas emissions.

Another problem is associated with the POME discharge into nearby water bodies. This can result in water contamination of the surrounding area, if not treated and handled appropriately. The palm oil mill needs to be located in the immediate vicinity of the plantation to ensure the quality of the fresh fruit bunches FFBs which are pressed to obtain the CPO. Therefore, the negative impacts of the palm oil mill can also affect surrounding rain forests or other areas of high conservation value.

Socio-economic impacts Table 4.4 shows the SWOT matrix regarding the socio-economic aspects of oil palm plantations in Indonesia. The high number of impacts reflects the great differences especially between the three case studies chosen on the local level. Regarding economic aspects the case study report revealed both strengths and weaknesses associated with palm oil production. On the one hand, the implementation of palm oil had positive impacts on the employment situation in most villages and improved the general situation of smallholders. This emphasizes the high economic importance of the production of palm oil. However, the influence

Table 4.4 SWOT matrix for the socio-economic impacts of the production of palm oil and biodiesel in Indonesia (IFEU and IC based on Wright 2011)

Feedstock production	*Feedstock production*
S Palm oil has improved overall employment situation in most of the case study villages	*W* Many jobs in initial phase of plantation are temporary and set with day laborers without most of the protections for permanent workers
S Smallholders claim to be better off with palm oil compared to the past	*W* Wages: at the national level, only around minimum wages; at the regional level, significantly below minimum wages (only 80 % of minimum wage)
S Wages of workers and bigger farmers in smallholder case study at the local level were above minimum wage (110 % and about 200 % per ha, respectively)	*W* Problem with child labor (age 9–17)
S At the local level, the state-owned plantation provides security of employment and social insurance for all their workers	*W* Agrochemical use, harvesting accidents, and restriction of rights of association and trade unions at the regional level
S Free health care for all employees of and all plasma smallholders associated with the state-owned plantation at the local level	*W* Weak bargain position and low income of smallholders due to little organization and their dependency on middlemen or farm gate prices
S In general, large plantations often have their own health clinics	*W* Competition between food use of palm oil and use as biofuel
S At the regional level, stable production of rice and slightly increased production of other food in the past 10 years	*W* Transition from net producers to net consumers of food makes people more vulnerable to high food prices
	W Smallholders of one case study region converted rice paddies into more profitable oil palm plantations causing a deficit in regional food production
	W Increasing number of conflicts across Indonesia over land rights and unfulfilled promises
	W In the case study regions, only 5 % of the workers at the plantation and 15 % at the mill are women
	W Female unskilled workers receive lower wages than male ones
	W At the national level, problems for smallholders in remote areas to gain access to money (unmanageable debts), good planting material, and knowledge about management
Conversion process	*Conversion process*
S At the mill associated with the state-owned plantation, unskilled workers' wage is much higher than minimum wage (nearly 340 %)	*W* Only one (state-owned) company for biofuel blending paying low prices to the producers for their biodiesel
S All permanent workers at the mill at the local level are provided with housing, health care, children's education, and other bonuses	
S Free health care for all employees of the mill at the local level	

Table 4.4 (continued)

Feedstock production	*Feedstock production*
O Well-paid feedstock for oil production	*T* Low potential for future employment generation at the regional level
Conversion process	*Conversion process*
O Increasing market	*T* Slower growth of the biofuel sector at the national level than predicted results in less job creation

of biodiesel production compared to other uses is difficult to identify. On the other hand, wages in the feedstock production sector for the workers and smallholder farmers, respectively, differed depending on the geographical scale. At the local level the wages were above the minimum wage (up to 200% in case of some plasma smallholders). The wages paid at national level were on average only around the minimum wage, at the regional level they were even below. Thus, no general statement regarding the economic impact of the palm oil sector in Indonesia as such is possible.

An important aspect identified as weakness is the fact that the employment generation on regional level is not expected to continue much. Most of the jobs are created in the initial phase of an oil palm plantation. However, the potential for further expansion was considered small due to the fact that this region was one of the first regions in which oil palm plantations were implemented. Therefore, only few areas remain for further expansion (Wright 2011). A weakness was observed regarding the type of jobs connected to the initiation of new plantations (working conditions). Those jobs are only temporary and not associated with the social and health protections of permanent jobs. This is a problem related to the agricultural sector in general occurring in connection with seasonal work. Weaknesses regarding economic aspects were identified for smallholders in remote areas not directly associated with a specific plantation. These so-called plasma smallholders heavily depend on single suppliers of seeds and buyers of the FFBs. This makes them very vulnerable. This group also faces the problem of accessing the start-up money for the plantations, appropriate knowledge on management techniques, and good planting materials. All these aspects result in them having lower yields and lower incomes. The unmanageable debts reported as a major problem in the case study report potentially results from that.

Regarding the conversion of the palm oil to biodiesel, a weakness was observed regarding the price biodiesel producers got paid for their product (economic aspect). There is only one domestic company operating as a blender of the biofuel in Indonesia. The company was criticized by biodiesel producers for setting low prices. This, again, reflects a weak bargaining position for single producers if depending on single companies for selling their products.

An explicit weakness was observed regarding the position of women among the workers (gender issue). First, only 5% and 15% of the workers at the plantations and at the conversion mill, respectively, were women. Furthermore, female unskilled workers also received lower wages than their male counterparts. This is probably due to the hard physical work on the plantations. On the other hand, this might reflect a general aspect of the perception of differences regarding gender in society. Women were for example reported to often work on smallholder plantations. Their work, however, was not perceived as paid work (Wright 2011).

The health care provision and the social security were identified as strengths on all surveyed levels for both the feedstock production and the feedstock conversion. In general, it is common for large plantations to have their own health clinics. This aspect is especially important for plantations located far away from other inhabited areas. At the state-owned plantation on the local level, even the associated smallholders cultivating their own plots were provided with health care.

A general problem connected to the palm oil productions in Indonesia is the aspect of child labor. This was reported for the regional level in particular. 75 % of the households were reported to let their children work on plantations to raise the low income. This aspect needs to be addressed as a problem not only associated with oil palm plantations but with the overall situation of the people living in this region.

Furthermore, the application of agrochemicals and harvesting accidents contribute to negative impacts on the working conditions at the regional level. In connection with restrictions regarding the rights of the workers, this needs to be addressed as an important weakness. In the case study report it was mainly reported for the regional level (Wright 2011).

The last important issue for the socio-economic aspects of the case studies refers to the land-use competition between food and palm oil production. Most of the aspects were found as clear weaknesses. Only at the regional level strength was identified. In North Sumatra, a stable or even slightly increased production of food crops was observed in the last 10 years. This is especially remarkable considering the fact that for this region a low potential for expansion of palm oil production was identified. Generally, this would be expected to result in an even heavier conflict of palm oil and food production for land. For all other plantations, the competition of palm oil cultivation and food production was addressed as a problem. This issue consists of several aspects closely related to each other. First, the conversion of land to oil palm plantations previously used for food production might be due to land grabbing and without or only with a limited agreement on the side of the owner of the land. This aspect is reflected in the reported increasing number of conflicts across Indonesia over land rights and unfulfilled conditions. The second possible reason for a conversion of land might be the economic incentive of the more profitable cultivation of palm oil trees. This aspect was reported for smallholders on the local level converting rice paddies into oil palm plantations. However, this is likely to create deficits regarding the production of food for the affected area. The economic problem of newly implemented oil palm plantations is the delayed financial output after 3–5 years. The combination of both aspects results in a transition of the affected people and the whole region from net producers to net consumers of food. This makes them more vulnerable to rising food prices. A third aspect regarding the competition of food and fuel lies within the sector of oil palm plantation. Oil palm has emerged as a feedstock for biodiesel production only in the last few years. Before, it was used for food (vegetable oil) and cosmetics only. Diverting the use of palm oil to biodiesel, therefore, also creates a competition between food and fuel.

Linkages: Correlations and trade-offs Linkages between the environmental and the socio-economic aspects of palm oil production in Indonesia refer to both trade-offs and negative correlations. A negative correlation is observed regarding the POME discharge into adjacent water bodies without capturing the emitted methane. This negatively affects the environment regarding the increase of greenhouse gas emissions and the danger of polluting affected water bodies. The last aspect is harmful to the environment and to the people in the surrounding villages at the same time. The pollution of drinking water is a threat to the health of the people. Another negative correlation is the application of agrochemicals. It negatively affects the health of workers and people from the surrounding villages, too. In relation to environmental impacts, it means a threat to the biodiversity of the surrounding areas. The third negative correlation refers to the aspect of land-use competition. Oil palm plantations compete for land with natural forests. This negatively affects the biodiversity of the affected high conservation value areas. Furthermore, it might increase the emissions of greenhouse gases in case of conversion of peat soils. On the other hand, it results in conflicts over land use and competition with the production of food in socio-economic terms.

The trade-off is associated with the overall implementation and maintenance of oil palm plantations. In terms of economic aspects, positive impacts are observed regarding the general economic situation (employment generation, income, and social insurance) of most of the affected farmers and villagers. In terms of environmental aspects, though, the impacts are mainly negative regarding several issues (see above).

4.3.3 Summary of the Results

Through the SWOT analyses on all Global-Bio-Pact case studies (see Rettenmaier et al. 2012a) several linkages between socio-economic and environmental impacts could be identified (see classification in Sect. 4.3.1). In the following chapter, a number of examples are given (non-exhaustive list):

Positive correlation between socio-economic and environmental impacts ('win-win situation')

- The non-intensive cultivation of *Jatropha* in the investigated case study is not disturbing (rather improving) the socio-economic situation of the affected people and does not negatively affect the environment. Potentially, it even improves the environmental properties of the cultivated land. Therefore, a positive correlation was identified between socio-economic aspects (e.g. economics, employment generation, and gender issues) and environmental aspects (e.g. soil improvement).

Trade-off between socio-economic and environmental impacts

- Regarding the intensive cultivation of *Jatropha*, negative environmental impacts were reported in the case study related to clearing of natural forests and the use of heavy machinery and pesticides. This negatively influences areas of high biodiversity, water quality as well as greenhouse gas emissions. Also soil erosion and the loss of soil fertility are affected. However, since in terms of socio-economic aspects, positive impacts on the economic situation of farmers and villagers were reported, an overall trade-off was identified.

Negative correlation between socio-economic and environmental impacts ('lose-lose situation')

- A negative correlation was identified for sugarcane bioethanol in case the harvest involves burning of the field which is associated with negative impacts on workers' health. It also increases air pollution and greenhouse gas emissions in terms of environmental aspects.
- A negative correlation was identified for palm oil biodiesel, in case the palm oil mill effluent (POME) is not properly treated: POME increases greenhouse gas emissions and decreases water quality of adjacent water bodies. At the same time, it negatively affects human health through the pollution of drinking water of surrounding villages.
- In case of inappropriate application of agrochemicals, a negative correlation was identified. In terms of environmental aspects, it is harmful to the biodiversity of adjacent areas and decreases water quality. Also, it has negative socio-economic impacts on workers' health and drinking water quality.
- Land-use conflicts and land-use changes (LUC) often lead to a negative correlation. From an environmental point of view, LUC threaten biodiversity and (in most cases) increase greenhouse gas emissions. In terms of socio-economic impacts, LUC often has an impact on food security issues: diverting land away from food and feed production makes the affected people more vulnerable to rising food prices.

Land-use conflicts were mostly reported in relation to an intensive, large-scale cultivation of a certain feedstock, in some cases connected to foreign investments. To prevent such land-use competition, a strict implementation of a country's laws and regulations is absolutely necessary. In those countries that are already facing the respective negative impacts, the application needs to be controlled thoroughly. For countries like Mali and Tanzania facing the broad-scale introduction of *Jatropha* for biodiesel production the situation is different. To prevent such negative impacts it is absolutely necessary to implement an appropriate framework beforehand. Thereby, these impacts might be able to be minimized.

4.3.4 Limitations and Remarks

All information regarding environmental and socio-economic impacts used for the SWOT analyses was entirely obtained from the Global-Bio-Pact case study reports. The information was condensed and interpreted by IFEU and Imperial College which bears the risk that some aspects have been omitted. For in-depth insights and a more comprehensive picture on the situation in each of the countries, the reader is referred to the original case study reports.

Two major limitations were identified:

- Completeness
- Reference point in time/baseline situation

Regarding completeness, it has to be kept in mind that the case study partners were asked to gather information related to certain predefined environmental and socio-economic aspects. As a consequence, other potentially important aspects were not addressed. Moreover, in some cases, it was not even possible to obtain the requested information related to some of the predefined aspects, so the picture given might be incomplete and even biased.

The authors had very limited possibilities to cross-check and validate the information provided by the partners. For example, neither direct land-use changes (dLUC) nor indirect land-use changes (iLUC) were reported in the case studies. Consequently, the greenhouse gas balances were calculated without dLUC and iLUC emissions. If the LUC emissions were taken into account, the results would be significantly influenced.

The second limitation is related to the fact that no reference point in time and reference land use (baseline situation) was defined. Data from different points in time were rarely provided in the case study reports. Such information, however, is absolutely necessary for two reasons: i) to identify developments or trends between two different points in time, i.e. the socio-economic and environmental situation before and after the implementation of the respective feedstock cultivation, and ii) to establish causality links between observed impacts and the underlying drivers.

Since most of the biomass feedstock (except *Jatropha*) used for biofuels have been cultivated since a long period for other purposes (mainly food/ feed), the difference between a business-as-usual scenario and a nonfood biomass scenario should be measured. Regarding feedstock cultivation, the assessment of environmental impacts heavily depends on the reference land use (baseline situation): if compared to unused land, annual crops usually perform significantly worse. However, if annual crops (for biofuel production) are compared to other annual crops (for food or feed production), differences are mostly less distinct. Due to the absence of a clear reference land use, it was not possible to link the reported impacts for the various types of feedstock to the implementation of biofuel production. Most impacts analyzed are rather connected to the general production of the respective agricultural commodity.

The fact that extensively cultivated *Jatropha* seems to perform better than the other crops can be regarded as an artifact. First, *Jatropha* has just recently been introduced as a potential feedstock for the production of biofuels. Until then, the nonfood plant was only cultivated as means of protection hedges yielding goods for small-scale trade. All other types of feedstock have been cultivated long since and were mainly used for food purposes or for high-value goods, making large-scale farming feasible. Therefore, the two groups of feedstock differ regarding three aspects: time and scale of implementation and their previous use.

Thus, the assessment of the impacts could only be conducted in terms of a description of the respective status quo and a knowledge-based outlook on possible impacts. This made the application of SWOT analysis to the conducted case studies quite difficult.

Regarding the environmental impacts of biofuels and bio-based products, the results are often ambiguous showing systematic trade-offs, i.e. a distinct pattern of advantages and disadvantages (Rettenmaier et al. 2011). Usually, the use of biofuels and bio-based products (instead of petroleum-based fuels and products) saves non-renewable energy resources and helps mitigating climate change[4]. At the same time, other environmental impacts are more pronounced, e.g. impacts on biodiversity, water, and soil. From a scientific point of view, an objective conclusion regarding the overall environmental performance cannot be drawn[5]. In other words: there are even trade-offs between different environmental impacts, not only between socio-economic and environmental impacts.

4.3.5 Interpretation

Since "the environment" actually means soil- to grow food; water- to drink, wash, and irrigate crops; air- to breathe, and a host of natural food and medicinal products, it becomes clear that preserving "the environment" actually means safeguarding food production, sustaining livelihoods, and preserving health. Poverty reduction, economic growth, and the maintenance of life-supporting environmental resources are therefore inextricably linked (OECD 2001). According to UNECA (2008), the pursuit of environmental sustainability is an essential part of the global effort to reduce poverty, because environmental degradation is inextricably and causally linked to problems of poverty, hunger, gender inequality, and health. Livelihood strategies and food security of the poor often depend directly on functioning ecosystems and the diversity of goods and ecological services they provide.

The concept of ecosystem services links environmental and socio-economic aspects. Ecosystem services are the benefits people obtain from ecosystems. These include provisioning, regulating, and cultural services that directly affect people and as well as supporting services needed to maintain the other services. Changes in these services affect human well-being through impacts on security, the necessary material for a good life, health, and social and cultural relations (Millennium Ecosystem Assessment 2003). Figure 4.3 shows the linkages between ecosystem services and human well-being.

Linking environmental and socio-economic impacts as done for the concept of ecosystem services is quite complex. First of all, this is because environmental impacts are a complex issue in themselves. They differ in terms of timescale (persistence), spatial scale (ubiquity), and (ir)reversibility, among others.

[4] Provided that no direct land-use changes (dLUC) and indirect land-use changes (iLUC) occur.

[5] An overall evaluation has to be based on (subjective) value-choices, e.g. by ranking the impact categories in a certain hierarchy (e.g. high, medium, and low priority). For obvious reasons, different individuals, organizations, and societies have different preferences; therefore different rankings may be the outcome of the same (objectively obtained) scientific results.

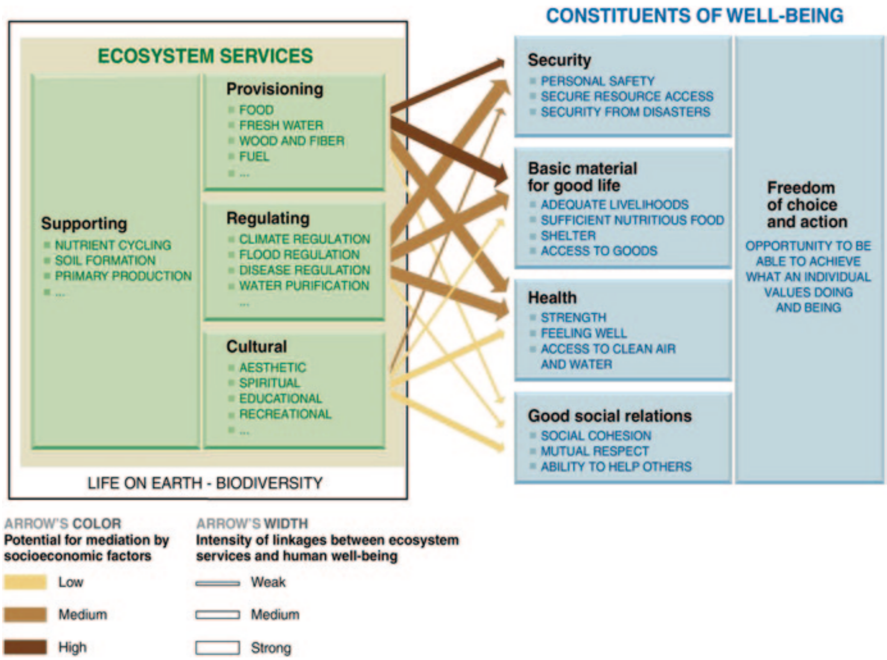

Fig. 4.3 Linkages between ecosystem services and human well-being (Millennium Ecosystem Assessment 2005)

Environmental impacts often develop insidiously over a long period of time, i.e. significant time lags might occur between the dose (release of a harmful substance) and the associated response (damage to organisms or ecosystems). Since ecosystems are functioning on a long timescale, environmental impacts tend to be overlooked by the often shortsighted view of politics and society. Frequently, short-term economic profits are preferred over long-term environmental benefits. This is one of the main reasons for trade-offs between socio-economic and environmental impacts.

Moreover, the relationship between dose and response is often nonlinear showing for example an abrupt change if a certain threshold is passed. In case this change is irreversible, the threshold is also called a tipping point. Last but not least, the response depends on the nature of the affected organisms or ecosystems, more specifically their resistance (ability to withstand) and resilience/elasticity (ability to tolerate). Thus, the same dose causes different responses in different environments.

Combining these insights into environmental impacts and the concept of ecosystem services (see above), this means that environmental impacts lead to changes in ecosystem services which in turn negatively affect the constituents of human well-being. Despite the complex relationship between dose and response (see above), one could postulate that there is a gradient from positive correlations to trade-offs to negative correlations, along which ecosystem services are increasingly deteriorated:

- **Positive correlations** (limited environmental impacts of a certain activity, no changes in ecosystem services, positive socio-economic impacts): The SWOT analysis of Global-Bio-Pact case studies suggests that non-intensive feedstock cultivation and conversion systems seem to result in positive correlations.
- **Trade-offs** (considerable negative environmental impacts, visible deterioration of ecosystem services, but still at least short-term positive socio-economic impacts): More intensive feedstock cultivation and conversion systems seem to entail trade-offs. This is the case for many Global-Bio-Pact systems. However, one has to keep in mind that there is a continuum rather than a sharp borderline between non-intensive and intensive cultivation.
- **Negative correlations** (severe negative environmental impacts, loss of ecosystem services, negative socio-economic impacts): Regarding the Global-Bio-Pact case studies, negative correlations between socio-economic and environmental impacts can mostly be explained by land-use conflicts and land-use changes as well as by inappropriate management practices – the latter both in terms of feedstock production (e.g. inappropriate application of agrochemicals) and conversion (e.g. inappropriate treatment of effluents).

This holds especially true for 'provisioning' and 'regulating' ecosystem services which affect some, but not all constituents of well-being. 'Security', 'basic material for good life' and 'health' are affected, whereas there is only a weak linkage between the ecosystem services mentioned above and 'good social relations' and 'freedom of choice and action'.

4.4 Conclusions

The main areas where environmental and socio-economic indicators are considered to be linked within the Global-Bio-Pact project are land use impacts on food security, ecosystem services, biodiversity, water, and soil.

Different approaches can be taken to link environmental and socio-economic issues, principles, criteria, and indicators. One of these approaches is to use the concept of ecosystem services. This concept proves to be very suitable for establishing the linkage between environmental and socio-economic impacts, but is still new in the business and project arena and requires further development. The number of companies that use approaches and standards such as the Corporate Ecosystem Services Review (ESR) or the Equator Principles is still very limited, particularly in the bioenergy sector.

It can be concluded that trade-offs and negative correlations between environmental and socio-economic impacts are a sign of deteriorations of ecosystem services which negatively affect the constituents of human well-being 'security', 'basic material for good life' and 'health'. They are often related to inappropriate management practices during feedstock production and conversion which either reflect the absence of respective regulations or at least a weak law enforcement by the country's institutions. Certification could help here, e.g. by raising awareness, but it is definitely not the silver bullet to prevent damage from ecosystems. This applies in particular when only a small share of the global production of an agricultural commodity is being certified, e.g. only the share of vegetable oil used for liquid biofuels production (but not the lion's share used for food or other purposes).

The second cause for trade-offs and negative correlations is land use conflicts and land-use change. For direct land-use change (dLUC), the same applies as for inappropriate management practices (see above). However, certification doesn't help resolving the issue of indirect land-use change (iLUC).

Furthermore, it can be concluded that the impacts associated with the production of a feedstock are fairly independent of its use, i.e. whether the feedstock is used for biofuels and bio-based products or for other purposes. Therefore, most of the conclusions drawn are applicable for the general cultivation of the respective feedstock. They do not necessarily reflect the specific impact of biofuel production as such. Therefore it is important to apply the same rules for all agricultural products irrespective of their use for food, feed, fiber, or fuel.

The authors would like to emphasize that the identified linkages (correlations and trade-offs) are case study-specific. Due to the limited number of case studies (one or two per feedstock), a trend or even a general rule (in the sense of a direct causal linkage) for a certain feedstock or for a certain biofuel or bio-based product cannot be deduced.

Most of the linkages between environmental and socio-economic impacts can be detected at local level whereas some linkages can only be detected at country level (or even higher), e.g. impacts on food security. Furthermore, some of the linkages regarding food security will need additional studies and a different methodology to be able to assess if biofuel production causes food insecurity and in how far biofuel mandates in developed countries and/ or globally rising energy prices contribute to that (see recent FAO (2012) report produced within the "Bioenergy and Food Security Criteria and Indicators" (BEFSCI) project).

In terms of harmonization of environmental and socio-economic sustainability criteria (Rettenmaier et al. 2012b), our analysis has shown that any strategy should especially focus on the mandates with sustainability requirements such as the European Renewable Energy Directive (2009/28/EC, RED), since these are to a large extent setting the scene. At European level, we therefore recommend to amend the RED by setting new mandatory environmental sustainability criteria regarding soil, water, and air protection, i.e. criteria that have a strong link to ecosystem services (e.g. UNEP et al. (2011)). This way, many social impacts affecting 'security', 'basic material for good life' and 'health' could be covered indirectly. Some of the voluntary certification systems do include such criteria, but since they are not needed to fulfill the requirements of the RED (so far, only criteria related to GHG emissions and biodiversity are mandatory), there is a risk that economic operators opt for the weakest (recognized) certification system which doesn't include the suggested criteria regarding soil, water, and air protection.

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Chapter 5
Socio-Economic Impacts of Biofuels on Land Use Change

Dominik Rutz and Rainer Janssen

Abstract The main focus of the current discussion on sustainability of biofuels and bio-products in relation to land use issues is on its environmental impacts of feedstock production. Thereby, a large emphasis is put on greenhouse gas (GHG) emissions and biodiversity. The impacts on socio-economic issues are far less discussed, although they urgently need to be addressed in policies and legislation. This chapter describes socio-economic impacts related to land use issues of biomass production for biofuels.

Keywords Land use change · Land use · Indirect land use change · Land cover · Land rights

5.1 Introduction

Before analyzing the impacts of biofuels and bio-products value chains on land use aspects and changes, the topic must be addressed in a more holistic approach, as land use changes occurred since ever in parallel with human development.

Land use is the human use of land which involves the management and modification of natural environment or wilderness into built environment such as fields, pastures, and settlements (Watson et al. 2000).

Historically, major shifts from natural and virgin ecosystems and vegetation to "used" land occurred due to the need for agricultural land and for wood. Thus, today, only a small part of Europe's land surface consists of virgin ecosystems. Most land has been influenced and changed by humans. In other continents, the percentage of virgin land is higher.

In many cases, the land use change had positive impacts, e.g., on biodiversity, as the structures of landscapes were diversified which created new habitats for more species. This happened in Europe, especially during the Medieval period.

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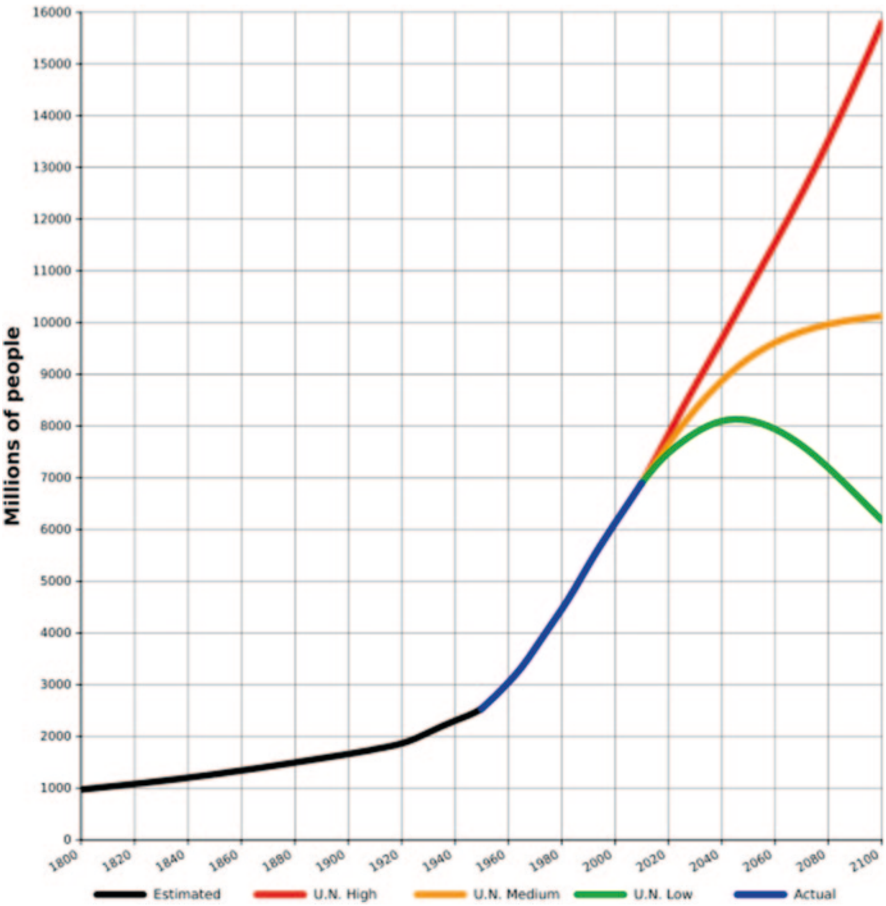

Fig. 5.1 World population from 1800 to 2100 based on UN 2010 projections and US Census Bureau historical estimates. (Source: Jmanrazor 2013)

Today, according to the US Census Bureau (2013), the world population reached more than 7.076 billion people and the growth rate is steadily augmenting (see Fig. 5.1). A larger population requires more food, feed, fuel, and fiber which can be compensated by higher agricultural productivity (EC 2010). However, pressure and competition on land use is increasing. Sustainable land use management practices and land use policies become hence increasingly important.

The production of biofuels and bio-products requires large amounts of feedstock, which is related to land use. This is obvious for dedicated energy crops; but also feedstock that is currently categorized as “residues” or “wastes” may have impacts on land use in the long term, as the general competition on carbon-based renewable sources is increasing. This is heavily influenced by prices for biofuels and biomass, as well as by prices and availability of fossil based sources.

Factors that are increasingly important in the current sustainability debate are the complexity of the issue and the interrelation of the different sectors. For example, biofuels have been frequently accused for having negative impacts on food security due to land use competition (see Chap. 5.4). It is thereby often neglected that large amounts of energy are also needed to produce food (see Chap. 17 of this book). Historically, horse and animal power was used to cultivate agricultural land for food and feed (= fuel) production. This is still the case for some niche applications and in several developing countries. During industrialization, this energy was steadily replaced by fossil fuels. With depleting fossil fuels and increasing prices of fossil fuels, biofuels and bio-products are gaining more importance again. Bioenergy will be an important future factor which ensures that food can be produced in the future as efficient as today. Thus, land will be always used for both, food and energy production with the need for both sectors to complement each other.

5.2 Definitions

In order to discuss about land use and land use changes, several definitions are needed that are described in the following sections.

5.2.1 Land Cover

Land cover is the observed physical and biological cover of the earth's land, as vegetation or man-made features (Watson et al. 2000). The terms "land cover" and "land use" are often confused as land use is "the total of arrangements, activities, and inputs that people undertake in a certain land cover type" (FAO 1997; FAO/UNEP 1999).

National categories of land cover differ. A general classification is given in the following list by the FAO's World Census of Agriculture (FAO 1986; FAO 1995; FAO/UNEP 1999; Watson et al. 2000). The following categories are listed in sequence of increasing intensity of land use:

- **Deserts** (barren land and waste land)
- **Non-forest wooded lands** (scrubland; may include national parks and wilderness recreational areas)
- **Wetlands**, non-forest (marshes)
- **Land under forest** (natural forests and most nonmanaged woodlands)
- **Land under forestry**/Silviculture
- **Land under shifting cultivation** (temporarily abandoned land that is not part of a holding)
- **Land under agroforestry** (permanent use of land at holding level, but with mixed crop growing, animal herding, and tree utilization)
- **Land with temporary fallow** (resting for a period of time, less than 5 years, before it is planted again with annual crops)

- **Land under permanent meadows and pastures** [used for herbaceous forage crops that are either managed/cultivated (pastures) or growing wild (grazing land); trees and shrubs may be present or grown purposely, but foraging is the most important use of the area; grazed woodlands]
- **Land under temporary meadows and pastures** (cultivated temporarily, for less than 5 years, for herbaceous forage crops, mowing, or pasturing, in alternation with arable cropping)
- **Land under permanent crops** (perennials; cultivated with long-term crops that do not have to be replanted for several years after each harvest; harvested components are not timber but fruits, latex, and other products that do not significantly harm the growth of the planted trees or shrubs: orchards, vineyards, rubber and oil palm plantations, coffee, tea, sisal, etc.)
- **Land under temporary crops** (annuals; cultivated with crops with a growing cycle of under 1 year, which must be newly sown or planted for further production after harvesting; not only small grain crops such as beets, wheat, and soybean but also biannuals that are destroyed at harvesting, such as cassava, yams, and sugarcane; bananas are transitional to the permanent crops category)
- **Land under temporary crops requiring wetland conditions** [wet-foot crops such as irrigated rice and jute (dry-foot crops with intermittent irrigation included in other categories)]
- **Land under protective cover** (greenhouses and other urban or peri-urban intensive use, formal or informal; vegetable growing, home gardening, residential parks, golf courses, etc.)
- **Land under residential/industrial/transportation facilities**

5.2.2 Land Use

Land use is the human use of land which involves the management and modification of natural environment or wilderness into built environment such as fields, pastures, and settlements (Watson et al. 2000). It also has been defined as "the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it" (FAO 1997; FAO/UNEP 1999; Watson et al. 2000).

5.2.3 Land Use Change

Land use change (LUC) is the change from one use to another use. Often, land use change is also referred to the change of nonused land (virgin land, abandoned land, degraded land) to another use. Thereby, distinction is made between direct land use change and indirect land use change.

Direct land use change (dLUC) is referred to the change of a specific land area that is directly converted from one status to another status. In the biofuels sector, dLUC is referred to the production of biofuel feedstock that is produced on land directly converted from another status to agricultural land for feedstock production (EC 2010).

If the feedstock for biofuels or bio-products is instead cultivated on existing agricultural land, it may then displace other crop production some of which ultimately may lead to the conversion of land into agricultural land. Through this route, the extra biofuel demand can lead *indirectly* to land use change, from which the term indirect land use change (iLUC) is derived (EC 2010). This indirect effect manifests itself through a change in demand for agricultural commodities, and their substitutes, in global markets.

In general, land use changes are always referred to a baseline status which needs to be defined. Depending on this baseline, land use changes can be determined and described, e.g., by using maps and images. Using data of the baseline and of the current or future situation, it is generally possible to determine the dLUC, whereas the iLUC can be, if at all, determined only in an abstract way, e.g., by using global land use models. However, also in models a distinction between dLUC and iLUC is often not made (Edwards et al. 2010; Laborde 2011).

Any land use change has impacts not only on the environment but also on socio-economic aspects. These impacts can be positive or negative. Impacts affected by land use changes may include biodiversity, water quality, soil properties, food prices and supply, land tenure, worker migration, rural development, income generation, and community and cultural stability, etc. iLUC usually has negative environmental impacts, whereas its socio-economic impacts are often negative and positive (mainly due to new income generation opportunities).

5.2.4 Land Use Rights, Land Tenure, and Ownership

An important factor for the determination of social impacts of land use change is the status of the ownership of the land (real property, real estate, realty, immovable property), often also called land tenure, and the associated land use rights (property rights). In general, land use rights and ownership must be respected; otherwise the setup of new cultivation areas is per se not sustainable. The following definitions for land access, land rights, property rights, land tenure, land tenure systems, and land tenure security can be given (UN-HABITAT 2008; UN-HABITAT 2003; Ciparisse 2003):

- **Land access** is the opportunity for temporary or permanent use and occupation of land for purposes of shelter, productive activity, or the enjoyment of recreation and rest. Land access is obtained by direct occupation, exchange (purchase or rental), though membership in family and kin groups, or by allocation by government, other landowners or management authorities.
- **Land rights** are socially or legally recognized entitlements to access, use, and control areas of land and related natural resources.
- **Property rights** are recognized interests in land or property vested in an individual or group and can apply separately to land or development on it. Rights may apply separately to land and to property on it (e.g., houses, apartments, or offices). A recognized interest may include customary, statutory, or informal social practices which enjoy social legitimacy at a given time and place.

- **Land tenure** is the way land is held or owned by individuals and groups, or the set of relationships legally or customarily defined among people with respect to land. In other words, tenure reflects relationships between people and land directly and between individuals and groups of people in their dealings in land.
- **Land tenure systems** are sets of formal or informal rules and institutions which determine access to, and control over, land and natural resources.
- **Land tenure security** is the (1) degree of confidence that land users will not be arbitrarily deprived of the rights they enjoy over land and the economic benefits that flow from it, (2) the certainty that an individual's rights to land will be recognized by others and protected in cases of specific challenges, or specifically, (3) the right of all individuals and groups to effective government protection against forced evictions.
- **Land titles** are official records of who owns a piece of land. They can also include information about mortgages, covenants, caveats, and easements.

There exist a great variety of land tenure and ownership systems that are influenced by historical, cultural, and economic factors. Some are very specific or outdated (allodial title, feudal land tenure, life estate, fee tail) and thus not considered here. Land tenure and ownership systems that are relevant for the bioenergy sector are described below, whereby the definitions are adapted from Kuhnen (1982), UN-HABITAT (2008), and Wikipedia (2013):

- **Fee simple, freehold, or private ownership of land**: This is the most complete ownership interest one can have in real property. It is ownership in perpetuity. The holder can typically freely sell or otherwise transfer that interest or use it to secure a mortgage loan. This picture of "complete ownership" is limited in most places by the obligation to pay a property tax and by the fact that if the land is mortgaged, there will be a claim on it in the form of a lien. In modern societies, this is the most common form of landownership. Land can also be owned by more than one party and there are various concurrent estate rules.
- **State ownership of land**: As a consequence of conquest, purchasing, gifts, and seizure, land belongs to the state in many countries in the same way as other areas belong to private people. In socialist countries, land has been turned into state property. State ownership plays a large role if public interests cannot be satisfied by private ownership, or if the land is not of interest to private people from an economic standpoint (catchment areas, wasteland, forest, frontiers, experimental farms, etc.). The state partially cultivates its own land (government farms and government forests) and also partially leases it out.
- **Government collectives**: Found in communist states, whereby government ownership of most agricultural land is combined in various ways with tenure for farming collectives.
- **Collective and communal ownership**: In this type of ownership, the right of disposition is in the hands of kinship or political groups that are larger than a single family, but not necessarily the whole state. In the forms of communal ownership found in Africa (a widespread phenomenon in sub-Saharan Africa), the land rights are generally controlled by the tribe, and the use of the land is regulated

by the chieftain or priest serving the land and earth deities. Every member that is born into the group has a lifelong right to a piece of land for his own usage. The tribes regard themselves as custodians of the land for future generations rather than proprietors.

- **Cooperative tenure**: Ownership is vested in the cooperative or group of which residents are co-owners.
- **Land grants**: In Islamic countries, land is granted to schools, mosques, orphanages, and similar institutions. This type of grant is often called a "waqf". The beneficiary receives an irrevocable right of use that is carried out by government organizations, generally in the form of being leased out. The institution that is granted the right of use receives the profit. Such lands are frequently in very bad condition as hardly any investments are made.
- **Farm tenancy**: Agricultural land that people can rent from someone for their usage for a period of time. In densely settled countries with private landownership, in some cases more than half of the land is cropped by tenants. One can differentiate between various forms of renting the land according to the type of payment that is demanded (occupational tenancy, cash tenancy, rent in kind, share tenancy).
- **Occupational tenancy**: The tenant works for a specific number of days on the landlord's farm in order to pay for the land he rents. In some cases, he uses his own draught animals and implements. This form is particularly found in Latin America where it is called a "colonate."
- **Cash tenancy**: The tenant pays a fixed rent for the land he rents and, thus, bears the full cropping and marketing risk himself; however, he also receives all the proceeds growing out of his labors. This form demands the ability to face a risk and is, thus, found in the case of tenants who are economically sound.
- **Rent in kind**: The tenant pays a fixed quantity of produce and, therefore, does not have to take the marketing risk himself. This form is found especially among landowners who rent out small parcels of land and who consume the rent in their own household.
- **Share tenancy** or **sharecropping**: This refers to a specific form of rent in kind that is widely spread, particularly in developing countries. In this case, the gross output is divided between the landlord and tenant. While the original size of the share was determined by the reciprocal obligations and the productivity of the land, the great demand for land has led increasingly to shares equaling 50/50. Under these conditions, each side receives only half of any proceeds resulting from additional inputs. There is little incentive, therefore, to increase productivity by means of working harder or making larger investments. Moreover, the contract is often drawn up for only 1 year. Even though it is often prolonged by tacit agreement, it leads to insecurity and a state of dependence. This has, along with the normally extremely small size of the plots under tenancy, resulted in many farmers being indebted and living in very poor economic and social conditions.
- **Traditional land tenure**: For example, most of the indigenous nations or tribes of North America had no formal notion of landownership. When Europeans first came to North America, they sometimes disregarded traditional land tenure and simply

seized land; or, they accommodated traditional land tenure by recognizing it as aboriginal title. This theory formed the basis for treaties with indigenous peoples.

- **Ownership of land by swearing to make productive use of it**: In several developing countries (e.g., in Egypt, Senegal), this method is still presently in use.
- **Leasehold, registered leasehold, or rental**: Land may be leased or rented by its owner to another party; a wide range of arrangements are possible, ranging from very short terms to 99-year leases and allowing various degrees of freedom in the use of the property.
- **Rights to use a common**: This includes rights such as the use of a road or the right to graze one's animals on commonly owned land.
- **Easements**: This allows somebody to make certain specific uses of land that is owned by someone else. The most classic easement is right-of-way, but it could also include (for example) the right to run an electrical power line across someone else's land.
- **Agricultural labor**: Someone works the land in exchange for money, payment in kind, or some combination of the two.
- **Customary ownership**: Ownership is vested in the tribe, group, community, or family. Land is allocated by customary authorities such as chiefs.
- **Nonformal tenure systems**: These include many categories with varying degrees of legality or illegality. They include regularized and unregularized squatting, unauthorized subdivisions on legally owned land, and various forms of unofficial rental arrangements. In some cases, several forms of tenure may coexist on the same plot, (e.g., tenants and subtenants), with each party entitled to certain rights.

Furthermore, a frequently used term of land use and agricultural system in the bioenergy sector, especially in developing countries, is **Smallholdings**. According to Kuhnen (1982), this is a widespread form of family farms throughout the world. It is the target of many agrarian reforms. In order to guarantee the continuation of yields of family farms from their land, it is necessary for them to observe the preservation of the ecological balance. As soon as the precondition of sufficient farm size no longer exists, the situation becomes less favorable and the living standard of the farm families drops.

5.3 The Use of Marginal and Degraded Land

In discussions about bioenergy, often the terms marginal land and degraded land are used. This is due to that fact that on this land usually no other crops, especially no food crops, are cultivated. It is therefore argued that the cultivation of feedstock for bioenergy on such areas has less negative socio-economic and environmental impacts. This applies e.g., for the cultivation of *Jatropha*, as this shrub can survive easily on such land.

The problem is that the yield on this land is usually also low for feedstock for bioenergy production. Therefore, higher inputs are required, such as fertilization and irrigation. Furthermore, this land is often used in developing countries by subsistence agriculture for grazing or for the collection of non-purposely grown food.

In the report of FAO (2000), four definitions on favored land, marginal land, fragile land, and degraded land, are given as shown below:

- **Favored land**: Land having no, or moderate, limitations to sustained application under a given use. Moderate limitations will reduce benefits but an overall advantage will be gained from the use of inputs. Wide options exist for diversification. With proper management, risk of irreversible damage is low. There exist no or moderate constraints related to soil, climatic, and terrain conditions. Soil fertility, if adequately maintained, is favorable. Relatively reliable rainfall and/or irrigation water is available. The level of yields depends not only on favorable biophysical conditions but on accessibility to inputs, market and credit facilities, and beneficial output/input ratios.
- **Marginal land**: Land having limitations which in aggregate are severe for sustained application of a given use. Increased inputs to maintain productivity or benefits will be only marginally justified. Limited options for diversification without the use of inputs. With inappropriate management, risks of irreversible degradation. The soil constraints are low fertility, poor drainage, shallowness, salinity, steepness of terrain, and unfavorable climatic conditions. Absence of markets creates difficult accessibility, restrictive land tenure, smallholdings, poor infrastructure, and unfavorable output/input ratios.
- **Fragile land**: Land that is sensitive to land degradation, as a result of inappropriate human intervention. Sustained production requires specific management practices. Land use is limited to a narrow choice of options. Soils are of low fertility, erodible, steep terrain high groundwater levels, and flood prone. Population pressure, food deficits, competition for land from other sectors, unavailability or high cost of inputs are the socio-economic constraints.
- **Degraded land**: Land that has lost part or all of its productive capacity as a result of inappropriate human intervention. Various forms and degrees of degradation, both reversible and irreversible, may occur. Rehabilitation of reversible forms of degradation requires investment. Biophysiological constraints are erosion, salinization, fertility depletion, lack of adequate drainage on soils, and terrain prone to deterioration. Socio-economic constraints are population pressure, land shortage, inadequate support for agriculture, lack of institutional framework, high cost of rehabilitation, and lack of investment.

5.4 Land Use Issues in Developing Countries

According to Kuhnen (1982), private ownership of land is historically a Western concept that was first introduced into many developing countries by Europeans. It arose under a specific legal order by original acquisitioning of land (occupying and making the land arable) or changes in ownership (conquest, contract, inheritance). Until today, some societies still have not developed any forms of personal, private rights to land that would grant a right of disposition. The question of private landownership is strongly affected by ideological points of view. Practical experience has shown that agricultural and social developments are possible with or without private ownership of land (Kuhnen 1982).

Due to the historical development of the landownership system in many developing countries, today, these countries often face socio-economic problems in the implementation and enforcement of proper legislation on land rights. Disadvantaged people are often women, smallholders, pastoralists, and small ethnic groups.

These often fragile landownership systems pose serious risks in developing countries, as often large amounts of feedstock are needed for the production of bioenergy which can be grown well in many developing countries due to favorable climatic conditions. This fact poses a serious risk on land use issues. Thus, much public criticism against bioenergy, and especially biofuels, was related to negative land use impacts in developing countries.

However, the main problems and negative impacts are not related to the characteristics of bioenergy value chains, but rather to agricultural systems in general. The cultivation of feedstock for biofuels is not per se different from the cultivation of other crops, be it for luxury goods (tobacco, coffee, cocoa, flowers), bulk commodities for the chemical industry (palm oil, soy oil), or even for food production.

Therefore, the main challenge in developing countries is not related to biofuels but to the agricultural sector in general. This challenge may be addressed by land reforms, but many developing countries face long-term problems in the implementation and enforcement of such reforms. An attempt is to grant land titles to farmers, but Ngaido (2004) mentions that land titling is not a panacea for reforming land tenure systems. Land reforms must consider environmental risks, the level of demand for agricultural land, the performance of existing tenure systems, the legacy of colonial and postcolonial reforms, and other socio-economic factors.

Irrespective of land tenure and ownership systems implemented in a country, some type of a cadastral database or registration system is needed to guarantee the rights of people, especially of disadvantaged people. A **cadastral database** is a comprehensive register of the boundaries and ownerships of properties in countries. It commonly includes details of the ownership, the tenure, the precise location (some include *GPS* coordinates), the dimensions (and area), the land cover and classification, and the value of individual parcels of land. In most countries, legal systems and cadastres have been setup to define the dimensions and location of land parcels. The cadastre is a fundamental source of data in disputes and lawsuits between landowners.

5.5 Land Grabbing

Land grabbing is the legal or illegal acquisition of large pieces of land in developing countries by domestic and transnational companies, governments, and individuals. Land grabbing occurred historically since a long time, but the term was particularly reused following the 2007–2008 world food price crisis. There are many different types and implementations of land grabbing.

The food price crisis led to increased interest of investors in the acquisition of additional agricultural land, especially in developing countries. Investors thereby include agribusinesses, governments, and speculative investors. In addition to the investment in food production, also investments in biofuels grew rapidly in the last years. The increased production of food and biofuels led to increasing pressure on land use.

In general, investment in the agricultural sector in developing countries is positive, since much agricultural land is cultivated far below its potential of productivity (Cotula et al. 2009) due to the lack of financing and investment. The problem is that this type of large-scale investment is often associated with negative impacts on land security, local consultation and compensation for land, displacement of local people, employment of local people, negotiation processes, other socio-economic issues, and the environment (Hall 2011).

5.6 Conclusion

Due to the growth of the world population, the need for food and energy increases rapidly. In addition, fossil resources are running out, thus creating the need for new types of energy, such as renewable energies. One of them is bioenergy which provides the only alternative for hydrocarbons to fossil fuels. The main bottleneck of bioenergy is the large need for feedstock. Feedstock can be covered to some extent by residues and wastes, but a large fraction will be purposely cultivated to meet the future energy needs. Therefore, large areas of land and investments in agriculture are needed. To some extent increases in agricultural efficiencies may compensate the demand for land, but the high global demand for land is likely to continue in the long term. Thereby, the poor are bearing disproportionate costs, but reaping few benefits, because of poor governance, including the weak protection of their resource rights, corrupt and unaccountable decision-making, the side-lining of their rights within trade regimes, and the policy neglect of smallholder agriculture (Anseeuw et al. 2012). Women are particularly vulnerable.

Negative impacts of increased land use change are not only caused by bioenergy, but also (and most likely to a large extent) by other factors such as population growth and dietary chnges. However, the recent development of the bioenergy sector has the potential to improve the agricultural sustainability in general, as for the first time sustainability standards are required for a whole product sector in the agricultural field. Initiatives on **mapping** and **zoning** of several crops used for biofuels, such as sugarcane, are important towards the protection of high-value land from the social and environmental point of view. Such initiatives have been recently developed for Brazil, Argentina, and Mozambique.

Another important issue in many countries is the enforcement of existing national legislation and the reduction of corruption. In many countries, good legislation on land use is in place, but weakly enforced.

Thereby it is important to always consider the specific framework conditions of the country. Different approaches for developed and developing countries will be needed. It has to be furthermore considered, which type of feedstock and biofuels are produced, on which land, under which conditions and at which production scale (Rutz and Janssen 2012).

Finally, the ultimate challenge will be to slow down the population growth to fulfill the needs of the current world population and also for future generations: food, feed, fiber, and fuels.

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Chapter 6
The Effects of Bioenergy Production on Food Security

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Abstract The purpose of this paper is to deliver a framework and initial application of a model-based assessment of the food security impacts of changes in bioenergy production and relevant policies on food security. In an economic framework, four pathways are established by which biofuel production potentially affects the dimensions of food security: (1) food availability in connection with the competition for arable land; (2) the contribution of biofuel use of feedstock to food price volatility; (3) biofuel markets as a source of income opportunities for farmers; (4) sector-wide contributions to macroeconomic performance and living standards. Computable general equilibrium (CGE) modeling is proposed as methodology for an encompassing empirical examination of these pathways, although the limitations of the tool and data warrant the use of complementary qualitative and quantitative analyses.

Keywords Food security · Food access · Nutrition · Food expenditures · Biofuels

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6.1 Introduction

The purpose of this paper is to deliver a framework and initial application of a model-based assessment of the food security impacts of changes in bioenergy production and relevant policies on food security. The climate change impact of biofuels is left out of the discussion, although it is obvious that the potential contribution of biofuels in decelerating global warming and in making future global energy supplies more sustainable is a major impetus in this sector. Developments in biofuel production in the USA and the European Union have been largely policy driven, setting these countries apart from a more market-oriented sector in Brazil. Government-imposed goals for substituting fossil fuel for transportation with biofuels were initially motivated on account of the positive greenhouse gas balance of biofuels. The public debate over induced deforestation and other undesired land use change effects has changed this positivism into concern. A clear response from the scientific community has been hampered by the methodological difficulties in assessing the land use effects of biofuels. Early contributions in the biofuel literature signaled negative greenhouse gas balances. Improved methods and data contributed to a more balanced discussion on differentiated biofuel commodities and production strategies (Wicke et al. 2012). At least a number of biofuel options show a potentially positive GHG balance.

This paper is organized as follows. After an introduction of the general concepts of food security below, Sect. 6.2 discusses four possible impact pathways for biofuels on food security from an economic perspective. The pathways relate to land competition, impact on short and long term developments in food prices, impact on farm income, and macroeconomic performance. Section 6.3 establishes a set of indicators for a quantitative exploration of the impact pathways, followed by an illustrative application in Sect. 6.4 on the impact of increased biofuel production on food prices and macroeconomic indicators in Argentina, Indonesia, and Brazil and the implications for food security in these regions and, via food prices, on several broadly defined regions in Africa. Section 6.5 concludes.

The current FAO definition of food security distinguishes four aspects: food availability, food access (consumption) at household and individual level, stability of food access over time, and food utilization resulting in a good nutritional status—the ultimate goal (FAO 1998). Food security is a challenge at several interrelated levels. National food availability is determined by domestic supply and the extent to which farm output is complemented by means of imported food, whether through market transactions or food aid, and mutations in food stocks. Where markets or aid workers fail to connect regions of surplus to regions of deficit, a surplus of food at national level may coincide with compromised food availability at local level. On the consumer side of the market, household food access is determined by income (from farming, labor, or other activities), household food production, household food stocks, and other assets that serve as buffer. Household and individual food access (and its stability over time) needs to be accompanied by good diet diversity and food quality, good health, sanitation, and safe drinking water in order to contribute to individual food utilization and a good nutrition status (IOB 2011).

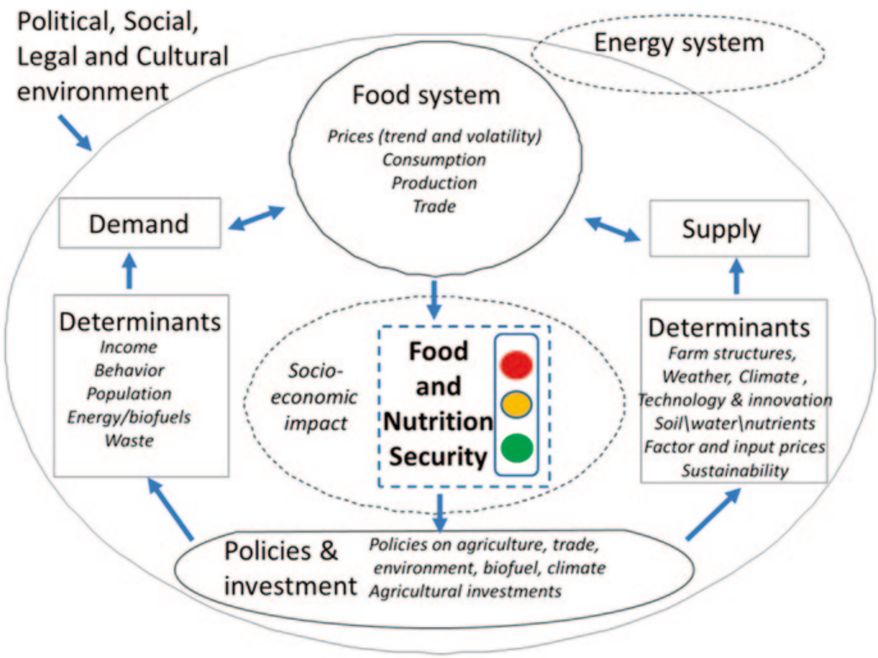

Fig. 6.1 Conceptual framework around food and nutrition security

Biofuels and food security are connected via multiple pathways, which can be analyzed with markets and natural resources as key starting points (Fig. 6.1). A useful reference for the analysis of socio-economic mechanisms is the Bioenergy and Food Security (BEFS) project (FAO 2010). Main focus in the debate on food–feed–fuel interaction has been on land competition and volatile food prices. Limited attention has been given to bioenergy's potential to promote rural development. As the sector develops, the impact of biofuel developments on macroeconomic growth is gaining interest. There is a shortage of comprehensive assessments of the impact of biofuel policies and investments on food security or nutritional outcomes that bring the various aspects together. This has motivated the High Level Panel of Experts (HLPE), a UN body to support food security strategies, to embark on a review on this topic. The first draft of this paper is largely focused on the ramifications of policy-driven biofuel use on land use and food prices (HLPE 2012), which follows the discussion in Sects. 6.1 and 6.2. A discussion on the potential role of biofuel crops as a cash crop or as stimulus for upgrading the agricultural performance in a region is largely omitted. While the omission can partially be explained by a lack of clear scientific evidence in this area, Sects. 6.3 and 6.4 aim to complement the analysis.

6.2 Connections Between Food Security and Biofuels

This chapter explores, at the conceptual level, the relations between biofuels and food security in an economic framework. Four dimensions are distinguished, which relate to the competition for land, food prices, income-earning opportunities, and the composition of macroeconomic growth.

6.2.1 Food Availability in Connection with the Competition for Arable Land

First-generation biofuels are ethanol, biodiesel, and pure plant oil, which are produced from agricultural feedstock such as corn, sugarcane, sugar beet, wheat, potato, rapeseed and soybean, sunflower and palm oil. Main biofuel producers in the world are Brazil, the USA, and the EU. OECD/FAO (2012) indicates that currently some 65 % of EU vegetable oil, 50 % of Brazilian sugarcane, and 37 % of US corn production is being used as feedstock for biofuel production. Other significant players are Thailand (ethanol and biodiesel), Argentina, and Indonesia (biodiesel), yet also developing countries with a high potential in sugarcane and/or vegetable oil production like India, Colombia, Philippines, and Malaysia are increasingly producing biofuels.

The production of bioenergy from feedstock typically reduces the availability of food, as the biomass is either used in the food/feed chain or in the energy chain. The main issue for food security may arise from land displacement and degradation, with consequently a reduction in food output, which could result in higher prices for staple food crops (FAO 2010). Shortfalls in domestic production could require increases in food imports expenses. As bioenergy feedstock production tends to be resource intensive (with widespread use of agrochemicals, fertilizers, and water), long-term soil quality and therefore land productivity could be affected adversely. In order to maintain its output, bioenergy production might have to further increase its use of land at the expense of land for food. If land displacement occurs, food producers may have to move to new lands where soil quality may be lower, hence affecting their productivity.

Recent literature suggests that a more differentiated discussion on biofuels is needed, particularly in relation to strategies for mitigating land displacement. Wicke et al. (2012) report on several options of reducing (direct and indirect) land use change. A main strategy for mitigating indirect land use change is the promotion of biofuel production with low risks for land displacement, such as currently unused residues from agriculture, forestry, and processing, as well as woody and grassy feedstock for biofuels, particularly those produced on degraded and marginal land.

The trade-off between using land for food or fuel may be illustrated by the case of Ghana. Ghana's economy is entirely dependent on imported crude oil and petroleum consumption is growing. As a consequence, Ghana's oil import bill is increasing, especially since the oil price hikes in recent years. As part of the government's energy program, biofuels is considered an alternative option to reduce Ghana's cost of oil imports. Production of *Jatropha* and palm oil for biodiesel and sugarcane for ethanol would address energy security, climate change, and balance of payments problems together with other problems such as high unemployment and low productivity in agriculture. Antwi et al. (2010) explore the country's potential to produce biofuels from agricultural products. They point at the fact that, at present, vegetable oil production is only at a very small scale. Hence, the country needs to invest in bioenergy production capacity, both in the processing as well as in the primary production if government's targets to replace gasoline with biofuels are to be met. Furthermore, the expansion of energy producing crops would need land area which is presently used to grow food. If the country wants to use its potential for producing renewable energy from agricultural crops, the authors argue that productivity of agricultural land needs to increase rapidly in order not to create any food shortage or hikes in food prices on the market. However, yield increases are not expected to be achieved easily (see for an overview of yield improving bottlenecks (Van Dijk et al. 2012, Van Berkum et al. (2011)).

The argument of Antwi et al. (2010) that increasing overall agricultural performance mitigates the food–fuel trade-off is intuitive, but oversimplifying the issue at stake for several reasons. The argumentation that biofuel investment must go hand in hand with wider yield growth to prevent food shortage in context of low agricultural productivity does not strictly apply to biofuels. Such reasoning would be valid for investments planned for any export or cash crop that does not contribute to local food supply. A priori rejections of biofuel investments in a context of (national) food insecurity may be motivated from the perspective of food sovereignty, with its focus on the production for domestic consumption and food self-sufficiency (Vía Campesina 1996). The food sovereignty movement rejects trade-based strategies to achieve food security in the absence of well-functioning international markets (Pieters et al. 2012). Applied to the case of biofuels, the benefits of the strategy in terms of reduced import dependency need to be balanced against the benefits of deeper global specialization.

6.2.2 Controversy over the Contribution of Biofuel Demand for Feedstock to Food Price Volatility

Food prices peaked in 2011, exceeding levels reached in the 2007/2008 crisis. Grain prices increased 92 % in nominal terms and 57 % in real terms from December 2005 to January 2012. The use of agricultural feedstock for biofuel results in upward pressure on agricultural prices and presents a partial cause for the price hikes. Therefore, the food security effects of biofuels relate to two separate price changes: more volatile food prices in the short run and upward pressure on food prices in the long run. These developments affect the access of poor consumers to food and the stability of access. A brief discussion of the impact of biofuels on the level and volatility of agricultural and food prices is presented below. Meijerink et al. (2011) provide a more elaborate discussion.

Rosegrant et al. (2008) and Mitchell (2008) argue that biofuels have been a major contributor to an upward price movement on the international grain markets in the 2000s. Expanded production of ethanol from maize, in particular, has increased total demand for maize and shifted land area away from production of maize for food and feed, stimulating increased prices for maize. Rising maize prices, in turn, have affected other grains. On the demand side, higher prices for maize have caused food consumers to shift from maize (which is still a significant staple food crop in much of the developing world) to rice and wheat. On the supply side, higher maize prices motivated some farmers to shift from rice, soybeans, and/or wheat cultivation to maize cultivation, which creates upward pressure for the food crops that are in lower supply as a result of this shift. Rosegrant et al. (2008) quantify the food price effects of biofuel policies by comparing a simulation of actual demand for food crops as biofuel feedstock through 2007 and a scenario simulating biofuel growth at the rate of 1990–2000 before the rapid takeoff in demand for bioethanol. The increased biofuel demand during the period, compared with previous historical rates of growth, is estimated to have accounted for 30 % of the increase in weighted average grain prices, with the biggest impact on maize prices (+ 39 %). Yet, several studies challenge the perception of biofuel policies having such a big impact on agricultural market balances and long-term price developments. Baffes and Haniotis (2010) point at the fact that worldwide biofuels account only for about 1.5 % of the area under gains/oilseeds.

The contribution of biofuel policies to the recent food price hikes has been the subject of intensive debate. Biofuel policies were particularly challenged as a factor contributing to the 2007–2008 hikes. There were several claims that biofuels raised the pressure on agricultural markets up to the point where failed harvests and sudden policy responses (e.g., export restrictions, lowering of import tariffs) could create large price movements. The common argumentation relates to the lack of flexibility in biofuels demand. Indeed, the blending mandates for biofuels introduced a rigid demand for biofuel feedstock: without the mandates, rising feedstock prices would result in lower use of biofuels. Arguments to the opposite have also been made; Wright (2011), DEFRA (2012), and Helming (2010) have proposed flexibility in delivery contracts for feedstock in biofuel supply chains as an instrument that contributes to stabilizing food prices. In time of tight food supply, market agents would be executing a call option on feedstock to divert supplies into the food market.

During the 2007–2008 food price hikes, prices of the biofuel substitutes—in particular, fossil oil—were rising at the same time. This leads to the fact that price rises in energy markets have a strong influence on food prices via rising input costs of farming. There is more to say about the strengthened links between energy and food markets. Baffes and Haniotis (2010) explain that there is a level at which energy prices provide a floor to agricultural prices: possibly, crude oil prices above US$ 50 per barrel effectively dictate maize prices. The argument is based on the strong correlation between maize and crude oil prices above that price level and the lack of such a correlation below that price level. Baffes and Haniotis examine the energy/nonenergy link, investigating among others six food commodities, and find that energy prices explain a considerable part of the commodity price variability. They conclude that prices of food commodities respond strongly to energy prices, with the responses further strengthening in periods of high prices. Next, the authors find that food commodity prices respond to energy prices by moving in a very synchronous manner, indicating that analyzing food markets requires an understanding of energy markets as well. The authors also conclude that agricultural commodity market fundamentals appear, in the short term, to be playing somewhat a lesser role than in the past, tending to be overshadowed by the much stronger pull of energy prices.

While increasing biofuels demand added to the tightening of feedstock and food markets, the transitions to full-blown food price crisis had more to do with sudden policy responses than with gradual market movements. Gilbert and Morgan (2010), for instance, found little direct evidence that demand for grains and oilseeds as biofuel feedstock was the cause of the 2007–2008 price spike. Interestingly, the energy–food nexus also sheds new light on the causes of price volatility. Hertel and Beckman (2011) examine how energy price volatility has been transmitted to commodity prices. They find that biofuels have played an important role in facilitating increased integration between energy and agricultural markets. Hertel and Beckman show that over the period 2001–2009 the correlation between monthly oil and corn prices was much stronger with oil prices exceeding US$ 75 per barrel. In that price range, US biofuel policy appears to be nonbinding: more ethanol is being produced than required according to the policy targets as ethanol production (from maize) is competitive with petroleum. In the absence of binding biofuel policy targets, by 2015, the contribution of energy price volatility to year-on-year corn price variation will be much greater—amounting to nearly two thirds of the crop supply-induced volatility. However, if the US biofuel policy targets are binding in 2015, then the role of energy price volatility in crop price volatility is diminished.

The discussion has addressed the impact of biofuels on food prices, which determines the price and is therefore a central factor in the accessibility of food to poor consumers. There is also a possible relation to be explored beyond food prices in relation to overall inflation. In countries that depend heavily on imported fossil fuels, oil price rises will give upward pressure on inflation rates—as indicated by rising consumer prices index (CPI). The development of a substantial domestic biofuels supply will, under such conditions, help to ease price inflation pressures. In theory, this may help to stabilize consumer purchasing power and the stability of access to food of poor consumers.

6.2.3 Biofuel Markets Provide a Potential Source of Income Opportunities for Farmers Operating at Different Scales

Limited attention has been given to bioenergy's marked potential to promote rural development, which some claim is particularly undeserved in relation to Africa. Lynd and Woods (2011), for example, argue that biofuel production could offer great opportunities to African farmers, especially pointing at the option to produce bioenergy from inedible plants (e.g., *Jatropha*) that grow on marginal land that is not well suited for growing food or from grass or *Agave* fiber. Producing these crops for bioenergy production on degraded soils or on particularly dry land would not compete for land for food production and would offer rural Africa huge opportunities to benefit from the bioenergy market developments. The authors emphasize, however, that the impact of bioenergy on income generation and therefore food (in-) security also depends on the technology employed (for biofuel production from agricultural commodity) and how the bioenergy supply chain is integrated into agricultural, social, and economic systems. To date, modern bioenergy supply chains are practically lacking in Africa; there are no bioenergy clusters established like in Brazil where, according to the authors, biomass production has been lifting 10 % of the Brazilian population out of poverty during the last decade. The latter suggests a very positive impact of Brazil's ethanol industry on food security in the country.

Such a positive effect of bioenergy production on food security depends on whether smallholder farmers and laborers are included or not in the biomass supply chain. The processor may well exert a strong influence on the crop choice and the scale of operation used for production. Private investors could favor large scale production because they entail lower production costs. However, the risk is that the smallholders are excluded from the supply chain or a fair share of value creation as they cannot provide the processing facilities with large quantities and/or are unable to invest in productivity growth.

Experience in Mozambique has revealed the difficulty of smallholders to benefit from bioenergy production. The country's biophysical potential exists with the long-term presence of sugarcane plantation in different parts of the country, while according to the national biofuels policy and strategy the exploitation of agro-energetic resources should contribute to the well-being of the population and promote socio-economic development particularly in rural areas. In practice, though, these objectives have not been achieved. Schut (2010) conclude that only few projects are located in remote rural areas while "biofuel developments mainly take place in areas near good infrastructure where there is skilled labour available and access to services and goods, processing and storage facilities" (p. 5164). Job creation is lower than expected although the industry is contributing to the generation of income, employment, and more indirect local spin-offs. The authors state that from promoting the biofuel production by smallholders for domestic purposes, the sector is currently dominated by foreign commercial investors whose main intention is supplying external markets (Schut et al. 2010). The results of this study suggest that without strong government incentives to include smallholders, economic factors drive investment location decisions that determine the direction of the biofuel developments. Policy measures that could enhance the position of the rural population are among others to build infrastructure (roads, ports) or to facilitate the establishment of farmer cooperatives that could aggregate their output and represent the interests of smallholders supplying the bioenergy industry.

6.2.4 Contributions to Macroeconomic Performance and Rising Living Standards

While promoting biofuel production may have strong distributional effects, biofuel developments may contribute to an overall improved macroeconomic performance and living standards. This is because biofuels production may generate growth linkages (i.e., multiplier or spillover effects) to the rest of the economy. For example, producing biofuels requires intermediate inputs, such as transport services to get the biofuels to consumers or export markets. In this case, expanding biofuels use generates additional demand for locally produced services, which may create new jobs and income opportunities for workers and households linked to the biofuels supply chain. Moreover, these new incomes will eventually be spent on consumer goods and services, which again generate additional demand for non-biofuel products.

Finally, there are macroeconomic linkages through which biofuels may stimulate economy-wide growth. For example, biofuels exports can relieve foreign exchange constraints, which often limit developing countries' ability to import the investment goods needed for the expansion of production in other sectors. Together, these economic linkages can generate gains that are far larger than those generated within the biofuels sector alone (FAO 2010).

This is also illustrated in Arndt (2010) in the case study on Mozambique, where the authors compare the economic impacts of a large-scale operation (sugarcane/ethanol) with a more pro-poor outgrower schemes (producing *Jatropha*/biodiesel). They find that large scale biofuel investments enhance growth and poverty reduction despite some displacement of food crops by biofuels. Benefits depend on production technology. An outgrower approach to producing biofuels is more pro-poor, due to the greater use of unskilled labor and accrual of land rents to smallholders, compared with the more capital-intensive plantation approach. Moreover, the benefits of outgrower schemes are enhanced if they result in technology spillovers to other crops. These results indicate that a carefully designed and managed biofuel policy holds the potential for substantial gains.

6.3 Methodology for an Economy-Wide Assessment of Food Security and Biofuels

The pathways for food security impact of biofuels and biofuel policies cover price effects, income effects, and macroeconomic effects. Key underlying mechanisms relate to the allocation of available land of different qualities over its possible alternative uses, and to the impact of biofuels on the energy or fuel balance in the production country. In order to evaluate the full impacts and trade-offs of biofuels production on food security, a framework is needed that captures the direct and indirect or economy-wide linkages and constraints at the macro- and microeconomic levels (FAO 2010). The economic method specifically designed to capture these impact pathways is known as "computable general equilibrium" (CGE) modeling.

Table 6.1 Proxy indicators

Dimension of relation of biofuels to food security	Relevant indicators in an assessment
1. Food availability	Change in agricultural production Change in agricultural land use Change in agricultural land prices Food self-sufficiency ratio as the ratio of volumes of total food consumption over total domestic food production
2. Food prices	Change in agricultural prices, world market, and regional prices
3. Household income from farming and other labor	Change in non-skilled wages Change in agricultural value added as proxy for farm income Change in food-basket purchasing power[a] Change in per capita food consumption in different regions
4. Macroeconomic performance	Development of percent share of biofuels in fuel consumption for transportation Trade balance in feedstock for biofuels Welfare change

[a] Composite indicator of weighted price and wage effects

A particular strength of CGE modeling is its scope for a consistent analysis across related economic systems that share or compete for resources such as land and investment capital. For biofuels and food security analysis, the interaction between the food and energy systems is pivotal. Global CGE analysis will allow analysis of energy and food price developments worldwide, which is important when comparing market interventions that will have implications for the global biofuel or agricultural markets. In contrast, a CGE analysis at the country level will allow a more in-depth examination of the cross-sector repercussions of demand and supply changes in biofuels, with often more attention on the distributional impact.

Table 6.1 provides a set of relevant indicators of food security for biofuel-related impact pathways, for use in applied equilibrium analysis. Typically, these are proxy indicators for food security outcomes at national and household level. The indicator set will also capture key mechanisms that determine food security outcomes, and builds upon the four pathways identified in Sect. 6.2. Whereas these types of indicators provide useful indications for ex ante policy analysis, when used as a basis for policy recommendations, such indicators should be interpreted in relation to observed data. In the following section, an example of an application of these indicators in an empirical framework is presented. This is followed by a discussion on the limitations of the type of analysis.

One major limitation that should be addressed up front is the lack of coverage of indicators on the stability of food security outcomes at the household or individual level. The main determinants of the risk of falling into a state of hunger and malnutrition are (excessive) price swings and fluctuations in income. Typically, these volatilities are not well addressed in the proposed framework, which has its strength in assessing developments and policy options over a time span of one or more decades. To put it simply, the strand of CGE modeling needed to assess the long term effects of biofuels on income and food prices, is of little use in assessing the fluctuations around a trend. Therefore, additional analytical frameworks are required to assess the relation between price and income volatility and food security. Such frameworks will, for the purpose of assessing the impact of biofuel developments on food security, need to advance well beyond the current state of the art in two areas: first, in disentangling the relative contribution of biofuels to (excessive) food price volatility from the other drivers (see the discussion above); second, in relating price and income fluctuations to food security and nutrition outcomes. The recent Global Monitoring Report provides an excellent overview of the state of affairs in this area (World Bank 2012).

6.4 Towards Quantifying the Impacts of Biofuel Policies on Food Security

In this section we indicate the potential results from an empirical application of the framework towards a biofuel policy. We use the MAGNET model (Modular Applied GeNeral Equilibrium Tool), an economic simulation model of the world economy. We make use of a baseline and a global biofuel scenario, both developed under an FP7 project.[1] Biofuel mandates in the transport fuel sector serve as a proxy for all biofuel policies. The methodology builds upon the approach developed in Banse et al. (2008, 2011) and Tabeau et al. (2011), in which biofuel demand is determined in the model by the relative prices of crude oil versus ethanol and biodiesel, including taxes and subsidies.

The bars in Fig. 6.2 indicate the biofuel ambitions across several countries, as reflected in law or energy policy. It reveals a widespread drive towards higher mandatory shares in transport fuel towards 2020. Based on projections of future use in transport fuel, the target shares have been computed into an absolute change in biofuel use. Apart from heavy expansion in US and China, the biofuel ambitions for 2020 as intended in China, India but also in Indonesia and Argentina, can be qualified as very challenging to realize because of the low initial levels (2007 data).

Under various documented assumptions, MAGNET solves the allocation issues that result from these biofuel ambitions (see Achterbosch et al. (2012) for a complete description). Latin America and Asia (e.g., Indonesia) and, surprisingly, Central Africa will become suppliers to the import regions for feedstock. The exporters are the major economic beneficiaries of heavier biofuel use. Land expansion at world level for producing agricultural feedstock is projected at 46 million hectares, mainly in Brazil and US. The biofuel targets lead to a modest 0.7 % increase in total agricultural production, as biofuel related crops are only a small share of total agricultural and food production. The volume of grain crops, especially maize, sugar,

[1] http://www3.lei.wur.nl/tapsim/.

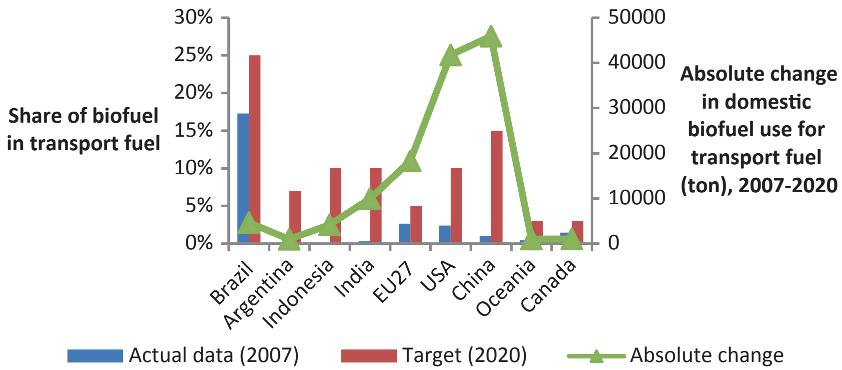

Fig. 6.2 Share of biofuels in fuel consumption for transportation for selected regions in 2020

and oilseed, expands in several regions; a slight substitution of food crops for an energy crop is suggested by the results.

Turning to the price dimension of food access, the backdrop for our analysis is that real world prices for food and agricultural products fall at an annual rate of 0.5% over the projection period in the baseline. As land is a relatively scarce resource, the extra land required to increase crop production for biofuels comes at a higher price. The higher crop price is transmitted to food prices either through direct input costs (e.g., grain) or through indirect input costs (e.g., feed grain costs that affect the price of meat). The impact on total agricultural prices is considered limited as biomass for biofuels is still a small share in total agricultural output. Under the ambitious biofuel policies, feedstock prices of grains, sugar, and oilseeds are estimated to increase all with about 3% in 2020 compared to the baseline. The prices of the by-products Distillers Dried Grains with Solubles (DDGS) and oilseed press cake decrease by about 15 and 10%, respectively. The crude oil price decreases slightly with about 2% as demand for crude oil decreases as it is substituted by biomass. The price increases are lower than in e.g., Banse et al. (2008 or 2012).[2]

Next to food prices, the other dimension on the consumption side is household income, which determines the room for expenditures. Poor consumers in developing countries spend 60% of their income or more on food expenditures. As poor and vulnerable households live on small surpluses and have few assets to cushion crisis situations, small income declines could mean a substantial marginalization of people's livelihood.

Farm incomes are important as driver of food security in the rural areas because most farmers produce insufficient amounts of food to sustain the food needs in the household. Biofuel ambitions provide a substantial impetus to farm income. The estimated increase in farm income in the biofuel crops (cereals, oilseeds, sugar) is about

[2] The main explanation is that we ran the model with a high elasticity of substitution between crude oil-based petrol on the one hand and biodiesel\ethanol on the other hand. See Achterbosch et al. (2012) for further explanation.

12 % for the major feedstock producing countries. In Africa farmers across the board, whether or not they produce biofuel crops, see incomes climb due to rising world agricultural prices. Rural wages also rise. Results suggest that overall the increased use of biofuels leads to small reductions in food consumption in countries that push biofuel use. The price effect outweighs the income effects in some regions. For North and Central Africa the results suggest reductions of 0.3 and 0.5 %, respectively. For Tanzania and South Africa, the effects are small but surprisingly positive. Key is that these regions are net exporters of agricultural products and importers of crude oil. The terms of trade improve and therefore the income in these countries increases.

6.5 Conclusion

The relations between first generation biofuels and food security require careful examination, which take into account the idiosyncratic conditions surrounding a planned investment or policy that aims to advance the use of biofuels. From an economic perspective, there are at least four possible impact pathways that connect biofuels to their impact on food security. The pathways relate to land competition, impact on short and long term developments in food prices, impact on farm income, and macroeconomic performance. Based on a limited qualitative assessment of these individual pathways, it is concluded that the direction of impacts on food security is not a priori clear. A basic framework is introduced for an encompassing analysis, and applied to a set of targets for biofuel share in fuel use for the purpose of illustrating the mechanisms at play. A preliminary conclusion from the exercise is that the level of biofuel ambition alone provides insufficient grounds to analyze their impact; the socio-economic setting (e.g., a policy framework aimed more at global trade integration or self-sufficiency in the region) that forms the backdrop for a biofuel policy is a key determinant of the impact of the biofuel policy on agricultural markets and global food security.

An illustrative analysis using a global modeling framework project shows that a global biofuel policy could contribute to upward pressure on land and food prices in several developing regions. While global price and land use effects appear to preclude a negative evaluation on food security, there are several positive in-country effects that call for further specification and analysis.

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Chapter 7
Socio-Economic Impacts of Sweet Sorghum Value Chains in Temperate and Tropical Regions

Dominik Rutz, Rainer Janssen and Cosette Khawaja

Abstract Sweet sorghum is raising considerable interest as a feedstock of either fermentable free sugars or lignocellulosic feedstock with the potential to produce fuel, food, feed, and a variety of other products. Sweet sorghum is a C4 plant with many potential advantages, including high water, nitrogen, and light efficiency, broad agroecological adaptation, as well as a rich genetic diversity for useful traits. For developing countries, sweet sorghum provides opportunities for the simultaneous production of food and bioenergy (e.g., bio-ethanol), thereby contributing to improved food security as well as increased access to affordable and renewable energy sources. In temperate and usually more industrialized regions (e.g., in Europe), sweet sorghum is seen as promising crop for the production of raw material for second-generation fuels or for biogas. This chapter describes some general aspect of sweet sorghum value chains and assesses its socio-economic impacts, including opportunities, risks, and challenges.

Keywords Sweet sorghum · SWOT · Temperate regions · Tropical regions · Ethanol · Biogas

7.1 Introduction

Sweet sorghum (Fig. 7.1) is a promising feedstock plant for different carbon-based renewable energy fuels and materials. Its high contents of fermentable free sugars allow good fermentation processes for ethanol production. Its high biomass productivity makes sweet sorghum a good and land-efficient energy crop that also provides

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Fig. 7.1 Panicle of sweet sorghum. (Source: D. Rutz, WIP)

digestible feedstock for biogas production or lignocellulosic material for second generation biofuels. Sweet sorghum is considered one of the most efficient crops to convert atmospheric CO_2 into sugar with large advantages compared to sugarcane production in some areas of the tropics, making it a promising crop for bioenergy while meeting food and feed needs.

However, despite of these promising characteristics, sweet sorghum is not yet widely cultivated for the production of biofuels. Much less research and breeding activities were implemented on this crop in comparison to other food and energy crops, such as corn or sugarcane. In consequence, the European Commission supported the project SWEETFUEL (Sweet Sorghum: An alternative energy crop) in the 7th Framework Programme to exploit the advantages of sweet sorghum as potential energy crop for bio-ethanol production (Braconnier et al. 2011; Janssen et al. 2010). Thereby, the main objective of SWEETFUEL is to optimize sweet sorghum varieties for different climatic and agroecological regions.

In the framework of this project, a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis was conducted (Rutz and Janssen 2012a) in order to get an overview of the advantages and disadvantages of different sweet sorghum and biomass sorghum value chains. The present chapter is based on these findings and summarizes the main results with regards to the socio-economic impacts of sweet sorghum value chains.

7.2 Sweet Sorghum as an Energy Crop

Sweet sorghum (*Sorghum bicolor* L. Moench) is a grass of the genus *Sorghum*, classified in the family of the *Poaceae*. Sorghum species are among the oldest cultivated crops in the agricultural history. It is believed that it originated from Africa. Wild varieties in the genus sorghum were observed in the northeastern regions of Africa, including Ethiopia and Sudan (Doggett 1988; Khawaja et al. 2013).

Sweet sorghum is similar to grain sorghum, but accumulates high amounts of sugar in the stems that can be used for a variety of uses such as food, fodder, fuel, and fiber.

Today, in addition to its cultivation for energy production, sweet sorghum is still a main food source especially in Asia and Africa and a feed source in developed and developing countries. Sweet sorghum is also valued for the production of commercial products such as alcohol (potable and industrial grade), syrups (natural and high fructose), glucose (liquid and powder), modified starches, maltodextrins, jaggery, sorbitol, and citric acid (downstream products from starch) (CFC-ICRISAT 2004; Khawaja et al. 2013). In addition, due to its fiber content, sweet sorghum can be used for bedding, roofing, fencing, paper, and chewing.

Sweet sorghum is an annual grass that is planted by seeds and can be cultivated in a wide range of climatic conditions, ranging from temperate to tropical regions. It is a C4 plant with many potential advantages, including high water, nitrogen and radiation use efficiency, broad agroecological adaptation as well as a rich genetic diversity for useful traits. A brief introduction in the agricultural characteristics of sweet sorghum is given in Box 7.1 (Rutz and Janssen 2012a). It can be intercropped with various other crops, such as jatropha (Fig. 7.2), pigeon pea, sweet potato, etc.

Box 7.1 Selected Characteristics of Sweet Sorghum

- Sorghum and especially sweet sorghum can grow in a broad environmental range from tropical to temperate regions. Sweet sorghum could be a promising energy crop in both developed and developing countries as well as for small and large scale value chains. As energy crop, it can be cultivated and further processed at very different scales; thus, smallholders but also industry could benefit.
- In tropical regions, sweet sorghum is permitting multiple breeding generations per year due to a short growth cycle of 3–4 months. In tropical and

Fig. 7.2 Intercropping of sweet sorghum with Jatropha in Mali. (Source: D. Rutz, WIP)

subtropical climates, sweet sorghum is very suitable to be integrated with sugarcane cultivation. This leads to strong interest of sugarcane producers (e.g., in Argentina, Colombia) in sweet sorghum cultivation.

- In temperate regions, usually only one harvest is possible, but the total biomass yield is high and it contributes to diversify the crop rotation.
- The high genetic variability of the genus Sorghum provides good breeding opportunities in order to create new improved varieties. The genetics of sorghum are relatively well known.
- Sweet sorghum is characterized by high water, radiation and nutrient use efficiency in comparison to other energy crops (e.g., maize, sugarcane). It is furthermore suitable for the cultivation on degraded soils, thus reducing potential land use change impacts. However, yields are usually lower on degraded or marginal soils.
- As an efficient C4 plant, sweet sorghum is one of the most efficient crops to convert atmospheric CO_2 into sugar and starch.
- All aboveground parts of the plant (stalk, leafs, grain) are valuable products. Since the potential use of sweet sorghum is very broad, it can be used for the production of food (sugar, grains), first and second generation ethanol, biomaterials, electricity from bagasse combustion, thermochemical biofuels and products, biogas, feed, and fodder.
- Bagasse and leaves can be used as fuel for process energy and power generation. It can be also used as fodder, which is an opportunity for subsistence agriculture of small-scale farmers.

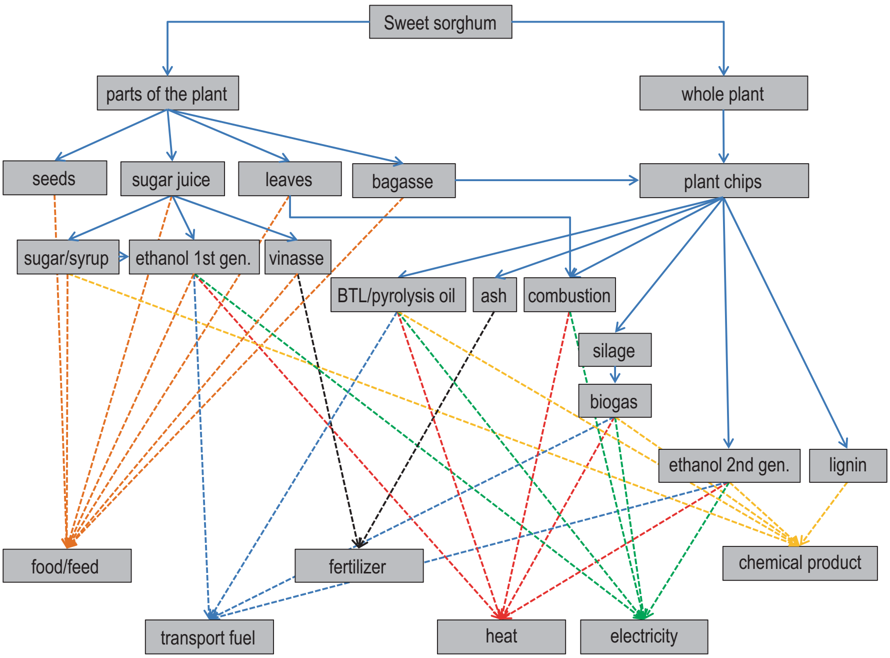

Fig. 7.3 Overview of products that can be derived from sweet sorghum

7.3 Scale of Sweet Sorghum Cultivation and Conversion Scenarios

Sweet sorghum is a promising energy crop in both developed and developing countries. It is suitable for small and large scale cultivation and value chains. The general value chain of sweet sorghum production systems is similar to other bioenergy/biomass production systems:

- Crop cultivation
- Harvesting
- Transport
- Milling (only for ethanol production)
- Processing to the fuel
- Direct use or further transport
- End use

The value chain is characterized by the conversion process and the main and co-products. An overview of the various products that can be derived from sweet sorghum is shown in Fig. 7.3.

The conversion technology and the desired products influence the scale of the production system. Thereby, a differentiation between the conversion steps must be made, as the scale is not necessarily the same for the different value chain steps. However, the border between large- and small-scale is fluent. In general small-scale systems describe value chains that involve many individual farmers that provide feedstock for a small ethanol plant, e.g., operated by the farmer's cooperative. A large-scale system is characterized by the involvement of large investors, feedstock cultivation on modern agro-industrial scale, often done by the ethanol plant company itself. Ethanol produced by large-scale systems is often sold on international commodity markets.

The scale of the value chain steps and production systems is important as this largely influences the socio-economic impacts of the system (Rutz and Janssen 2012b, c). Depending on the perspective of the value chain actors, this includes positive and negative impacts.

Finally, the application of conversion technologies is influenced by the climatic conditions under which sweet sorghum is cultivated, as well as by the status of development of the country.

In tropical climates, the sugar productivity of sweet sorghum is very high and thus, small- to large-scale first generation ethanol production systems are suitable. In temperate regions, the sugar content is less, but the productivity of the biomass is high, so that sweet sorghum is currently used for biogas production. The production of second generation biofuels is still not realized at a fully commercial scale today. In general, production of second generation biofuels is more suitable for temperate regions under the current framework conditions due to the high investment needs.

Generally, the following parameters characterize the agricultural and conversion systems of the sweet sorghum ethanol chain and have a large impact on sustainability issues:

- **Scale of the system:** small-, medium-, large-scale
- **Actors of the cultivation system:** farmers, industrial farming
- **Actors of the production system:** villagers, centralized ethanol plant
- **Business relationships between the actors:** outgrower model, cooperatives, contracted workers
- **Economy of the country:** emerging country, developing country

7.3.1 Tropical Production Systems

The sustainability of the cultivation and conversion of sweet sorghum in subtropical and tropical climate is affected by various factors. Since many potential cultivation areas of these climatic regions are either in developing or emerging countries, socio-economic impacts, negative or positive, are of very high importance. Thereby, "tropical regions" and "developing countries" are no synonyms, of course, but these climatic regions are especially prone to impacts of climate change which may affect the poorest people, namely small-scale and subsistence farmers in developing countries.

A focus of the sweet sorghum value chains in subtropical and tropical climates for energy production is on the production of first generation ethanol. The following list shows production scenarios for first generation ethanol:

- Small-scale feedstock production for a large-scale ethanol plant
- Small-scale feedstock and syrup production for a large-scale ethanol plant
- Small-scale feedstock, syrup, and ethanol production
- Large-scale feedstock production for a large-scale ethanol plant

7.3.2 Temperate Production Systems

The production systems in temperate regions are different to those in tropical regions, as the sugar content of the crop is lower and often too low for sugar extraction and processing to first generation ethanol.

However, it is a good feedstock for biogas production as the high content of sugars, compared to other crops, makes it very digestible. The methane (CH_4) yield of sorghum is assumed at 80 m³/t of fresh feedstock, as stated in German legislation (BMU 2012; Rutz et al. 2012). In comparison, the methane yield of corn silage (whole crop) is 106 m³/t and of sugar beet 75 m³/t of fresh feedstock. Therefore, sweet sorghum is an increasingly applied feedstock plant for biogas, for instance in Germany. For biogas production, the sweet sorghum biomass is chipped during the harvest and then stored as silage until its use. The silage is fed into the digester and during the anaerobic digestion (AD) process, biogas is produced which is used for combined heat and power (CHP) production. Alternatively, the biogas can be further upgraded to biomethane and injected as natural gas substitute into the natural gas grid or used directly as transport fuel replacing conventional gasoline and natural gas. In all AD processes, digestate is produced as by-product and used as fertilizer substituting mineral fertilizer. Typical sizes of biogas plants in Europe have a capacity of about 450 kW_{el}. In agricultural biogas plants, the farmer is often the feedstock producer as well as the operator and owner of the plant.

A future option would be to use sweet sorghum for second generation biofuels for either for thermo-chemical or biological conversion. However, this is not yet commercially applied. Therefore, it is challenging to discuss about its socio-economic impacts, especially as production costs are difficult to predict.

In the second generation ethanol process, the biomass is crushed and pre-treated in order to render the cellulose accessible for a subsequent hydrolysis step. After the hydrolysis of the cellulose for breaking down the long chains into sugars, the substrate is fermented. The ethanol is used as transport fuel replacing conventional gasoline. Vinasse is obtained as by-product and can be either used as feed replacing soy meal or as fertilizer replacing mineral fertilizer. Surplus electricity from the process can be fed into the power grid. The use of sweet sorghum for second generation ethanol production is still not applied at commercial scale today. A general good overview on second-generation biofuels facilities is given, e.g., by IEA Task 39 (2013) and Janssen et al. (2013) (Fig. 7.4).

Fig. 7.4 Typical agricultural biogas plant in Germany using energy crops (corn) and other substrates as feedstock material. (Source: D. Rutz, WIP)

7.4 Socio-Economic Impacts

This chapter addresses selected socio-economic impacts of sweet sorghum value chains. The main focus is thereby on different scales of first generation ethanol production systems in tropical regions of developing countries, as well as on biogas and second generation bioethanol systems in temperate regions of developed countries.

7.4.1 Land Use

Land use is the human use of land which involves the management and modification of natural environment or wilderness into built environment such as fields, pastures, and settlements (Watson et al. 2000). Land use change (LUC) is the change from one use to another use. Often, land use change is also referred to the change of non-used land (virgin land, abandoned land, degraded land) to another use. Thereby distinction is made between direct land use change and indirect land use change (see also Rutz and Janssen 2013, Chap. 5 of this book). Insecurity of land ownership and tenure rights are an important aspect for rural and indigenous communities, especially in developing countries (Mwakasonda and Farioli 2012).

A major advantage of sweet sorghum compared to other crops is that it can grow under harsher conditions. It can still be well cultivated on marginal soils with a wide range of pH, salinity, and soil structure that are unsuitable for food production, although the productivity may be reduced on these lands. Selected land use impacts of sweet sorghum value chains in tropical and temperate regions are presented in Tables 7.1 and 7.2.

Table 7.1 Land-use impacts of sweet sorghum use in large- and small-scale first-generation ethanol production systems in tropical regions

Large-scale cultivation and large-scale conversion	Small-scale cultivation and large-scale conversion	Small-scale cultivation and small-scale conversion
If centralized ethanol plants set-up own large-scale sweet sorghum plantations in developing countries, this may happen by negatively affecting the poor (land grabbing). There is a risk of displacement and marginalization of local communities and smallholders There is a higher risk that sweet sorghum is cultivated in monocultures with negative environmental (e.g., soil fertility, soil compaction, deforestation) and socio-economic (ecosystem services) impacts The land use competition may be high, as larger plants usually select good quality agricultural land The land use efficiency (t per ha) and overall process efficiency of these systems may be higher	Existing agricultural structures and sizes of farms can be maintained. Due to the smaller structures of these systems, the (bio)diversity and ecosystem services may be larger The land use efficiency of these systems may be lower than for large-scale cultivation, but larger ethanol facilities may support smaller farmers, e.g., through training or agricultural equipment	Existing agricultural structures and sizes of farms can be maintained. Due to the smaller structures of these systems, the (bio)diversity and ecosystem services may be larger The land use efficiency of these systems is generally lower due to lack of resources and knowledge. This may be partly compensated if good cooperative structures exist Sweet sorghum cultivation systems can be easily integrated into existing small-scale agricultural structures without negatively affecting small farmers and villagers (no land grabbing) Villagers are themselves responsible for suitable land use and production practices. They are not forced by large companies to adapt to their rules

Table 7.2 Land-use impacts of sweet sorghum use in biogas and second-generation biofuels production facilities in temperate regions

Biogas production	Second-generation biofuels
Sweet sorghum is generally a good alternative to other crops for biogas production, especially as an alternative to corn in drier areas. Thus, it broadens crop alternatives and crop rotation. However, increased energy crop production for biogas has led in some areas to increased prices for land rental.	Sweet sorghum is an annual crop. Thus, for second-generation biofuels production, woody crops or residues may be preferred, as impacts on land use are usually lower for woody crops than for annual crops.

7.4.2 Job Creation, Health and Working Conditions

In general, the production of biofuels generates more employment opportunities and jobs than the production of fossil fuels, as the processing takes place on a smaller scale and involves more stakeholders. This also applies to the use of sweet sorghum for bioenergy production.

Table 7.3 Impacts of large- and small-scale first-generation ethanol production systems from sweet sorghum on job creation, health, and working conditions in tropical regions

Large-scale cultivation and large-scale conversion	Small-scale cultivation and large-scale conversion	Small-scale cultivation and small-scale conversion
In centralized systems (with mechanical harvesting technologies), fewer workers may be needed; thus, less job opportunities are created Mechanical harvesting avoids hard and dangerous work Larger companies must on the one hand comply with stricter rules on health and on working conditions, this is however, on the other hand, often not implemented, especially in developing countries	In the crop cultivation step, more workers are needed than in the large-scale system In the conversion step, only slightly more workers are needed (due to more administration to deal with many smallholders)	Due to general lower mechanization rates of the conversion process, more employment is generated per litre ethanol than in larger systems Ethanol production at small-scale level not only creates direct employment in the value chain, but also indirect employment through related microenterprises Smaller farmers can influence their working conditions

The example of an ethanol plant using sweet sorghum in Uganda shows that up to 250 jobs were expected to be created in Kayunga District for the operation of an ethanol plant with 20 million litres ethanol output per year (Muzaale 2011: Uganda Investment Forum 2013). However, it has to be recognized that these are expected figures; real data are not available to the authors. In addition to the direct workers at the facility, sweet sorghum seeds have been given to 6,000 farmers in order to plant sweet sorghum (Muzaale 2011).

Besides the potential to generate jobs, health issues and working conditions must be considered, especially in developing countries. However, this applies to any business, independently if biofuels or other sectors are considered. It is, in general, not expected that the cultivation and processing of sweet sorghum has larger negative impacts on health issues and working conditions than the cultivation and processing of other crops. In comparison to manual harvesting of sugarcane, sweet sorghum has several advantages, as it is not burned before harvest. Furthermore, the crop is easier to handle during the harvest.

Selected impacts of sweet sorghum on job creation, health, and working conditions in tropical and temperate regions are presented in Tables 7.3 and 7.4.

7.4.3 Profits for Farmers, Plant Operators, and End Consumers

Economic facts of sweet sorghum value chains depend on many factors. A distinction must be made between the profits and benefits for the involved farmers and plant operators and benefits for the end consumers. Economic data are especially available for ethanol production from sweet sorghum in the US (Amosson et al. 2011; Morris et al. 2009). A comparison of the risk and benefits between the alternative plant sizes and locations in the US are provided by Lau et al. (2006).

Table 7.4 Impacts of biogas and second-generation biofuels production from sweet sorghum on job creation, health, and working conditions in temperate regions

Biogas production	Second-generation biofuels
The cultivation of sweet sorghum for biogas production has not per se any impacts on jobs creation in comparison to other crops for biogas production. However, due to the smaller scale of biogas systems, in comparison to second-generation biofuels systems, biogas production generates generally more job opportunities compared to second-generation biofuels Rules on health safety and working conditions are usually implemented in most developed countries	As the whole value chain is on a very large scale, fewer jobs may be generated than in smaller systems Rules on health safety and working conditions are usually implemented in most developed countries

Table 7.5 Impacts on profits of sweet sorghum in large- and small-scale first-generation ethanol production systems in tropical regions

Large-scale cultivation and large-scale conversion	Small-scale cultivation and large-scale conversion	Small-scale cultivation and small-scale conversion
Since smallholders are not involved, there is no revenue generation for local farmers unless contract agriculture can be established The revenues for the plant operators are generally larger in larger plants Due to the higher efficiency and economies of scale, the quality of the products may be better and the prices of the end product lower	Depending on the contracts, small-farmers may have the security that the plant operator buys their feedstock, thus generating a stable income However, the sale of the stalks depends on the centralized ethanol plant which is buying the stalks. If only few local mills exist, farmers have no influence on the stalk prices and are thus vulnerable	A longer value chain for ethanol production on smaller scale generates more local revenues in comparison to the sale of stalks or syrup, only Small-scale farmers can themselves decide if ethanol is sold to external markets or also used for local consumption, e.g., for cooking. Thus, access to modern energy is increased

An economic evaluation for sweet sorghum in Zambia was made by Chagwiza and Fraser (2012).

Selected impacts on profit generation of sweet sorghum in tropical and temperate regions are presented in Tables 7.5 and 7.6.

7.4.4 Efficiency of the Whole Process

The efficiency of the value chain depends especially on the scale of the single production steps, as well as on climatic conditions and the agricultural and industrial practices. Overall efficiencies are comparable to ethanol from sugarcane or sugar beet, although they may be little lower (Vecchiet 2010).

Selected impacts on the efficiency of the value chains in tropical and temperate regions are presented in Tables 7.7 and 7.8.

Table 7.6 Impacts on profits of sweet sorghum in biogas and second-generation biofuels production facilities in temperate regions

Biogas production	Second-generation biofuels
Biogas plants are much smaller than second-generation biofuels plants. Thus, more people (farmers) profit from higher revenues, especially as usually the feedstock producer is at the same time the plant operator. However, the revenues depend on public support schemes. The use of sweet sorghum instead of other crops does not have a real impact on the profits	The profits are quite uncertain as no real commercial second-generation biofuels plant exists The use of sweet sorghum instead of other crops does not have a real impact on the profits

Table 7.7 Impacts on the efficiency of sweet sorghum value chains in large- and small-scale first-generation ethanol production systems in tropical regions

Large-scale cultivation and large-scale conversion	Small-scale cultivation and large-scale conversion	Small-scale cultivation and small-scale conversion
The large-scale cultivation and conversion of sweet sorghum increases the overall efficiency of the value chain. This is due to scale effects and due to the general higher investments. Furthermore, access to improved seeds, input materials, and technology is generally available. Harvesting can be done with efficient machinery The conversion process is usually efficient, especially for new and modern plants	Small-scale farmers can benefit from improved input material such as seeds, pesticides, fertilizers, etc. from the large-scale ethanol plant. This increases the overall efficiency of the agricultural production. As the ethanol production is on large-scale, the efficiency is generally higher However, small farmers may be vulnerable to dependencies on improved seeds provided by the large-scale ethanol plant The large-scale ethanol plant may also provide training for the farmers	Farmers are often not trained in best agricultural practices to increase yields. If not properly trained, e.g., on the application of pesticides, negative environmental and human health impacts may occur and efficiency is reduced. Furthermore, access to improved sweet sorghum varieties may be limited for small-scale farmers Small farmers are vulnerable to dependencies on improved seeds (e.g., hybrid and GMO seeds) Sweet sorghum cultivation and ethanol production on small-scale is usually less efficient than on larger scales

GMO genetically modified

Table 7.8 Impacts on the efficiency of sweet sorghum value chains in biogas and second-generation biofuels production facilities in temperate regions

Biogas production	Second-generation biofuels
Land-use efficiency of biogas (biomethane) from sweet sorghum is higher than of other first-generation biofuels (e.g., biodiesel from rapeseed or ethanol from sugar beet), especially in the transport sector If biogas is used in a CHP unit to produce electricity, the “waste heat” should be also used. This is currently a bottleneck in several European biogas plants	Real data on the efficiency of second-generation biofuels are hardly available, especially if sweet sorghum is considered as feedstock

CHP combined heat and power

Table 7.9 Contribution to rural development and national revenues of sweet sorghum value chains in large- and small-scale first-generation ethanol production systems in tropical regions

Large-scale cultivation and large-scale conversion	Small-scale cultivation and large-scale conversion	Small-scale cultivation and small-scale conversion
The contribution of a large-scale system to the rural development depends very much on the implementation of the system. The opportunity exists that investors of large-scale systems bring also investment for general infrastructure into the region However, there is the risk that revenues and income only goes to the investors, which are not settled in the vicinity of the plant, thus not generating any value for the region. This is even worse if investors are settled in other countries	At least a part of the revenues contribute to the rural development in the vicinity of the plant, as small-scale farmers earn from their feedstock sales	Most of the revenues stay within the vicinity of the small-scale system. On the other hand, especially in developing countries, there is often a lack of money available for investment in efficient value chains. Thus, the whole project may not be implemented due to lack of financial sources

Table 7.10 Contribution to rural development and national revenues of sweet sorghum value chains in biogas and second-generation biofuels production facilities in temperate regions

Biogas production	Second-generation biofuels
In several countries in temperate regions, biogas contributes to the rural development, as the farmers are often also the plant operators. There is, however, no difference of sweet sorghum in comparison to other energy crops such as corn.	The contribution of second-generation biofuels to rural development is difficult to estimate as fully commercial plants are not yet available. However, given the large size of the plants and the high feedstock demand, it is estimated that they will significantly contribute to the rural development in the vicinity of the plant.

7.4.5 Contribution to Rural Development and National Revenues

Today, it is commonly agreed upon that the production of biofuels such as bioethanol can potentially generate additional income for rural communities and thus contribute to generate national revenues in developed and developing countries. Sweet sorghum is a crop with versatile options for use, so that uses can be easily adapted to the needs especially of the rural poor in developing countries.

Tables 7.9 and 7.10 present selected impacts of sweet sorghum chains on the contribution to rural development and national revenues in tropical and temperate regions.

Fig. 7.5 Collection of firewood for cooking by a woman in Mali. (Source: D. Rutz, WIP)

7.4.6 Water Availability and Climate Change

In general, sweet sorghum is very water efficient and grows well under dryer conditions (Munyinda et al. 2012), in comparison with, e.g., sugarcane in tropical regions. In water-limited tropical and subtropical environments, sweet sorghum still grows well with precipitation of 600–1,000 mm/year rainfall. Sweet sorghum has thus especially positive characteristics for small-scale agricultural production systems where the installation of irrigation systems is not possible due to the lack of water or financing.

The water efficiency is also a benefit in temperate regions, as rainfall is becoming scarcer in summer in many regions due to climate change. In temperate climates, sweet sorghum has advantages over maize due to its low water requirements as well as lower nutrient (e.g., nitrogen) needs. However, sweet sorghum is sensible to cold temperatures and less productive than maize.

7.4.7 Substitution of Traditional Energy

The global demand for biofuels is continuously increasing (e.g., through mandates and targets) due to the need to substitute traditional energy. Traditional energy consists, on the one hand, of fossil fuels that are depleting and, on the other hand, of firewood that is used in climatic conditions where the trees are not regrowing (nonrenewable wood).

The use of sweet sorghum for ethanol production can substitute petrol and thus contribute to energy security, especially in the transport sector. Thereby, sweet sorghum is especially promising, as it can grow on soils and under climatic conditions where other (food) crops do not grow.

Firewood is mainly used for cooking in dry tropical and subtropical regions of developing countries. The problem is that firewood has to be collected from constantly larger distances, usually by women. Thus, in general, more time is needed for the provision of cooking energy (Fig. 7.5). Furthermore, the cutting of trees in these sensitive regions leads to desertification and loss of ecosystem services. Other

Fig. 7.6 Three-stone fire-place for cooking in Mali. (Source: D. Rutz, WIP)

negative impacts are indoor air pollution (Fig. 7.6), mainly affecting women and children. About 2.7 billion people burn biomass (wood, animal dung, crop waste) using open fires to cook and heat their homes (WHO 2013). Ethanol from sweet sorghum could be used in efficient stoves for these needs, and sweet sorghum can be even cultivated by these people. However, a major problem is often the lack of financial resources of these households to buy the stoves and the ethanol.

7.4.8 Food and Energy Security

In comparison with current sugar and starch crops for bio-ethanol production, sweet sorghum offers important benefits with respect to food security as it can serve as multiple purpose crop for food, feed, and fuel at the same time. Its seeds are valuable cereals and the leaves are high-value feed, thus contributing significantly to enhancing food supply and improving food security, especially in rural areas of developing countries that are prone to food insecurity. However, in larger systems, where sweet sorghum is harvested mechanically, usually only the stalks are removed from the fields, as the simultaneous harvest of stalks and grains is not yet mature. In addition to the grain used for human or animal consumption, sweet sorghum accumulates sugars with little competition between grain and sugar production. The bagasse can be used as animal feed and it is reported to have a better nutritional value than the bagasse of sugarcane (Almodares and Hadi 2009).

The production of bio-ethanol based on traditional food crops may lead to increases of agricultural commodity prices which negatively affect access to food, particularly in net food importing developing countries and for the poorest therein. Significant price increases have already occurred in major bio-ethanol feedstock markets such as corn and sugar.

According to FAO, food security is influenced by four main aspects: availability, access, stability, and utilisation (FAO 2007). Thereby, food availability can be threatened by bio-ethanol production through competition with food production

Table 7.11 Impacts on food security of sweet sorghum in large- and small-scale first-generation ethanol production systems in tropical regions on food and energy security

Large-scale cultivation and large-scale conversion	Small-scale cultivation and large-scale conversion	Small-scale cultivation and small-scale conversion
Large scale systems may contribute to regional development which penetrates to the poorest of the region and it could thus lead to increased food access On the other hand, if the local population is not benefitting from the large-scale production system, there is the risk that food access and also availability in the region is reduced	Farmers could generally also benefit from increasing food prices, as their income from sweet sorghum cultivation is higher. This applies only if the ethanol plant forwards the high prices to the farmers	The cultivation of sweet sorghum may increase the income of small farmers, thus leading to increased food access. Farmers could generally also benefit from increasing food prices, as their income from sweet sorghum cultivation is higher Sweet sorghum enriches the diversity of agricultural products of small farmers, thus reducing risks if only one or few crops are cultivated. Sweet sorghum is edible and can be used as multipurpose crop for own consumption, which is not possible for other (toxic) crops like jatropha

over land, water, and other productive resources. This resource competition concerns present sugar and starch feedstock and will be reduced for second-generation technologies based on lignocellulosic biomass. Access to food (the ability of households to buy food) is affected if food prices rise faster than real incomes, leading to food insecurity.

Finally, sweet sorghum can be associated with existing agricultural (e.g., sugarcane) systems, thereby increasing (energy, food, and feed) productivity and leading to a revitalization of agricultural production which is currently suffering from low investment and low productivity, especially in rural areas of developing countries (Janssen et al. 2009).

Some selected impacts of sweet sorghum in large- and small-scale first generation ethanol production systems in tropical regions on food and energy security are presented in Table 7.11.

7.4.9 Public Acceptance and Acceptance of the Involved Stakeholders

Public acceptance is a prerequisite for the development of biofuels. The public perception largely depends on cultural aspects, history and economy of the producing countries, objectives of importing countries, environmental and social targets, as well as on the positive or negative impacts on individuals and communities. The

Table 7.12 Public acceptance and acceptance of the involved stakeholders of sweet sorghum in large- and small-scale first-generation ethanol production systems in tropical regions

Large-scale cultivation and large-scale conversion	Small-scale cultivation and large-scale conversion	Small-scale cultivation and small-scale conversion
At the local level, the public acceptance of large-scale production systems depends largely on the associated benefits of the local people. If the project is accompanied by sustainable investments in infrastructure, the acceptance is higher At the international level, ethanol from sweet sorghum was not yet widely mentioned in the media, due to the currently low use of sweet sorghum for ethanol	The public acceptance mainly depends on the conditions offered by large ethanol plants to the farmers Manual harvesting of sorghum causes itching. Therefore, farmers often hesitate to cultivate sweet sorghum	The public acceptance of smaller systems is generally high, as long as the system is operational and as long as all involved stakeholders benefit from it The cultivation of sweet sorghum for ethanol production may be relatively new to many farmers, so that awareness campaigns and training is needed Manual harvesting of sorghum causes itching. Therefore, farmers often hesitate to cultivate sweet sorghum

Table 7.13 Public acceptance and acceptance of the involved stakeholders of sweet sorghum in biogas and second-generation biofuels production facilities in temperate regions

Biogas production	Second–generation biofuels
The extension of corn cultivation for biogas production (e.g., in Germany) has led to public protests in areas with high corn density. As sweet sorghum looks similar to corn, the public acceptance of sweet sorghum in these areas may be reduced, due to the negative perception on corn The acceptance of sweet sorghum as energy crop by farmers depends on their experiences with the crop. Especially in temperate regions, sweet sorghum is a relatively new crop for biogas production	If second generation will become commercial, people may wonder why sweet sorghum, an annual crop, should be used for the production of second–generation biofuels instead of woody plants and residues The use of bagasse from sweet sorghum would be good, but will be hardly available in temperate regions in the near future. It is not clear if sweet sorghum will be accepted by plant operators of second–generation biofuel plants, as experience is low. Especially for second–generation ethanol plants, it is difficult to switch from one feedstock to another, as the biological fermentation conditions have to be modified

use of sweet sorghum is so far not very much under public debate, as its use for bioenergy is still small.

Furthermore, besides the public acceptance, also the acceptance of the crop by biofuel market actors is needed. The use of sweet sorghum for bioenergy is still new and has little application in comparison to, e.g., soy, corn, and sugarcane. Thus, some farmers that had no experience with sweet sorghum so far may hesitate to cultivate this crop.

Selected impacts on the public acceptance and acceptance of the involved stakeholders of sweet sorghum value chains in tropical and temperate regions are presented in Tables 7.12 and 7.13.

Table 7.14 Impacts on investments of sweet sorghum in large- and small-scale first-generation ethanol production systems in tropical regions

Large-scale cultivation and large-scale conversion	Small-scale cultivation and large-scale conversion	Small-scale cultivation and small-scale conversion
Large facilities need large investments. Investors in developing countries that are interested in ethanol production are very limited If investors from foreign countries intend to invest in large-scale ethanol systems, they are likely to be named as "landgrabbers." The political instability and lack of suitable infrastructure often makes investments risky	Models exist where the ethanol plant operator provides resources for an efficient cultivation of the feedstock by the small farmers. However, these arrangements may not be done in a fair way, as the involved parties are often not at eye level	Access to agricultural input (fertilizer, pesticide) is expensive and limited for small-scale farmers Equipment for ethanol production (presses, distilleries) may be too expensive for small-scale producers Harvesting machinery for sweet sorghum may be too expensive

7.4.10 Investment Needs for the System Setup and for the Operation

Sweet sorghum can be cultivated with very low financial resources. Farmers need agricultural land and seeds to grow the crop (about 3–6 kg seeds/ha) (Sweethanol 2011). The plant can be easily reproduced by seeds. However, good productivity and efficiency of the cultivation need inputs such as human work, energy, fertilizers, and pesticides, and thus sufficient financial resources.

Even if the feedstock production can be done at a very low cost, considerable financial resources are needed for the further processing steps, such as transport, milling, and conversion to ethanol. However, the availability of financial resources is often a key limiting factor, especially in developing countries.

Table 7.14 shows selected impacts of sweet sorghum value chains in tropical climate.

7.5 Conclusion

The use of sweet sorghum as an energy crop is not only very promising with regards to its high yields and environmental benefits, but especially due to its advantageous socio-economic implications. This is mainly due to the fact that sweet sorghum can grow under soils and climatic conditions that do not allow the cultivation of other (food) crops, such as corn or sugarcane. Furthermore, it is an edible plant with many different use options. Especially, small-scale farmers can quickly change between energy production (ethanol) and food production (sugar and syrup). This advantage is also applicable for ethanol plant operators, similar to the sugar/ethanol bio-refineries using sugarcane (e.g., in Brazil). This allows farmers and plant operators to adjust the production according to best market prices. With regard to its socio-economic benefits, sweet sorghum is an interesting crop, especially for developing countries. Large contributions to rural development can be expected for the cultivation of sweet sorghum in temperate regions, too.

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Chapter 8
The Use of Soybean By-Products as a Biofuel: The Argentine Case

Jorge Antonio Hilbert and Sofia Galligani

Abstract Soybean production is immersed within a productive system that cannot be analyzed on its own. A number of political and market factors, both nationally and internationally, explain the development and growth of soybean production throughout the globe. In the case of Argentina, the evolution of the agricultural system of soybean production has been characterized by continuous technological improvement. This has changed the whole agricultural system and set the base for society growing demands for environmental and socially responsible goods. An advancement of the regulatory frameworks has allowed a better control of the future development of land use. In Argentina's case the law of minimum budget is an example towards that direction. Over the last decades, soybean cultivation has faced unprecedented growth. Since the 70's soy cultivation areas have grown, representing 37,000 ha in the 1970/1971 campaign to more than 17 million ha today. The Argentinean soy industry is one of the most dynamic economic sectors of the country, generating almost 30 % of the external currencies' income due to exports and representing almost 30 % of GDP from the agro-industrial sector. Argentina is the world's leading exporter in soybean oil, soy meal and soy biodiesel and the third one in soybeans.

Keywords Soybean · Argentina · Oil crop · Dedicated energy crop · Coproduct · Soy market · Biodiesel

8.1 Introduction

Biofuels derived from coproducts of food crops require specific treatment and study, since conventional approaches developed for dedicated energy crops are not suitable to understand the soybean based biodiesel production in Argentina.

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Fig. 8.1 Soy bean in Argentina. (Source: D. Rutz, WIP)

Soybean (Fig. 8.1) production for Biodiesel is immersed within a productive system that cannot be analyzed on its own. A number of political and market factors, both nationally and internationally, explain the development and growth of soybean production throughout the globe. Only 4.4 % of the soybean production is used to produce biodiesel. This is a theoretical calculation since this crop is not cultivated for energy purposes, a byproduct of its transformation is used.

In the case of Argentina, the evolution of the agricultural system of soybean production has been characterized by continuous technological improvement. This has changed the whole agricultural system and set the base for societies growing demands for environmental and socially responsible goods.

In terms of social and environmental aspects, institutions are crucial for the public and private sector. Argentina has developed an important and sophisticated network of institutions related to agriculture and agribusiness. A growing influence of several organizations that mainly focus on feedstock production has been significant:

- INTA (Instituto Nacional de Tecnologia Agropecuaria)
- AACREA (Asociación de Empresarios Agropecuarios)
- PROSOJA (Profecionales especialisados en cultivo de Soja)
- AAPRESID (Asociación Argentina de Productores en Siembra Directa)

Important organizations that are more oriented towards agroindustry and agribusiness include:

- INTI (Instituto Naciondel de Tecnologia Industrial)
- ACSOJA (Asociacion de la cadena de la soja Argentina)
- MAIZAR (Asociacion Maiz Argentino)
- ASAGA (Asociasion Argentina de Grasas y Aceites)
- CARBIO (Cámara Argentina de Biocombustibles)

The growth of sustainable development awareness has been taking place in the whole agricultural system, with special emphasis in soybean production. This materializes in a wealth of whole research done by the mentioned organizations.

There is also a parallel concern on social aspects coming from the public side (municipal, provincial and federal governments) and the private sector through new trends in enterprise management such as fair trade, social enterprises, Corporate Social Responsibility (CSR) and sustainability certification schemes. The development of this trend has been institutionalized through the Argentinean Social Responsibility Institute (IARSE) with specific tools to address this important issue. There are important advances that have been reflected in concrete decisions such as:

- Criteria and indicator development
- Good agricultural and agro-industrial practices
- Certified agriculture
- Biofuel certification schemes: Camara Argentina de Biocombustibles (CARBIO), Roundtable on Responsible Soy (RTRS)
- Regulatory advances allowing a better accountability and management of land usage

Technological development has allowed unquestionable improvements in the preservation of the environment, such as:

- Reduction of agrochemicals toxicity
- Application technologies (good agricultural practices)
- Direct seeding technology
- Precision agriculture
- Increment in unitary production that reduces the pressure due to utilization of new lands

The advancement of the regulatory framework has allowed a better control of the future development of land usage. In Argentina's case the law of minimum budget is an example towards that direction.

The Argentinean soy industry is one of the most dynamic economic sectors of the country, generating almost 30 % of the external currencies income due to exports and representing almost 30 % of GDP from the agro-industrial sector. Argentina is the world's leading exporter in soybean oil, soy meal and soy biodiesel and the third one in soybeans.

8.2 Recent Soybean Complex Outlook

The soy harvest in 2012 was around 40.1 million t. Considering the 2010/2011 harvest the cultivated area is estimated at around 18,900,000 ha. There was an increase in the area under cultivation with respect to the previous crop year by 3.0 %. In terms of production the volume in 2011 was 48.9 million t, 7.7 % more than in 2012. In Fig. 8.2 a breakdown of the 2010/2011 harvest is presented. Within the "added value" sector, the availability can be divided into internal consumption and export (Fig. 8.2). Thereby, 80 % of the export goes to the world's leading demander for soybeans, China. The soybean exports will be close to 12.5 million t and this has an estimated value of more than US$ 4.6 billion before taxes. The distribution is displayed in Fig. 8.2.

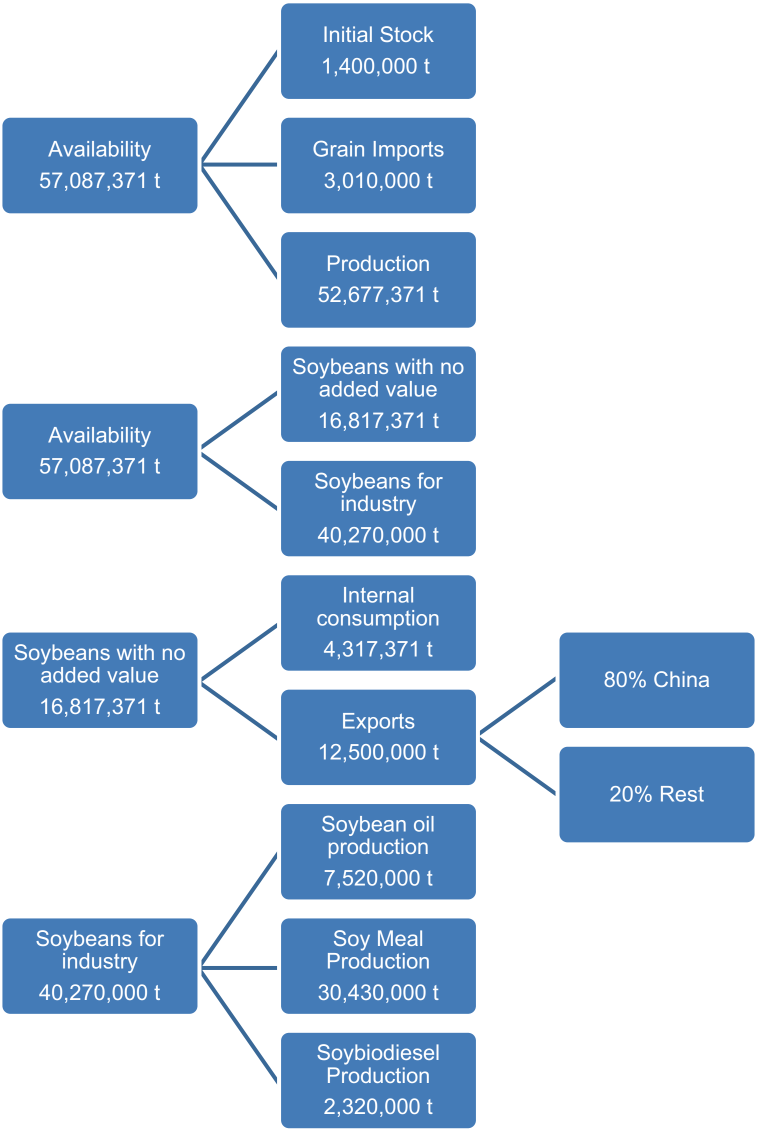

Fig. 8.2 Breakdown of the use of the soy harvest in the 2010/2011 season

As mentioned before, Argentina is the leading exporter of soybean oil. The production is estimated at more than 7.5 million t. More than 5.2 million t are exported with an estimated value of more than US$ 4.3 billion before taxes. China and India are the main importers accounting for more than 80 % of Argentina's exports (see Fig. 8.2).

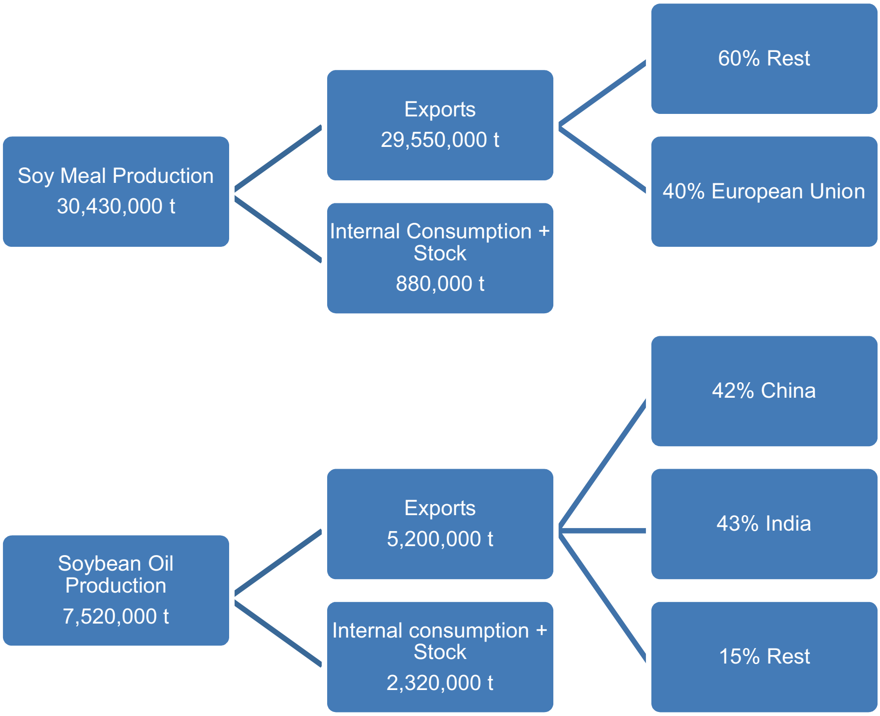

Fig. 8.3 Soybean oil and meal production in the 2010/2011 season

Argentina is also the leading exporter of soy meal and the production is estimated at more than 30 million t, of which 29.5 million t are exported, accounting for a value of more than US$ 10 billion before taxes. The European Union imports nearly 40 % of the soy meal exported by Argentina (Fig. 8.3).

The second transformation industry has biodiesel as one of its main product. Argentina has quickly become the world-leading producer and exporter of soy biodiesel with a production of more than 2.3 million t (Fig. 8.4). Going into the biorefinery stage, several glycerine plants are now in operation, making the country also the leader in glycerine exports.

Agriculture in Argentina is heavily regulated with high taxes being paid by the sector in different stages of the supply chain. In order to understand both the government intervention and the agricultural businesses situation, it is worth understanding how the export taxes impact on the production in terms of quantity and money. The commerce is subject to export changes, primarily export tax for biodiesel, with tax fluctuations according to government's criteria, being also the case with soybean (see Table 8.1).

An important issue, which is commonly described, relates to the impact of biofuel production on social aspects and development in different countries and areas.

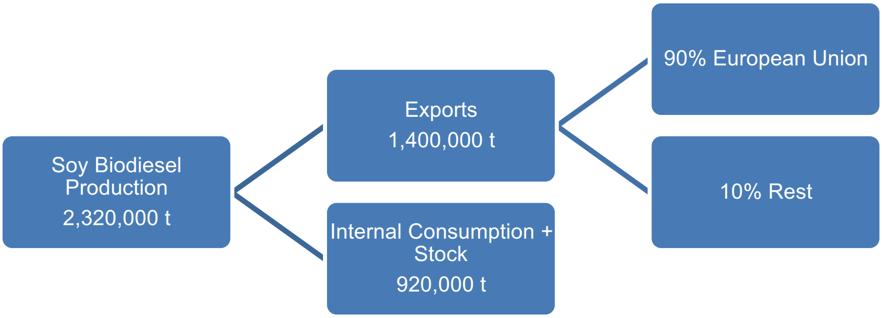

Fig. 8.4 Soy biodiesel production in the 2010/2011 season

Table 8.1 Million t and estimated US$ taxed in the soy complex for the 2010/2011 season (Ministry of Agriculture)

Product	Million t	Export Tax per t (Jun 09–Jun 10)	Estimate Export Tax paid in US$
Soybeans	4,375,000	374	1,636,541,667
Soymeal	1,664,000	346	575,633,067
Soybean oil	9,456,000	824	7,793,004,800
Soy Biodiesel	238,000	838	199,498,740
Total	15,733,000		10,204,678,273

These impacts go beyond local changes in employment and other social indicators. While the soybean industry delivers a large amount of resources to the nation, its real impact is difficult to measure. According to Table 8.1, the public sector received more than US$ 10 billion from the soy sector in terms of export tax collected from more than 15 million t of products. The estimated US$ collected by export taxes represents nearly 4 % of Argentina's GDP. This is a high number as for example Argentina's health and education expenses are nearly 5 % and 3 % of the GDP, respectively.

Nearly 30 % of the total amount, called the soy fund, is directly distributed between all the Argentinian provinces. The fund has an important role in federal distribution of this productive sector. These figures give a comparative perspective of the impact of the soybean chain in the country; for example Argentina's large and widely spread public education covers the whole country. This percentage represents also the magnitude of the soy industry for Argentina's fiscal stability and the indirect social impact of this activity as a whole.

In terms of total tax collection, the soy industry accounts for nearly 30 % of the total export tax collected. This sector is important for the country's monetary policy; those US$ are later bought by the Central Bank and used to keep the exchange rate fixed at the value determined by the monetary authority. The export tax also allows maintaining low internal food prices with a significant impact on food security for the low-income people.

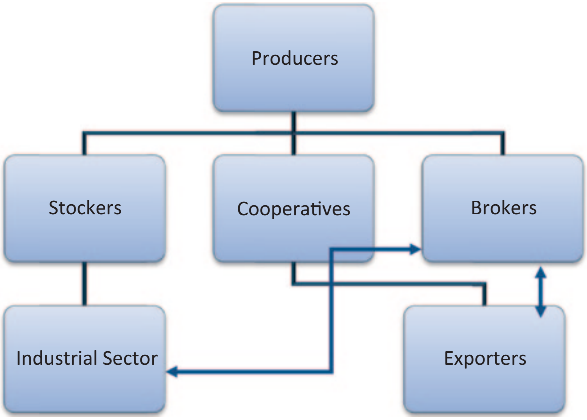

Fig. 8.5 Actors in the commercialization of the agro-business in Argentina

8.3 Agro-Product Commercialization

Following research done by the 'Bolsa de Comercio de Rosario', agricultural product commercialization is different from other goods (e.g. industrial goods), which determines the characteristics of the soy sector as a whole. The following list gives an overview on the characteristics of the soy sector in Argentina. (Hilbert 2012)

- Production is spread over thousands of producers.
- Most parts from agricultural products are harvested and placed in the market in short term (seasonally). This means that the price tends to decrease during the harvest period and to increase once the stock becomes diminishing.
- For ecological and profitability reasons, production is concentrated on a regional basis.
- Small number of internal demanders (exporters and processors). The participation of cereal brokers enables the concentration of the disperse stocks.
- Climatic factors are essential for the total production, and therefore also for the final price.
- With difference from most of the world's oil crop complexes such as rapeseed, Argentinean oil complex pays export taxes and in several cases also import rates in the destination markets.
- The different forces acting freely define the local prices of all intermediate products.
- The fact that most of the production is export-oriented means that internal prices are influenced by international prices and controlled by export tax application on different commodities.

Figures 8.5 and 8.6 present the different actors in the agricultural production. It does not have to be taken literally but for a general approach is a good reflection of how the Argentinean agro-sector is structured. The brokers are an important link in this system given that they can interact in the whole commercialization chain.

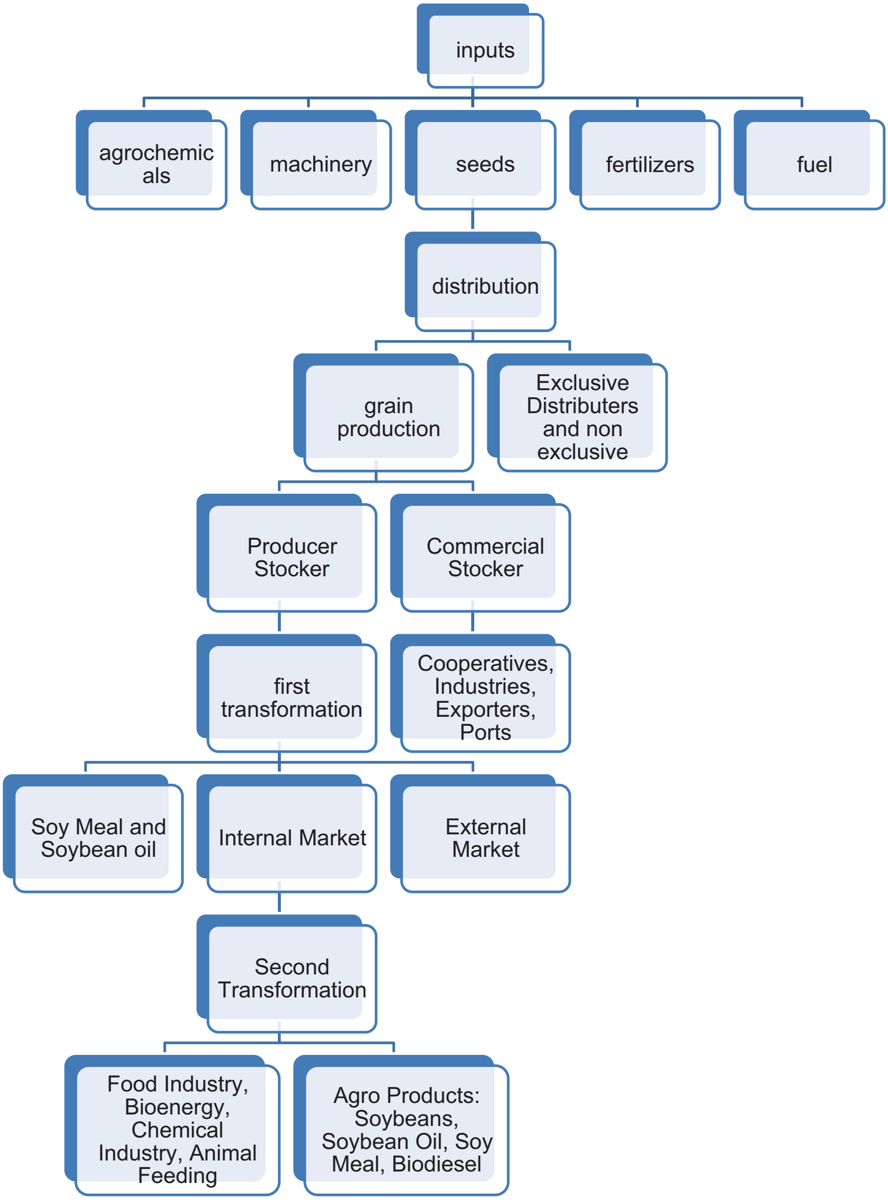

Fig. 8.6 Argentina's soy agribusiness system

In the last couple of years the activity of brokers has been growing considerably. They are selling products from the producers and their retribution consists of a variable commission. They also bring transparency to the whole operation given that they are grouped in a stock exchange such as the one in Rosario, Argentina. In the

Fig. 8.6 the different actors and processes that interact throughout the soy chain are presented.

The described production complex and industrial transformation facilities are the basis on which the Argentine biodiesel sector developed. Economies of scale and the efficiency of the soy chain are exploited to make the Argentinean biodiesel a competitive product. Despite the increase in the biodiesel tax from 14 % (2008) to a variable rate 24 % (2012), the strong international demand encourages new investments. The production is concentrated around Rosario (Province of Santa Fe), on the Paraná River, in soy and soybean oil export complexes. Thus, the province of Santa Fe has 80 % of the national production, compared to 8 % for Buenos Aires Province and 7 % for c province.

Large national companies such as the oil manufacturers General Deheza, Vicentin, Eurnekian, and Citrusvil[1] and transnational corporations (Dreyfus, Glencore and Bunge) build industrial plants with a capacity exceeding 225 million l per year[2]. As the export is fragile, they also participate in the internal market. The obligation to add 5 % to fuel could not have been achieved by 2010 without the contribution of these high capacity plants. (Hilbert 2012)

Soybean production is characterized by no-tilling technics on more than 82 % of the area together with other modern technologies such as precision agriculture. This gives an important advantage in greenhouse gas (GHG) emissions savings and energy balance. GHG savings range between 72 and 80 % depending on the region. (Hilbert and Galbusera 2012b)

The industrial plants responsible for the principal market share of biodiesel are characterized by large scale and efficiency. Most are located besides the processing complex and ports which gives enormous advantages with respect to energy use and emissions. Raw materials are coming from a radius no larger than 300 km, which also helps to increase efficiency.

In the last years new biorefineries were developed in order to get higher value products of the biodiesel process such as glycerine and other coproducts. This enlarges the benefits of the chain and increases the country's income. In 2011 biodiesel was exported for more than US$ 2,000 million.

8.4 Land Use and Production

The extraordinary growth of soybean production is without doubt correlated with the growth of cultivated areas. Nevertheless, it is worth noting that the increase rate of cultivated areas has been lower than the growth rate in production. This reflects

[1] This group privileges the installation of a biodiesel plant near its oil factory (at Frías, Province of Santiago del Estero), becoming the only mega-plant located far from Rosario.

[2] On average, Argentina biodiesel factories have a capacity of 135 million liters per year. On the other hand, the Brazilian and European factories can process an average of 80 to 100 million liters per plant per year.

the success in the average performance of soy cultivation and primary production caused by agronomical techniques, genetic material and farm machinery improvements. (USDA 2011)

The increase of soybean production has been extremely correlated with its demand growth at global level. In that sense, Keyzer et al. (2005) argues that world cereal feed demand will be significantly higher in the next 30 years than is currently projected by international organizations. Linked with the expansion of meat consumption, it is expected that the world demand for soybean and soy products will increase steadily.

Supply factors are needed to understand the increase of soybean production, making them profitable for agricultural producers. As seen in Shurtleff and Aoyagi (2007), the 1960's has been marked by a technological evolution in agriculture, plague and weed control improvement, and increased profit margins both for plantation and harvest.

Thompson (1981) provided earlier support to this hypothesis, saying, "The increase in supply and use of soybeans during the past 40 years has been a dramatic change in world agriculture—the 'Dark Green Evolution'. The driving forces have been expanding population and income levels, increasing demand for protein and edible oils, pressures on other crop prices, and production and utilization research". These factors contributed to form a higher land concentration and a gradual reduction of the importance of small producers.

In Argentina Giancola et al. (2009) compare low medium and maximum yield in the different eco-regions of Argentina finding out differences that range from 54 % in the central areas to 155 % in new areas of crop expansion in the north west and north east region. This is a relative measure of the potential increase in production without expanding the crop to new areas in the country.

Traditionally the agricultural production model was based on land possession (or rent) destined for the development of a low number of activities with a high level of integration between them using a high dosage of capital. The new model is based on outsourcing the production. It has the following pillars:

- Separation between land ownership and companies that use the land for production purposes. The contractors are the dynamic actors in this kind of model. In parallel a large number of service/input providers appear given the new demands of companies. This means that a new network of producers, contractors and service/inputs suppliers is formed.
- Appearance of companies that coordinate financial capital, decide which activities to develop, and hire land and labor associated with production. All such transactions are by contract.
- Incorporation of state-of-the-art technology.
- Separation between the place where the production is taking place and the territorial origin of the people working on the land. Migration is high within the country during the farming season generating a high volume of people traveling through the country and in this way helping different regional economies due to the increase in consumption. (Hilbert 2012)

The traditional way of farming had an important transformation in Argentina with consequences on the land concentration and organization of farmers. In the first place, in addition to the traditional farmers new actors entered the business, renting the land. Owners of the land either cultivate it or lend it, receiving the benefits of the soybean production: this has been known in Argentina as 'two layer' beneficiaries.

There are two groups of rent land actors called 'contratistas': the first group owns high-tech farm machinery and they are in charge of drilling, spreading and harvesting signing contracts for a certain percentage share of the yield. The other group rents the land with a contract of a certain amount of grain at the end of the campaign. The risks in the second case are much higher.

In addition to these traditional actors, the evolution of the agricultural production system in Argentina and the good results of the business produced new forms of associations and actors.

Drilling pools are associations of different actors that can be or not be from the farming sector. They gather money to invest in farming production and share the net benefits after harvesting.

Common investment funds are new companies with new technology that enables them to efficiently manage large amounts of land in different eco-regions, searching in the financial markets for people willing to invest in agriculture. These actors inject a new dynamism to the rural world, since they stimulate the whole chain of primary production and enable land owners to receive increasing revenues for renting their land, preventing them from selling and losing their participation.

In 1960–1970 the introduction of new soybean seeds marked a breakthrough in the sector. In the final years of the 1970's, those seeds began commercializing, increasing the performance of the planted areas. Genetically modified seeds became common ever since, accounting for the consistent growth in performance, and doing so, increasing profit margins. For instance, in the USA most planted soybean seed is genetically modified. In Argentina the phenomenon is quite similar, in 1996 the use of genetically modified soybeans, the Round-up Ready (RR) soy, was approved. The use of RR soybean has led to increased yields and expansion of cultivation into areas that were previously considered unsuitable due to heavy weed infestations and high risk of water deficits. Today, GM soy accounts for more than 98 % of soybean produced in Argentina. In Argentina's case the changes that explain the clear success of soybean are the results of innovations in the institutional, organizational and technological environments.

The two main technological factors that lead to the spectacular soybean expansion in Argentina are the no-till farming system and the introduction of genetically modified soybean. Other newer factors are in the pipeline, such as integrated pest control and precision farming.

In Argentina, the no-till farming system has been developed since the late 1980s. The first objective was to reduce soil erosion and degradation. This method is a way of growing crops from year to year without disturbing the soil through tillage, and a system of conservation that keeps in the surface the weeds from the preceding crop. This emergent agricultural technique prevents soil erosion and degradation, as well as allowing improvements in physical, chemical and biological soil conditions.

Moreover, it shows good results in improving the efficiency of the use of water, a very important parameter and usually the limiting factor for production. The main earnings of the no-till farming system are (ACSOJA 2009):

- 96 % less soil erosion
- 66 % less fuel use
- lower carbon emissions
- higher water quality
- higher biological activity
- increase in soil biodiversity
- increase in soil fertility
- higher production stability and performance
- expansion in less suitable areas
- lower production costs
- lower time use

The no-till farming system has been adopted by approximately 85 % of the farmers (PAA-FAUBA, based on AAPRESID data).

8.5 Land Use

A very important law was enforced two years ago, which establishes the minimum requirements for defining the different uses of land by the provinces. Each province is responsible for its territory and has to define the different regions and uses according to the agro-ecological and social particularities. Most of the main provinces have already mapped their land. This puts an end to an unplanned agricultural expansion protecting conservation areas.

Agricultural areas in general and soybean areas in particular are well defined.

The possible correlation between agricultural frontier expansions over livestock has to be considered. For this phenomenon several hypotheses exist to explain this expansion. The most plausible hypothesis is the emergence of feed lots for cattle breeding as an alternative to feeding the cattle on the fields by grazing. This system went from 1.5 million heads in 2001 to almost 5.5 million heads in 2009 explaining the growth of both number of heads and agricultural production at the same time. Although there are little official data available, the calculated growth between 2001 and 2009 represents an annual increment of 17 % with more than 0.5 million heads passing from pasture grazing to intensive and confined feeding, liberating land for higher income agriculture production. Data suggest that soybean expansion shared a downward tendency in livestock, which started to reverse over the last decade because of the emergence of feed lots.

At this moment, there seems to be evidence to sustain that the advance of agriculture and soybean production has been correlated with a diminishing livestock production through the occupation of traditionally farming areas.

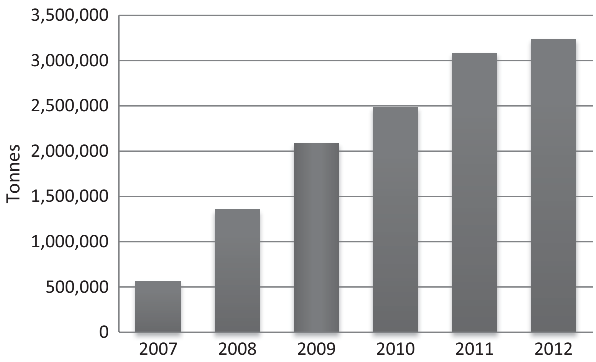

Fig. 8.7 Installed capacity of soy biodiesel in Argentina. (Source: adapted from Hilbert 2012)

8.6 Soy Biodiesel Production and Installed Capacity

The growth rate of the installed soy production capacity shows the positive perspectives within the biodiesel sector. In Argentina and the EU the installed capacity went from 6.2 million t in 2006 to 323 million t in 2012.

There is an important percentage of the installed capacity that is not being used. Although Argentina presented a used capacity above 60 % during 2009 this number was significantly increased during 2010 with the new demand in the internal market due to the mandatory blend. During recent years, a whole industry was put in place in exporter countries such as Argentina working towards a very high efficiency, transforming the chain to low energy demand and a low carbon footprint.

The export margin for the whole EU is around 1.5 million t per year. However, the investment projects currently underway could push the installed capacity to 3.7 million t per year over the next couple of years, making the export margin even higher.

Argentina's installed capacity at the end of 2010 was 24 times the capacity of 2006 and even higher by 2012 (Fig. 8.7). Argentina currently possesses state of the art soy biodiesel production facilities, in line with top quality standards. The same technologies as in developed countries (USA, Germany, Italy, etc.) are being used. Argentine industry could be divided, according to CADER, into three classes, each with different strengths and weaknesses:

- **Oil Crushers**: representing large multinational oilseed crushers with the largest plants and ample access to feedstock;
- **Large Independents**: large plants but without access to their own feedstock
- **Small Independents**: small and medium producers with none of the above, but counting on the government's support from a policy level.

The soy biodiesel industry in Argentina is currently characterized by:

- Short distances between production areas and ports
- State-of-the-art storage capacity in ports, environmental friendly facilities in terms of greenhouse gases emissions

- Leading crushing industry recognized in the world by its efficiency over other similar facilities worldwide
- High efficiency levels reaching 97.5 % in the transesterification phase, meaning that from 1,000 kg of soy oil 975 kg of soy biodiesel are made.
- Usage of private ports for loading, located inside the soy oil and soy biodiesel facilities, minimizing the need of transportation.
- High participation of hundreds of companies along the whole chain of value

A vital point to be mentioned is that Argentina's soy biodiesel market, as in the rest of the world, is dependent on governmental policies (see Box 8.1). The growth since 2007 has been motivated mainly by international markets and mandatory blend requirements overseas that generated a new demand for this type of fuels. The biofuel Law enacted in 2007 (Law 26.093), created a special regime for 15 years, establishing a 5 % mandated percentage of biodiesel in diesel fuels. In order to increase this incrementally, the production incentives were enforced during 2010 and increased that same year to 7 % and was increased in the last trimetre of 2013 to 10 % to cope with increasing oil imports and difficulties in exports to the EU. The reason for the government acting to stimulate biodiesel production was the need for alternative fuel options in order to reduce the dependence on fossil fuels.

8.7 Soy Biodiesel Trading

Soy biodiesel trading has experienced an elevated growth in Argentina. In May 2006 the Argentine Biofuels Law 26.093 was enacted. Its focus was the development of a domestic biofuels market, and it established a B5 and E5 requirement beginning 1 January 2010. However, a global biofuels industry had already been launched by the time the law was enforced, and many large consumers such as Europe and the United States had already established ambitious targets. The Argentine private sector, led by the large oilseed crushers, saw a market opportunity and was among the first to build large biodiesel plants, typically using foreign technology, and focusing on export markets (primarily Europe). Argentina is, in fact, only one of two countries that developed their export markets ahead of their domestic one, driven by an abundance of feedstock, comparatively smaller domestic markets, and a desire to generate hard currency through exports.

The Biofuels Law gave the general basis on "what must be done in this matter". The Executive Branch of the Government was responsible for its regulation or on "how the law would be implemented" although significant changes in this policy have been recently implemented during 2012.

Since there are different drivers and forces and multiple factors at a national and international level to be considered, the regulations were slow to be implemented. Law 26.093 was not regulated until late 2007 by Resolution 109/07, but by then a number of biodiesel plants were already operating. Also, a very important resolution referred to the safety requirements. These rulings, along with Resolutions 226/08, 1296/08, 6/10, and 7/10 constitute the basic framework on which the biodiesel industry works at a national level. Although this framework is already in place there are several administrative acts such as the update of the reference price that bring up considerable turbulence when delays occur.

Box 8.1: Legal and Regulatory Framework for Biodiesel in Argentina

- Resolution 129/01: Defines biodiesel.
- Law 26.093/06: Biofuels Law. Biodiesel and ethanol mandates. Participating enterprises. Application Authority.
- Decree 109/07: Regulations for Biofuels Law.
- Resolution 266/08: Registry of universities authorized to perform technical, environmental, and safety audits on biofuels plants.
- Resolution 1296/08: Fire safety requirements for biofuels plants.
- Resolution 6/10: Quality specifications for biodiesel.
- Resolution 7/10: Announces the list of producers that comprise the domestic mandate during 2010, as well as the formula used to determine the wholesale price.

8.8 Export Policies

In 2001 Argentina introduced different policy measures in order to face one of the most serious economic crisis in its modern history. Under this framework, in 2002 by National Law 25.561 it was declared a public national social and economic emergency. An important intervention on the financial and exchange rates was implemented with the view to attempt to solve as rapidly as possible the social unrest.

The government decided to introduce by Resolution 11/2002 export taxes for all products, with the objective to restore public revenues and to protect the most damaged social sectors in Argentina. The income taxes are used to expand and strengthen social programs for unemployment, food security and payment of external debts in due time. Having in mind these goals, there is no date to foreseen a possible withdrawal of such measures. Those initial levels were lately increased at a different rate for several agricultural, oil and gas products.

It is important to analyze the effect of policies regarding the export tax on different products, mainly on the soybean supply chain on the WTO standards and regulations, as the export market is very important for Argentina. Following multilateral aspects need to be considered:

- The use of export duties are considered compatible with WTO rules; GATT Article XI.1 states: "No prohibitions or restrictions other than duties, taxes or other charges, whether made effective through quotas, import or export licenses or other measures, shall be instituted or maintained by any contracting party on the importation of any product of the territory of any other contracting party or on the exportation or sale for export of any product destined for the territory of any other contracting party". Export taxes are exempted due to the words "other than".

- Export duties are not considered a subsidy for production or export. There are legal precedents at WTO backing this interpretation like Canada—USA in timberland (WT/DS/194/R), particularly because the WTO Subsidy Agreement foresees to consider such practice if there is only a financial contribution from the government.
- Related to differential export taxes (DET), the existence and extension of such measures is in closed connection with tariff progressivity, meaning that there can be a situation where a raw material has zero or reduced import levy and the end product has a higher duty, in the middle, all the intermediate products have import duties in a scale and progressive level.
- Argentina always supports a full liberalization of agro-food tariffs worldwide, and the country is ready to accept such challenges if all countries agree to modify and eliminate tariff protections at the border.

The fact that several countries, as mentioned above, established support schemes for biofuels, opened-up an attractive biodiesel export market for Argentina. As a result, there was continuous investment in refineries for the production of biodiesel, even small and medium-sized ones, as seen in Table 8.2. However, in the middle of 2012, the EU position seems to be changing substantially. An EU Directive proposal was published by the European Commission, amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources. Expressing the need to reduce biofuels from food crops, allegedly due to indirect land use change and due to the life cycle analysis overall GHG emissions. This action, when it takes its effect will have serious negative impact on the industry, also in Argentina. The EU imposed antidumping import duties on Argentine biodiesel of 216.64–245.67 euros ($295.86–335.50) per metric ton, effective November 27, 2013. Europe took the step and other measures to reduce Argentine biodiesel imports on concerns that Argentina was selling supplies at below cost, making it harder for European producers to compete. This latest measures parcticaly closed the market for Argentina. Argentina filed a complaint to the World Trade Organization against a European Union antidumping measure.

8.9 Internal Policies

An interesting point is the coexistence of two policies that seem contradictory. On one hand soy biodiesel exports are affected by export taxes, and on the other hand production is promoted via the introduction of a quota for diesel fuel. In practice, export taxes as shown depreciate the end price received by farmers and cause a decrease in the expansion of the crop to new territories away from the central ports. On the other hand, it promotes high efficiency methods in primary production.

Related to differential export taxes (DET), the existence and extension of such measures are in close connection with tariff progressivity. When a raw material has zero or reduced import levy and the end product has a higher duty, in the middle, all the intermediate products have progressive import duties. From this perspective, at the beginning export taxes policy on biodiesel did not work as an obstacle for the growth of the sector. The latest measures regarding a significant increase in export taxes over biodiesel, together with a decrease in the reference price paid in the internal market for the mandatory blend is dramatically changing this new industry. As in the rest of the world, biodiesel is highly dependent on variable political decisions.

8.10 Certification of Biodiesel in Argentina

Sustainability certification of biofuels is growing very fast in Argentina, considering that in 2010 there were no companies certified as sustainable and that in the last 16 months a total of almost 30 certificates have been issued, with more to come. It can be stated that sustainability certification is rapidly increasing and has a good future.

During 2011, approximately 50,000 t of sustainable biodiesel were exported to the EU. It is expected that during 2012, this amount will quadruple. One of the main drivers for this growth has been mandatory requirements being enforced in different European countries. It is true that Germany was the first to promote sustainability certification for its blending targets, but other countries are starting to follow. It is expected that by 2013 this will spread through all of the European Union, making it a sine-qua-non requirement for biodiesel use.

Besides, there is a tendency to spread these requirements to other markets besides biofuels. Verification schemes like RTRS (Round Table for Sustainable Soybean) and ISCC (International Sustainability and Carbon Certification) Plus, take into account more than what is strictly mandated by the European Directive. Food and feed are markets where sustainable processes will be demanded shortly by consumers, just like quality requirements have been so far.

However, this situation might be affected by changes in rules. The introduction of indirect land use change effects or changes in GHG calculation methodology might greatly affect the current course of sustainability certification.

Also, it is possible that the introduction of new certification schemes, with pending EC approval, modify the current status of certificates. More schemes mean more possibilities to choose from, but consumer and market acceptance will always be a strong factor.

8.11 Conclusion

Biodiesel production in Argentina is based on one of the biggest and most productive oil—feed—seed production chains. The present industry added more steps and increased industrial value to end products such as raw soybean oil following the biorefinery concept. Once converted into biofuel, glycerine, high protein feed etc., the industry's value chain continues on through two more links: blending and distribution, and final markets.

Table 8.2 Biodiesel production capacity in Argentina in 2006–2012. (Source: Programa Nacional Biocombustible 2012 and Agriculture Secretary 2012)

	Biodiesel Producer	2006	2007	2008	2009	2010	2011	2012
1	Advanced Organic Material S.A.	16,000	16,000	48,000	48,000	48,000	48,000	48,000
2	Agrupacion de Col. San Antonio							50,000
3	Aripar Cereales S.A.					50,000	50,000	50,000
4	B.H Biocombustibles SRL						4,000	10,800
5	Biocombustibles Tres Arroyos							6,600
6	Biomadero S.A.	30,000	30,000	30,000	72,000	72,000	72,000	48,000
7	Colalao del Valle S.A.							18,000
8	Cremer y Asociados S.A.							50,000
9	Cargill						240,000	240,000
10	Diaser S.A.		30,000	30,000	96,000	96,000	96,000	96,000
11	Diferoil S.A.				30,000	30,000	30,000	30,000
12	Ecofuel S.A.		200,000	200,000	240,000	240,000	240,000	
13	Ecopor S.A.				10,200	10,200	10,200	10,200
14	ENRESA							50,000
15	Energias Renovables Argentinas S.A.			6,500	6,500	9,600	9,600	22,000
16	Explora S.A.			120,000	120,000	120,000	120,000	120,000
17	Hector Bolzan and Cia S.A.					10,800	10,800	10,800
18	LDC Argentina S.A.			305,000	305,000	305,000	305,000	305,000
19	Mikop s.A.					40,000	40,000	80,000
20	Molinos Rio de la Plata S.A.			100,000	100,000	100,000	100,000	100,000
21	New Fuel S.A.					10,000	10,000	
22	Oil Fox S.A.					50,000	50,000	
23	Patagonia Bioenergía S.A.				250,000	250,000	250,000	250,000
24	Pitey S.A.	18,000	18,000	18,000	18,000	18,000	18,000	18,000
25	Prochem Bio S.A.							20,000
26	Renova S.A.		200,000	200,000	480,000	480,000	480,000	480,000
27	Rosario Bio Energy S.A.					36,000	36,000	38,400
28	Soyenergy S.A.	18,000	18,000	18,000	18,000	18,000	18,000	18,000
29	Unitec Bio S.A.			230,000	230,000	230,000	230,000	230,000
30	T6 Industrial S.A.							480,000
31	Vicentin S.A.	48,000	48,000	48,000	63,400	63,400	63,400	158,400
32	Viluco S.A.					200,000	200,000	200,000
	Production Capacity	130,000	560,000	1,353,500	2,087,100	2,487,000	2,951,000	3,238,200

The biodiesel industry is highly concentrated mostly based in Santa Fe province, in the heart of the soy and oilseed crushing industry. The downstream blending terminals are located close to population centers such as the city of Buenos Aires, and Rosario, in Santa Fe province. The domestic biofuels market has commenced in Argentina with little publicity, so most citizens are not aware of the mandatory blend.

Regarding the newest internal market response to a national strategy in order to lower imports and vulnerability from foreign providers, the mandatory blend is increasing and will surely reach a level of 10 % in the near future although new constraints are present during 2012 due to changes in internal reference prices.

Although some delays occurred during the first steps of biodiesel introduction into the internal market, significant positive implications were identified for the country: new investment, job creation, a cleaner, domestically sourced renewable energy matrix, and above all, a clear move towards more sustainability and compliance with environmental obligations.

A big part of this success is borne of Argentina's abundance of natural resources such as in soy oil, which will be a valuable feedstock for the global industry for many years to come. Argentina currently has an excess of soy oil. No conflicts are present regarding food/fuel issues since all the industry is based on a food production coproduct, which has a lower dietary value according to modern medical recommendations.

The growth of soybean areas has been mainly occurred on areas that were previously pasturelands, agricultural land for other crops, or unexploited areas in a minor proportion. The decrease in livestock production and the intensification of cattle breeding using feedlots released land for soy production.

The biodiesel industry has become strategic for the country contributing to a significant hard currency income through the complex (more than US$ 2,000 million in 2011), important tax revenue from export taxes and a decrease in the imported oil expenses.

When taken into account, marginal analysis is pretty conclusive regarding the superiority profit-wise of soy production over other activities. This superiority is driven by demand and increase in prices of several productions of the soybean chain. Soy biodiesel does not push soy production, but the other way around.

Looking at the environmental aspect the introduction of the biodiesel blend together with the effect of Argentine biodiesel use overseas produced an overall impact on GHG emissions of more than 4 million t during 2011.

The future expansion of this industry in the country is heavily dependent on internal and external changes in policies so at this stage a forecast is difficult to construct.

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Chapter 9
Socio-Economic Impacts of Palm Oil and Biodiesel: The Case of Indonesia

Alison Wright

Abstract Indonesia is now the world's leading producer of palm oil. Expansion of palm oil production in the country is driving significant socio-economic change in many of the Indonesia's rural areas, bringing employment and income, while transforming rural communities and triggering social tensions. While palm oil is predominantly in demand for traditional food and some non-food uses, it is also used as a feedstock for biofuel, both domestically and for export. Debate about whether, and under what conditions, palm oil should be used as a feedstock for biodiesel has prompted renewed scrutiny of its impacts. While much discussion has centered on the environmental dimensions of palm oil production, particularly its role in forest and peat land conversion, the social and economic impacts must also be accounted for. This chapter presents some of the key findings from research conducted in Sumatra in 2011 by Greenlight Biofuels, Indonesia, in the framework of the Global-Bio-Pact project. The study focused on four local and one regional scale case studies, identifying and analyzing the socio-economic impacts of palm oil production and conversion. This chapter discusses a selection of these impacts, highlighting some of the complexities and variations in impacts found in the study.

Keywords Palm oil · Indonesia · Palm oil market · Plantation ownership models

9.1 Introduction

Indonesia's rural areas are undergoing rapid change. Population growth and migration alongside changes in agriculture are fuelling both socio-economic and environmental changes. One of the most significant drivers of change in many rural areas of Indonesia is the expansion of oil palm plantations. Simultaneously demonized as a contributor to deforestation and trigger of social conflict and celebrated for creating jobs and reducing rural poverty, palm oil is a contentious, but undeniably significant factor in Indonesia's rural change.

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Indonesia is now the world's leading producer of palm oil, with an annual production of 23.5 million t in 2011 (GAPKI 2012), a figure which continues to grow year on year. Increases in palm oil output in recent years have come primarily from the expansion of plantation area. As suitable land in the traditional plantation areas has become scarce, expansion has spread to the more outlying provinces. The impacts of palm oil, both positive and negative, are hence being felt by an ever increasing number of people throughout Indonesia.

Indonesia's palm oil is principally used for the production of cooking oil, with consumption increases in markets such as India and China a key factor driving growth in demand. Palm oil is also further processed for use in a range of other food and non-food applications. The use of palm oil as a feedstock for biodiesel has been a relatively new development. Indonesia only began industrial scale biodiesel production in 2005. Despite early expectations, domestic palm oil biodiesel production in Indonesia has remained relatively low, and use of palm oil for biodiesel elsewhere, particularly in the European Union, has been beset by controversy. The role of biofuels in contributing to demand for palm oil is therefore currently unclear. Nevertheless, debate about whether, and under what conditions, palm oil should be used as a feedstock for biodiesel has prompted renewed scrutiny of its impacts. While much discussion has centered on the environmental dimensions of palm oil production, particularly its role in forest and peat land conversion, the social and economic impacts must also be accounted for.

This chapter presents some of the key findings from research conducted in Sumatra in 2011 by Greenlight Biofuels, Indonesia, in the framework of the Global-Bio-Pact project. The study in Indonesia focused on socio-economic impacts of palm oil production and conversion in four local and one regional scale case studies. The first part of this chapter provides an overview of palm oil production in Indonesia, including its prospects for use as a biofuel. In the second part the chapter presents a brief analysis of the research findings for the selection of socio-economic impacts.

9.2 Palm Oil in Indonesia

9.2.1 Trends in Palm Oil Production

Indonesia's position as the world's leading producer of palm oil has been a result of the rapid growth in output over recent decades. Production grew at an average of 1.2 million t per year between 2006 and 2011 (DG Estate Crops 2012), with production reaching an estimated 23.5 million t in 2011 (GAPKI 2012). The Indonesian government's target of 35 million t of crude palm oil (CPO) by 2025 (PWC 2012) indicates an ambition to continue to increase production. This increase in palm oil output has come primarily from expansion of the planted area: between 1997 and 2010 oil palm area increased from 2.9 to 7.8 million ha

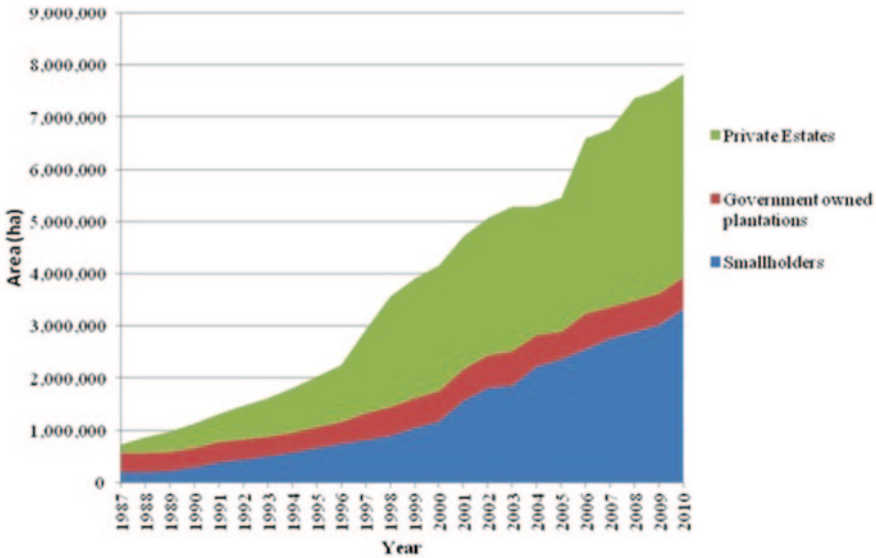

Fig. 9.1 Expansion of oil palm area by ownership category. (Data from DG Estate Crops 2012)

(Fig. 9.1), which translates into average growth rates of 8 % per annum over this period, and makes oil palm plantations Indonesia's fastest expanding land user. Increases in palm oil yields per ha have further accelerated growth in output. Between 1997 and 2007, average yields increased from 1.9 to 2.7 t of CPO per ha, with most of the yield gains in recent years attributed to improved planting material (Sheil et al. 2009).

9.2.2 *Plantation Ownership Models in Indonesia*

There are three main ownership models operating in Indonesian oil palm plantations:

- Privately owned estates
- Independent smallholders
- Government owned plantations

Many privately owned and government estates have been developed using some form of the Nucleus Estate Smallholder (NES) or *Perkebunan Inti Rakyat* (PIR) scheme, described below. There are notable differences between production systems used in each ownership model, which in turn affect yields. Reported yields are highest in state-owned plantations, which in 2006 produced average annual yields of 3.4 t of crude palm oil (CPO) per ha, followed by private estates with 2.8 t per ha (although there are considerable variations in yields between private

Fig. 9.2 Worker with a fresh fruit bunch (FFB) in Indonesia. (Source: D. Rutz, WIP)

plantations). Average smallholder[1] yields were the lowest, at only 2.2 t per ha[2] (World Bank 2010).

Estates operating the NES model of production are divided into two areas: a core plantation area (‘nucleus’) run by the plantation company, which also owns the associated palm oil mill, and a surrounding plantation area (‘plasma’) cultivated by smallholder producers. Plasma (outgrower) smallholders may be members of the local community or migrants. The company clears the plantation area at the outset, and provides agricultural inputs and management services in the early stages of plantation development. When the oil palms reach maturity, the company turns the plasma area over to smallholders or to a smallholder cooperative, with a typical land allocation of 2 ha per family[3].

Independent smallholders are producers who establish themselves independently of mills, but generally sell their fresh fruit bunches[4] (FFBs) (Fig. 9.2) to nearby plantation companies. Despite the increasing significance of this group, little is known about their landholdings. Data about the economic status of independent smallholders is also limited, although they appear to be a diverse group, from farmers cultivating their own small plots of land to those operating small plantations in conjunction with absent landlords known as *Petani berdasi* (lit. ‘white collar farmers’). On average, independent smallholders have the lowest yields, and hence the lowest financial returns of any group of producers.

Although private estates still occupy the largest share of planted area (50 %), the fastest growth over the last decade has come from smallholder areas, which

[1] National data on smallholders does not distinguish between different categories of producers, and includes both independent growers and smallholders involved in NES schemes. Differences in growth rates and yields between different types of smallholders are therefore difficult to establish.

[2] Data on yields is for comparison only and should be treated with caution. Yields are very dependent on the age of the plantation, and year on year variations also affected by weather conditions.

[3] In cases where smallholders are from the local community, they have typically turned over to the company considerably more land than they receive as their allocation. Although models vary, this can mean communities hand over 10 ha of land for every 1 ha they are allocated (Marti 2008).

[4] The fruit of the oil palm tree are known as fresh fruit bunches, which are processed into CPO.

grew at an average of 12 % per year and now occupy around 42 % of oil palm areas (Fig. 9.1). The remaining 8 % is controlled by state owned plantations (DG Estate Crops 2012). This area is expected to continue to grow at an estimated annual expansion rate of 400,000–500,000 ha from 2006 to 2020 (Bisinfocus 2006).

9.2.3 Geography of Indonesia's Palm Oil Development

Oil palm expansion in Indonesia has a distinct geography. The vast majority of Indonesia's oil palm plantation area is located in Sumatra and Kalimantan (Fig. 9.3). The country's first plantations were developed on the island of Sumatra, and today the region is home to 75 % of the county's mature palm area and accounts for 80 % of palm oil production (USDA—FAS 2009a). Palm oil production in Sumatra continues to be more profitable than in remote regions due to more favorable climate and soils and better established infrastructure. Expansion of plantation area is still occurring in Sumatra, although rates of area growth are slower here than in other regions with larger areas of contiguous land (ibid).

Expansion of oil palm plantations into regions outside Sumatra accelerated from the late 1980s, with much of the growth occurring in the region of Kalimantan on the island of Borneo. Kalimantan now accounts for 17 % of national palm oil production. Area expansion has been rapid in Central and East Kalimantan in particular, with an average growth rate of 13 % over the last decade (USDA—FAS 2009a). Even more recently, expansion of oil palm plantation area has been taking place in provinces on the islands of Sulawesi and Papua. Production in these regions, however, is much lower than in Sumatra and Kalimantan, and makes a much smaller contribution to Gross Regional Domestic Product (GRDP).

The composition of palm oil producers differs between producing regions. While large, private plantations are found in all producing areas, there is a greater smallholder presence in Sumatra, (occupying 43.9 % of the total planted area) than in Kalimantan (31.3 %) (IPOC 2006; cited in Sheil et al. 2009). State owned plantation companies are also more significant to production in Sumatra; in North Sumatra, the Government of Indonesia controls nearly 70 % of the larger plantations, either directly or through joint enterprises (BPS SUMUT, cited in US Embassy undated).

9.3 Palm Oil as a Feedstock for Biofuel

The potential for biofuels to contribute to Indonesia's energy mix, and in particular the potential of palm oil as an energy crop has been recognized in recent years by the Government of Indonesia. Indonesia's National Energy Policy, launched in 2006, outlined a strategic vision for shifting the composition of the nation's energy mix. This included a commitment to increase the contribution of renewable energy sources, including a target of 5 % from biofuels (10 % in transportation). Biofuels were seen as a particularly attractive option not only because of Indonesia's

Fig. 9.3 Regional distribution of palm oil production in Indonesia. (Source: Compiled data from IPOC 2009; IPOC 2006; Ministry of Agriculture 2008)

abundant source of feedstock, but also because they held the potential to reduce the expenditure burden of fuel subsidies while slowing energy sector carbon emissions and creating jobs (Butler 2008). As the most abundant source of feedstock, plans to increase biofuel production centered on palm oil.

The Indonesian government set ambitious targets for biofuel production: it was initially stated that biodiesel production would aim to reach 4 billion L by 2017 (FAO 2008). The government anticipated that Indonesia's biodiesel producers would consume increasing volumes of CPO and outlined plans for palm oil area expansion. Between 2010 and 2015, the government planned to develop 1.5 million ha of new oil palm plantations, and between 2016 and 2025, the plantation area for biodiesel was planned to increase by an additional 4 million ha[5] (Andriani et al. 2010).

Despite government targets, actual production of biodiesel is falling short of expectations. Although output has been boosted in recent years, production for 2011 was estimated to be around 650 million L. It was reported in 2011 that there were 22 plants producing biodiesel, with a total installed capacity was of 3,936 million L, but that only 17 % of this capacity was being used (USDA—FAS 2011).

The dominant influence on the fortunes of the biofuels industry in Indonesia is the economics of production; both CPO and oil prices determine the degree to which biodiesel production is profitable. Following initial industry enthusiasm in 2006, high CPO prices in 2007 and early 2008 made biodiesel production uneconomical leading to high levels of unutilized capacity. The political context has also damaged the confidence of producers and investors and affected incentives. The majority of biodiesel produced in Indonesia is sold domestically to the state oil and gas company, PT Pertamina. Disputes over the purchase price by PT Pertamina have caused production to stall, while subsidy levels affect profitability (Sasistiya 2010). Although there have been some changes to the biodiesel pricing formula, and the biofuel subsidy has been implemented, this continues to act as a brake on the development of the industry. The future of Indonesia's biodiesel industry, and by extension the implications for domestic demand for palm oil by the sector, are therefore uncertain.

Beyond the domestic market, the opportunities for biodiesel producers to export, and the potential for palm oil to be exported for processing into biodiesel will depend primarily on conditions in export markets, particularly in Europe: currently palm-based biodiesel does not meet the minimum carbon saving of 39 % required by the European Renewable Energy Directive. Nevertheless, European countries are the most significant importers of Indonesian biodiesel, with Italy, Spain and the Netherlands consuming over 80 % of Indonesia's biodiesel exports in 2010 (USDA—FAS 2011).

[5] Based on the projected figures for the development of biofuels by 2010. See Indonesia's road map for biofuel development. http://www.indobiofuel.com/Timnas%20BBM%204.php and http://www.indobiofuel.com/Timnas%20BBM%206.php.

9.4 Introduction to the Research and Case Studies

The research upon which this chapter is based comprised of both desk based research and three small-scale field studies. The objectives of the study were to identify, analyze and evaluate social and economic impacts of palm oil production and conversion at the local, regional and national scales. The evidence gathered through this study contributed to the development of socio-economic impact indicators for biofuel production and conversion. As most socio-economic impacts of the palm oil chain are concentrated at the production (plantation) stage, there was a bias in the case study selection and data collection toward production level impacts.

9.4.1 Regional Case Study: North Sumatra

At the regional scale, North Sumatra Province was selected as the case study region. Palm oil production in Indonesia began in North Sumatra; the first oil palm plantations established during the Dutch colonial era, and the region remains one of the centers of the Indonesian palm oil industry. The most recent data indicates that North Sumatra has approximately 1.06 million ha of oil palm harvested area, producing 3.23 million t of CPO annually[6] (Ministry of Agriculture 2010). After 1968, during the Suharto era, North Sumatra's oil palm plantation area was significantly expanded, mainly through investment in state-run companies. Much of the plantation development in the region also took place under the Nucleus Estate and Smallholder Scheme (van Gelder 2004). This initiative not only increased the overall plantation area and saw a greater role for private companies in the sector, but also meant that smallholders became increasingly important to oil palm cultivation in North Sumatra.

Continued increases in palm oil production since the mid-1980s have rested primarily on large scale land conversion and expansion of plantation area. Until quite recently, plantation areas in North Sumatra have continued to be expanded, although as availability of large areas of contiguous land in Sumatran provinces has declined, the rate of conversion has slowed. While land shortage may have slowed the expansion of large private estates, it seems to have encouraged the involvement of independent smallholders in the sector, who are able to cultivate smaller plots of land; smallholders cultivate an estimated 37 % of the oil palm area in North Sumatra (World Bank 2010) (Fig. 9.4). The history of palm oil development in North Sumatra means that state owned plantations, which controlled 304,771 ha of oil palm area in 2008 (BPS SUMUT 2012) are over represented in terms of cultivated area relative to Indonesia as a whole (Fig. 9.3). Although data for total palm oil area per district is not available, the main producing areas in North Sumatra are in the east of the province, concentrated in the districts of Asahan, Labuhan Batu, Langkat and Simalungun (Fig. 9.5).

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[6] 2008 preliminary figures.

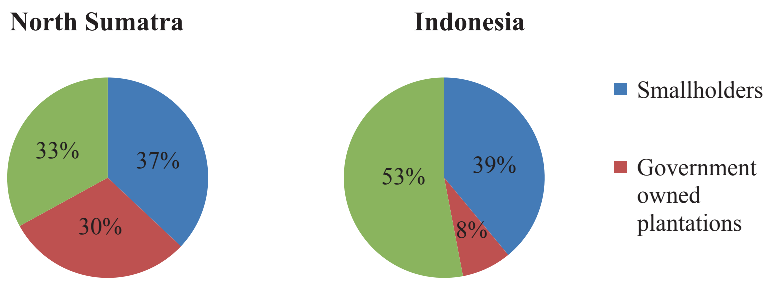

Fig. 9.4 Plantation ownership in North Sumatra in comparison to the national average. (Data Source: BPS SUMUT 2011; DG Estate Crops 2011)

9.4.2 Local Case Studies

Three case studies were selected to represent palm oil production. These included one palm oil plantation and two contrasting examples of independent smallholders. At the conversion stage, the palm oil mill associated with the plantation was studied. Due to the limited scale of biodiesel production in Indonesia it was not possible to study a specific biodiesel refinery. This issue was partially addressed through a desktop study. The specific case studies chosen were:

- **Aek Raso Plantation** in Labuhan Batu District of North Sumatra. This is an established, state-owned plantation with an associated plasma smallholder scheme. This case study was selected as a typical example of a plantation in the region, and also allowed for the study of outgrowers.
- **Independent smallholders in Desa Asam Jawa**, also in Labuhan Batu District. This represents an example of established smallholders, in a favorably situated location, in close proximity to Aek Raso Plantaion
- **Independent smallholders in Desa Harapan Makmur**, Tanjung Jabung Timor District of Jambi province. This example was selected to represent a contrast to Asam Jawa, being g recently established, and in a more isolated location.
- **Aek Raso Mill**, located on Aek Raso Plantation. This was selected as a typical example of an Indonesian palm oil mill.

9.4.3 Methodology

At the national and regional scale, data was collected through a desk-based review of publically available data and existing reports. Analysis of this data informed the selection of the chosen impacts and the design of the data collection for the local case studies.

At the local scale, rapid impact assessment methods were used to collect data. For the smallholder case studies, semi-structured interviews were conducted with farmers, both individually and in groups. In the case of Aek Raso plasma farmers

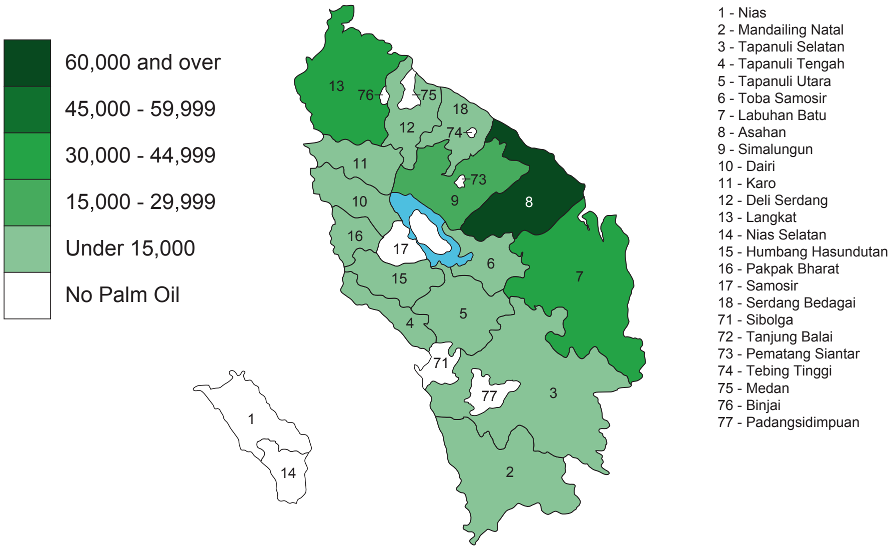

Fig. 9.5 Smallholder oil palm area, North Sumatra. (Data from: BPS SUMUT 2011)

and farmers in Asam Jawa, five farmers were interviewed individually in each location. In Harapan Makmur, a group discussion with eight farmers was followed by interviews with two farmers. In the case of the plantation and the mill, information was obtained from interviews with estate and mill managers and with head office staff, in conjunction with data provided at the estate level. The information obtained allowed for the identification and understanding of the main socio-economic impacts of relevance in each example.

The data collection for this study did not involve conducting a full field survey or social impact assessment, and the small sample size should be emphasized when considering the wider applicability of the findings. As no baseline datasets were available for any of the local case study locations, information about past conditions relied largely on people's memories. While this gives a sense of changes overtime, the inherent limitations of this method should be stressed.

9.5 Analysis of Impacts

The focus of much discussion and concern about palm oil expansion surrounds its environmental impacts; it is widely agreed that palm oil is a key driver of deforestation and habitat loss in Indonesia and elsewhere. These issues have been particularly prominent in biofuel debates, where the requirement for carbon savings has amplified concerns about forest and peat land conversion. Alongside environmental concerns, however, are the socio-economic impacts of palm oil expansion, which in many ways are more nuanced. Central justifications for promoting palm oil expansion and by extension biofuel development in Indonesia have focused on job creation, rural development and poverty alleviation. Meanwhile, the acquisition of ever more land by palm oil companies to develop and expand plantations is a key trigger of social conflict in Indonesia's rural areas.

Finally an overview of a selection of socio-economic impacts is presented which feature particularly prominently in the literature: job creation and smallholder incomes; food security; social conflict and gender impacts. For each category of impact, an overview of the issue is provided, together with a brief discussion of the evidence gathered from the case studies.

9.5.1 Job Creation and Smallholder Incomes

Arguments supporting the expansion of palm oil production in Indonesia frequently refer to the importance of the crop as a generator of employment in rural areas. Employment creation is also a key objective of Indonesia's biofuel policy; it was initially anticipated that by 2010, the biofuel industry would have created 3.6 million jobs in rural areas and led to a 16% reduction of poverty, mostly due to associated plantation expansion (Timnas 2006; Dillon et al. 2008).

The aggregate impact of palm oil production and conversion on employment at national and regional scales is difficult to establish due to the lack of accurate data. Estimates of employment in the sector vary widely; total employment may be anywhere from 1.7 million to over 4 million jobs (Wakker 2005; Antar 2009). Data on employment in the sector at the regional scale was also unavailable for most regions, including North Sumatra, although estimates have been made of the significance of palm oil employment at regional level: it has been suggested that palm oil supports up to 57% of the population in Riau and between 10 and 50% of the population in a further 11 regions (Winrock 2009).

Estimates of the intensity of employment in oil palm cultivation also vary in the literature, from the Ministry of Agriculture's estimate of one person for every 2 ha (cited in World Bank 2010), to one person for every 3.5 ha in PT SMART plantations (based on data from PT SMART 2011). Variations in these estimates may be partly explained by fluctuations in employment intensity over the life cycle of oil palm plantations. It has been estimated that on large estates, the initial 4 year establishment phase requires a total of 532 person days per ha, with most labor being required in the 1st year, in contrast to the operational phase, which requires 83 person days per ha per year (Tomich et al. 1998; cited in Papenfus 2000). Many of the jobs created in the initial stages of plantation establishment are therefore temporary, and during times of higher labor demand casual day laborers are often used (Marti 2008).

In the case of North Sumatra, where large plantations are well established and there is limited expansion, these findings suggest that plantation employment is likely to remain relatively constant with low potential for future employment generation by plantations. This is supported by the migration figures for North Sumatra: while in the past the region was a target for migrants, since the mid-1980s the province has seen negative net migration rates. It is also possible that existing plantation employment in the region may be eroded; Situmorang (2010) reports that the trend of casualisation of employment is prevalent in the region.

In addition to employment creation on plantations, palm oil makes an important contribution to smallholder incomes in many areas of Indonesia. As was previously noted, smallholder shares of palm oil production show significant variation. In North Sumatra, which has one of the highest levels of smallholder production in the country, the total smallholder area expanded by an average of 9,875 ha per year between 2006 and 2009 (BPS SUMUT).

The local case studies provided further evidence of spatial and temporal variation in palm oil employment. The intensity of employment in Aek Raso Plantation was lower than figures quoted in the literature, with one field or administration level worker for every 10 ha. This may be partly because this plantation is well established and employs fewer workers than during the establishment phase. In addition to workers on the 'nucleus' estate, 1,749 plasma farmers were supported by the development of this plantation. During the first 7 years these farmers were employed as laborers; since then they have been farming their own smallholder plots and earning income from the sale of FFBs. After the cost of inputs was deducted, average annual household income was calculated as 3,446 € (Rp 41,847,410) for a typical 2 ha plot. This compares favorably with the local annual minimum wage of 1,023 € (Rp 12,426,000). The associated mill also employed 72 people, 19 % of the plantation employment.

In the case of independent smallholders, palm oil production contributed to smallholder income and created additional employment in the villages studied, although there were notable differences between the two case studies. In Asam Jawa, the average annual income for a farmer cultivating a 2 ha plot was calculated as 2,124 € (Rp 25,793,354), after the cost of inputs was deducted[7], around 60 % of the amount earned by plasma farmers in the same area. In contrast, average annual smallholder incomes in Harapan Makmur were calculated at 1,046 € (Rp 12,702,377), after costs were deducted. These differences were a result of a number of factors. A key issue was the variation in average yields between the two villages (9.6 t FFB/ha/year in Harapan Makmur in contrast to 13.58 t FFB/ha/year in Asam Jawa[8]). Smallholders in Harapan Makmur only began cultivating palm oil in 2005, in contrast to Asam Jawa, where palm oil planting peaked in 1989–1990: lower yields would thus be expected as trees have yet to reach peak

[7] Incomes were calculated using average mid-point FFB selling prices reported by farmers over the previous year (May 2010–May 2011). FFB prices fluctuate; the most significant, but not only, determinant being CPO prices. Prices during the year preceding the study were higher than in previous years.

[8] All yields in the production case study are quoted in t/FFB/ha. To convert these figures into CPO yields requires that the oil extraction rate (OER) be factored in. Oil extraction rates also vary between groups of producers due to quality of FFBs, ranging from 18 % for low yielding smallholders to 24 % for the most productive and well managed estates (Abdullah and Wahid 2008).

harvest. Nevertheless, poorer planting materials and sub-optimal management were also undoubtedly factors influencing yields in Harapan Makmur. In Asam Jawa, farmers had been able to access improved planting materials, along with advice through both formal and informal channels. These differences appeared to be principally a result of situations of the two villages.

The FFB prices commanded by each group of smallholders also differed, affecting incomes. Farmers in Harapan Makmur sold FFB for below the factory gate price. Their isolation from the nearest mill meant that they were dependent on a chain of buyers. In contrast, several of the farmers interviewed in Asam Jawa were able to sell their FFB directly to the nearest mill, located only 7 km away.

Additional employment generated by smallholders also differed between the case studies. While it was difficult to calculate with accuracy the precise number of jobs created, in Asam Jawa most oil palm smallholders were found to have taken other jobs themselves (between 87 and 39% of smallholder household incomes were from other sources) and hired labor from within the village to work on oil palm plots. It was estimated that oil palm cultivation created 57,900 days of employment per year across the village as a whole and interviews indicated that oil palm cultivation had improved the overall employment situation in the village. In contrast, in Harapan Makmur most farmers cultivated their own land, with only 5% of smallholders using hired labor.

While the data is limited and estimates vary, the available evidence appears to indicate not only that the significance of the palm oil sector for employment generation varies between regions, but also that job creation varies over time, due to the plantation life cycle. The plantation visited for this study, which was mature and well established, had notably lower employment intensity than that suggested in the literature. The contribution of palm oil production to smallholder income also displays regional variations. Not only do numbers of smallholders vary between regions, it was also found that the situation of smallholders in terms of their access to markets and extension services is an important determinant of yields and incomes. Furthermore, the local case studies indicate that additional employment by smallholders may be a locally significant factor, particularly in areas where smallholders have been established for longer and are more successful.

9.5.2 Food Security

A long term trend since the 1970s has been a decline in food insecurity in Indonesia, although problems do still persist, which are more evident in some parts of the country than others. Some of the regions categorized as chronically food insecure, such as South Sumatra and Central Kalimantan, are also key palm oil producing regions. While the expansion of oil palm plantations has the potential to impact food security at different scales, the links between the two variables are complex and also variable between regions.

In some regions, land used for oil palm was previously used for food production. This has been highlighted as a concern in the province of Jambi in particular

(Wirasaputra et al. 2009) where there is now a deficit in cereal production, a situation that has been attributed largely to expansion of palm oil producing area (WFP 2007). In the case study region of North Sumatra, while expansion of large scale plantations has slowed, land conversion by smallholders to more profitable oil palm is continuing, potentially impacting on food availability (Situmorang 2010). Even in regions where oil palm is not replacing food producing land on a large scale, the land used often supports the livelihoods of many rural people. When land is converted to oil palm, local people lose the benefits of mixed livelihood strategies (World Bank 2010; Orth 2007), potentially increasing their vulnerability to food insecurity.

The implications of palm oil production on access to food are mainly a function of its impacts on poverty, which are inconclusive. In North Sumatra, the districts in which food access is more of a concern, particularly those in the south and west of the province, have much lower levels of palm oil production, suggesting a smaller role for palm oil in alleviating poverty and increasing access to food. The most significant issue relating to food security in North Sumatra, as in many provinces, is the poor nutritional status of children, which is a concern across the province, in both palm oil and non-palm oil producing districts. This issue is most difficult to connect to palm oil directly, being attributable to factors such as educational status and position of women.

In contrast, other regions have benefitted from infrastructure improvements associated with the development of palm oil, which allow farmers to access markets. The income benefits of converting food producing land to oil palm mean that farmers are able to buy food and increase their food security. On the other hand, the transition from being net producers to net consumers of food potentially leaves people vulnerable to high food prices.

In the local case studies, palm oil appeared to impact to varying extents on the dimensions of food security. Aek Raso plantation was developed on forested land, which was reportedly not used for food production. Plasma farmers were previously landless migrants and therefore did not have to give up food producing land in order to cultivate palm oil. Meanwhile, in Asam Jawa smallholder rubber plots were mostly converted in order to plant oil palm; rice is not grown in the village, and while food crops are grown in gardens these did not appear to have been sacrificed in order to grow oil palm. It can therefore be assumed that in neither of these case studies did oil palm impact significantly on food producing land and therefore food availability.

The situation in Harapan Makmur was found to be quite different to the other case studies, and illustrative of the issues highlighted in relation to land conversion in Jambi. Most oil palm land in the village was previously used for rice production, and it was estimated that a total of 975 ha of rice producing land in the village has been lost since 2005. According to the farmers, however, they had struggled to cultivate rice successfully since moving to the village as transmigrants in the 1970s. The overall impacts of this land conversion on food security in the village were difficult to assess. The crop is still in its early years of production, so many farmers are in a transitional phase where trees are yet to produce or production is still low. Most negotiate this stage by continuing to grow rice around the trees.

Palm oil production is likely to also have affected food security in each of the case studies through its impact on income. Both plasma farmers on Aek Raso plantation and smallholders in Asam Jawa reported income increases in real terms since starting cultivating palm oil. As previously landless migrants, the impact on household food security of this increased income is likely to have been more significant for the plasma farmers, as smallholders in Asam Jawa were found to have come from higher than average socio-economic groups. In Harapan Makmur, the income benefits for smallholders are highly variable between farmers, as success with the crop has varied; the expected income benefits of palm oil have therefore not been felt by all farmers. The diversity of experiences were difficult to quantify during limited farmer interviews, but do suggest a number of potential impacts on food security in this village associated with palm oil cultivation.

The extent to which oil palm expansion affects food security and the mechanisms by which these impacts occur therefore varies between regions. The case studies also indicate that decisions made at the local scale which may increase food security, by planting oil palm to increase income, can have negative aggregate impacts at the regional scale, by reducing overall food production. The data gathered for this study was insufficient to provide a conclusive picture within the selected case studies, but does indicate some of the factors which could be explored further.

9.5.3 Social Conflicts

The plantation sector in Indonesia is the most conflict prone land based sector in the county. In 2010, 660 active social conflicts related to palm oil companies were recorded, an upward trend from previous years (in 2009, 240 conflicts were being monitored by Sawit Watch, an Indonesian NGO) (Kompas 2011). Most conflicts centre on disputes over land rights or unfulfilled promises by plantation companies. To establish plantations, companies must acquire access to large tracts of land, which are frequently occupied by local communities. In many areas of Indonesia communities lack formal property rights and customary rights are often weak. Even when companies have legal right to use the land, failure to adequately consult local communities and seek informed consent before starting plantation development can sow the seeds of conflict.

While data suggests that most regions hosting palm oil plantations have experienced some level of social conflict, there appear to be conflict ‘hotspots’. In 2008, for example, conflicts were concentrated in South Sumatra, West Kalimantan and Jambi. The case study region of North Sumatra has a lower incidence of palm oil related conflicts than many other provinces, with 13 active conflicts being monitored in 2008. Evidence found about conflicts in the region suggested that most are the result of historical grievances between companies (both state owned and private) and local communities. During Suharto’s New Order period (1967–1998), when most palm oil plantation establishment in North Sumatra occurred, rights for companies to acquire and open land for plantations were strengthened, to the detriment of community rights over land. Conflicts related to present company practices of land acquisition, which are often given a high profile in NGO campaigns, are less of an issue in North Sumatra.

In the case of Aek Raso plantation, no evidence of conflicts was found in relation to land rights. The only issue raised in interviews with surrounding communities concerned a complaint about palm oil mill effluent (POME) contaminating local water sources[9]. The context of the plantation's development means that the risk of conflict has been low from the outset. Both the main plantation and plasma areas were developed on state forest land, which appears not to have been encumbered by pre-existing land claims or customary rights. As far as it could be established, there have been no acquisitions of land from surrounding communities; the plasma scheme was focused on landless migrants, who were therefore not surrendering any land for the plasma development, as has been the case elsewhere.

The likelihood and number of conflicts occurring between palm oil plantation companies and local communities again show variation both over time and between regions, and appear to be affected by the context in which plantations are established. Risk of conflict is highest during the process of land acquisition, and regions with a higher frequency of conflicts appear to be those when expansion is still taking place. Nevertheless, some conflicts do persist for many years, as the case study region of North Sumatra illustrates.

9.5.4 Gender Impacts

The gender impacts of palm oil production are perhaps some of the least well explored. Gender disaggregated data is not available at any scale for plantation employment and information about possible gender issues in the palm oil chain in Indonesia comes from anecdotal evidence only. Marti (2008), for example, draws attention to evidence of gender inequality in plantation employment, reporting that women are often employed to do tasks perceived as 'easier', and therefore lower paid and without bonus systems associated with 'men's work'. It is also suggested that there is a preference for employing women as causal laborers to avoid paid time off for menstrual and maternity leave.

Another issue is the gender dimension of health issues related to work on plantations. Health risks associated with agrochemicals are higher for women, especially when pregnant or breastfeeding. Marti (2008) also notes that as women are more likely to be illiterate and therefore unable to read labels, they may be more at risk from chemicals stored in the home.

The overall picture in Indonesia with regard to gender is one of pronounced inequality. In 2002, the last time it was calculated, Indonesia's GDI[10] score was 90 % of

[9] Details of the dispute over mill effluent were not obtained from mill management as the issue was raised by the community subsequent to the mill visit. A full analysis of the plantation's development was not conducted. This would be necessary in order to confirm the situation with regard to the plantation's land use and land acquisitions.

[10] The **Gender-related Development Index (GDI)** measures achievement in the same basic capabilities as the Human Development Index (HDI) (life expectancy, literacy, education and standards of living), but takes note of inequality in achievement between women and men.

its HDI score. This placed Indonesia 91st out of 144 countries assessed in terms gender equality in basic human development. Data on women in the workforce indicates that labor force discrimination is prevalent in Indonesia. Women comprise 38 % of the labor force, and are more likely to be unemployed than men: in 2008, the female unemployment rate was 9.7 % in comparison to 7.6 % for men (Dep. Nakertrans 2011). In the formal sector, women receive lower wages and are concentrated in low-skilled and lower paid occupations. North Sumatra's basic gender inequality is worse than in the country as a whole: in 2002, the region's GDI score was 87.1 % of its HDI score in the same year, placing it 20th amongst 30 Indonesian provinces (BAPPENAS 2007).

The case studies all found clear gendered division of labor within the palm oil sector. The labor force in Aek Raso plantation is overwhelmingly male (97 %). All ten women employed at the plantation were reported to work in administration roles. Women were not represented amongst the management, and it was stated that women do not do field work as the work is not thought suitable for them. While this does mean that issues concerning chemical exposure can be assumed not to be relevant in this case, it does reflect entrenched ideas about gendered employment rolls. Data on wages did not allow for men and women's pay to be compared. A similar situation was found at the Aek Raso mill, where 86 % of workers were male, and management explained that only certain jobs were considered suitable for women on health grounds.

The smallholder case studies also revealed a clear gendered division of labor. Most manual work on the farms, and all hired labor, was again done by men, although to varying extents women's unpaid labor was used on family farms. In all villages, the role of women in the village economy was described as 'housewives', but all farmers mentioned that their wives help out with tasks on the farm when they have time, most commonly manually clearing weeds, gathering FFB after harvesting and book keeping, described as 'lighter work'. It did not appear that women were involved in spraying herbicides. It did, however, emerge from interviews that the standard daily rate paid for unskilled women's labor was lower than that of men's: 2.22 € (Rp 27,000) in comparison to 4.12 € (Rp 50,000).

The lack of gender disaggregated data, combined with prevailing ideas about gender roles makes it difficult to establish the extent of gender discrimination or gender specific impacts within the palm oil sector. Nevertheless, given the national and regional gender context, together with the male dominated nature of employment in the palm oil sector, it seems likely that the development of the industry is doing little to contribute to gender equality in Indonesia.

9.6 Conclusion

Even without demand for palm oil as a feedstock for biodiesel, the impacts of the crop on an increasing number of Indonesia's provinces is significant. Expansion of plantations is creating new employment opportunities and transforming rural economies, but also triggering social conflict in some areas. Meanwhile the increasing role of smallholders in the sector represents an opportunity to boost rural incomes.

The market for Indonesia's palm oil for use as a biofuel, both domestically and internationally, is still uncertain and subject to debate; a key theme in which is sustainability. This chapter has illustrated that questions about sustainability should extend beyond environmental dimensions to encompass considerations of social and economic impacts.

Both social and economic impacts do, however, appear to show significant regional and temporal variations, as the brief analysis in this chapter has exemplified. Impacts on regions with established palm oil plantations, such as North Sumatra, are likely to differ substantially from regions where plantations are currently expanding, particularly in terms of employment intensity and social conflict. The study also demonstrated the complexity of some socio-economic impacts; while palm oil production undoubtedly impacts in various ways on the dimensions of food security, the links of causality require further analysis and also appear to differ between regions.

The examples analyzed in this study also suggest that the potential for smallholders to benefit from palm oil production varies regionally; in this case, smallholders in North Sumatra experienced greater benefits than those in Jambi. The key conclusion from these findings is that any generalizations about the socio-economic impacts of palm oil, and any examples claiming to be 'representative' should be treated with caution.

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Chapter 10
Socio-Economic Experiences of Different Jatropha Business Models in Africa

Estomih Sawe and Jensen Shuma

Abstract In Africa, a major motivation for embarking on biofuels, particularly from jatropha, is a desire to promote socio-economic, rural development and to reduce poverty. Despite their potential socio-economic benefits, biofuels investments can also lead to negative impacts such as human displacements. One option for suitable feedstock for biofuels is jatropha which can grow on marginal land. It can be used in different business models and for multiple purposes. Its oil produces biodiesel, soap, lotion, floor polish and as a by-product press cake that can be used as fertilizer. In many African rural areas, jatropha is used as a live fence by smallholder farmers and grows well under intercropping situations. This farming model has proven to be socio-economically the most successful, beneficial, and sustainable in Africa. Some of the challenges associated with jatropha are—despite claims of being a "miracle crop"—its commercial production which has yet to take off in Africa and commercial plantings which have not been widely implemented to date. In addition, its agronomic requirements, yield levels, and economics are highly unknown in the region. The crop takes 3–5 years to produce sizable quantities of seed. At the current low yields, the profitability of jatropha feedstock production for both community and large scale production is greatly compromised if the intended product is biodiesel alone. Furthermore, the amount of land required to produce a given quantity of biodiesel under plantation conditions largely depends on the productivity of feedstock. Consequently, substantial amounts of land are required to support jatropha based biodiesel production if seed yields remain low. The conversion of large tracts of land associated with this can adversely affect biodiversity, habitat and ecosystem integrity, climate change, mitigation capacity, household food security, and community land rights. It is therefore important to minimize such impacts by carefully considering among others the business model to be adopted in promoting jatropha for bioenergy production in Africa.

Keywords Jatropha · Africa · Tanzania · Small-scale farmers · Large-scale plantations

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10.1 Introduction

Africa is blessed with a huge potential of land for biofuel production, which could considerably contribute to export earnings, reduction of fossil oil imports, as well as generation of employment and rural economic growth. The African continent has a size of 30.22 million km² and a population of more than one billion people. About 15 % of the world population has thus available arable land of more than a billion hectares. Out of this land, about 630 million ha is suitable for cultivation; however, presently only less than 10 % of this land is in use. The continent has a forest cover of about 650 million ha or 21.8 % of the land area, which is about 17 % of the global forest cover (Sawe et al. 2012).

Currently (2012), the continent consumes about 5 million barrels (300 million l) of petroleum products per day (Viceroy Invest 2009). The production of liquid biofuels is insignificant, and electrification is available for less than 5 % of the population. According to Pimentel (2008), over 50 % of Africa's land has the right climate for growing jatropha (*Jatropha curcas)*. Since 2005, several local and multilateral companies have been acquiring large portions of land all over the African countries to invest in first-generation biofuel feedstock production. Jatropha has been one of the feedstock for biodiesel production. A large potential of jatropha production in Africa exists in many countries including Ghana, Madagascar, Mozambique, Tanzania, and Mali.

10.2 Liquid Biofuels Development in Africa

Africa has the potential of producing different forms of biofuels (solids, gases, and liquids) for its socio-economic development. Solid biofuels are the main source of energy for cooking using inefficient, traditional stoves in most African countries. Liquid biofuels (ethanol, biodiesel, and straight vegetable oils) still account for only a small share of total energy supplies in the continent. However, Africa has huge potential for biofuels production due to large, unused land and rural populations seeking for new income generation opportunities. A few countries produce small amounts of ethanol (e.g., Malawi, Zimbabwe, and Ethiopia) or vegetable oil (e.g., Tanzania, Mali) from jatropha, mostly for local markets. Different efforts for large-scale biofuels development are being initiated and several countries are developing national biofuels policies, strategies, and regulatory frameworks (Janssen and Rutz 2012).

A variety of feedstock can be grown to produce biofuels in Africa; those with greatest interest are sugarcane and cassava for ethanol, as well as jatropha for straight vegetable oil or biodiesel production. In this chapter, different models for liquid biofuels production in Africa are presented and discussed.

Fig. 10.1 Jatropha shrubs in Mali. (Source: D. Rutz, WIP)

Fig. 10.2 Jatropha fruits and seeds. (Source: D. Rutz, WIP)

10.3 Jatropha as Biofuel Crop in Africa

Jatropha curcas is a perennial and drought resistant plant (Fig. 10.1) with a life-cycle of 30–50 years. While it is not indigenous to Africa, it has been naturalized in many parts of the continent. Smallholder farmers have been growing this crop for many decades for reasons other than biofuels. Many trees older than 30 years, and in some cases older than 50 years, are grown as fences or in the wild. The plant grows in tropical, subtropical, and semiarid regions at altitudes of up to 500 m. It can grow in areas where annual rainfall is as low as 300 mm and on poor soils with reduced yield of seeds. In order to achieve sufficient high yields, appropriate rain-fall patterns of 1,200 mm and the use of fertilizers on poor soils are required. It takes 3–5 years before jatropha produces first fruits (Fig. 10.2) and considerable yields, but after that, harvesting is possible every 6–12 months. Jatropha seeds have a high oil percentage of 30, but the oil is poisonous to people and animals. Generally, pure plant oil yield varies between 400 and 2,200 l/ha. Selected feedstock characteristics are indicated in Table 10.1.

Fig. 10.3 Jatropha potential in Africa (*green*). (WordPress 2007)

10.4 Jatropha Development Models in Africa

The following different jatropha production, processing, and marketing models, currently emerging in Africa, are presented and discussed in this paragraph:

- *Stand-alone large-scale plantations* owned by large-scale farmers who are the main producers and suppliers of jatropha products
- *Large-scale plantations contracting smallholders as outgrowers* producing seeds for the plantation owners
- *Contracted small-scale farmers* producing for private organizations or companies who have no own farms
- *Independent small-scale farmers* (some organized in associations or cooperatives) locally producing, processing, and using oil for soap and energy production and selling extra oil or seeds to local biodiesel producing companies operating at district or regional towns

10.4.1 Jatropha Value Chains

There are three major functions taking place in jatropha production in Tanzania. These functions include *cultivation* which pertains to jatropha growing and seed harvesting, *processing* which includes activities of pressing the seeds to separate the oil and the seedcake, and *product use* of oil and seedcake. Present jatropha value

Table 10.1 Jatropha feedstock characteristics. (Source: Sielhorst 2008)

Characteristic	Quantity
Preferential rainfall (mm/year)	600–1,200
Required economical scale for competitive biofuel production (ha)	400–1,000
Fertilizer use	Low
Pesticide use	Low
Sensitivity to water supply	Medium
Mechanization potential	Low
Smallholder potential/outgrower scheme potential	High
Maximum time between harvesting and processing	Several months
Seed oil content	30 %
Oil yields (l/ha)	400–2,200

Fig. 10.4 Large-scale jatropha plantation. (J. Shuma, TATEDO)

chains are not fully driven by market forces, and many production incentives exist for developing jatropha farming.

Due to the emergence of various products of commercial value from jatropha trees, there have been a growing number of jatropha seed collectors and traders. Some women groups who extract oil and make soap have been potential buyers of jatropha seeds. Some women groups have decided to specialize in soap making and marketing and thus buy jatropha oil from their colleagues who extract the oil from the seeds. Interestingly, there is varying value addition per hour for every function along the chain.

10.4.2 Large-Scale Plantation Models

Large-scale plantation business models (1,000 ha or more; Fig. 10.4) normally are capital intensive, often using tractors, large amounts of fertilizers and pesticides, and expensive irrigation with contracted labor. In Africa most of the large-scale plantations are established by foreign companies with the objective of producing jatropha oil for export markets.

Large-scale jatropha plantations in Africa were visualized to be a new source of high revenues, employment, and production of substitute for petrol diesel. The main product from this model is jatropha oil, which has high potential for export. The economic viability of growing jatropha as a cash crop depends, to a large extent, on the yield obtained when it is grown in plantations. Some companies initially anticipated financial returns of 93 % per year of their investment, but these figures have now been scaled down (Viceroy Invest 2009).

This model has been observed to have the least potential to enhance rural development, although it could contribute to rural employment. In recent years, some companies which have practiced this model in Africa have experienced financial problems due to several reasons (i.e., financial crisis, lack of adequate capital, and overestimated yields). Until today, large plantation projects in Africa concerning jatropha cultivation have not proven to be successful due to their inability to generate sufficient revenues, as well as the destruction of natural resources (e.g., forest, biodiversity). Among the companies known that have invested in jatropha in Tanzania are Sun Biofuels, D1 Oils (UK), and Flora Eco Power (Germany). They have faced poor production performance, low yields, and low revenues leading to a withdrawal of BP from its joint venture with D1 Oils. Another example was the Swedish company Bio-Massive, which leased land in Tanzania to set up jatropha plantations. They have announced losses until 2009. The Dutch company BioShape who had also acquired land in Tanzania has officially declared bankruptcy in 2010 the jatropha plantations (Sawe et al. 2012).

Based on such negative experiences and other social and environmental concerns, South Africa banned jatropha planting in 2010, the government in Zimbabwe has banned export of jatropha products and in Tanzania, the government has reportedly suspended approvals for new biofuel projects until clear policy and regulations are put in place.

Several multinational companies invested in advertising for jatropha, promising a guaranteed return on investment with cultivation on marginal lands, but these promises have proven to be absolutely unrealistic. These companies have already abandoned their projects in Africa, because yields were far below expectations on good land. Investing in large plantations of jatropha is thus neither economically viable nor environmentally sustainable. According to the report of Friends of the Earth International on "Jatropha—money doesn't grow on trees" (Pohl 2010), there are ten reasons on why jatropha is neither a profitable nor sustainable investment. In summary, jatropha as cash crop does not guarantee high returns, cannot thrive on marginal land, requires significant amounts of water, and is not pest resistant. Large jatropha plantations also compete with food production, have negative impacts on biodiversity, and are likely to increase carbon emissions. The displacement of people from their original land areas was minimal since most of the land was used for annual crop production and other lands were reserved for natural forests and woodlands.

However, the failure of large plantation models does not necessarily lead to a total failure of jatropha cultivation in Africa, as it is possible to achieve success with other production models. Successful production models for jatropha involve smallholder farmers as outgrowers or independent farmers. The feedstock for these models is cumulatively gathered from extensive networks of smallholder farmers. Avoiding the large investments needed for plantations, seed collection by outgrowers, and processing to produce oil and press cake for biogas production and as bio fertilizer application, seems to be a suitable business model.

10.4.3 Large-Scale Plantations Contracting

This business model involves a central company facilitating seed collection from jatropha farmers. For biodiesel and Straight Vegetable Oil (SVO) production, a company is required to promote jatropha cultivation to small-scale farmers using outgrower and collection schemes.

Some large-scale jatropha plantations have agreements with smallholder farmers to provide inputs and technical support for jatropha production and in turn buy all seeds from small-scale farmers. However, the potential positive socio-economic impact of this scheme depends on a number of issues including the quality of provided support services and the fairness of the terms of contract.

Jatropha seeds are collected from smallholders' farm hedges and public areas. The production of seeds is performed by smallholder groups or individuals as outgrowers supported by companies. Some smallholder farmers can locally produce, process, and use jatropha oil as well as its by-products for meeting their own needs. Jatropha production may also be done through group farming on dedicated communal land areas. Family labor is used during seed collection and processing (by farmer groups) using manual oil presses. Farmers may thereby intercrop jatropha with other food crops. The seeds are collected from farmers and supplied to collection centers. The company hires trucks for transporting seeds to the conversion facility located in urban areas, where they are processed to Straight Jatropha Oil (SJO). There are no agrochemical inputs used by smallholder farmers during production of jatropha seeds, however, some chemicals are used during conversion of jatropha oil into biodiesel.

This jatropha production model generates income for smallholders, employees, transporters, and jatropha companies. Typical examples of such outgrower models in Africa are found in Mpanda, Tanzania (Prokon), and Koulikoro, Mali (Mali Biocaburant). Economic assessments have shown that collection and sales of seeds give the lowest added value. Oil extraction is more profitable than seed collection, but not as good as soap making. Even though all assessed activities contribute to the rural economy it may still take some time, until such jatropha models can significantly contribute to rural development.

The price for seeds is established by agreements between the company and the farmers. Different collection areas have different prices: the longer the transport, or the higher the expenses for transport, the lower the price for the seeds. Collectors are always given the option to bring seeds to the factory gate (for a "factory-gate price"); otherwise, the company organizes and pays for the transport of the seeds.

Jatropha seed collection (especially for smallholders) is labor intensive which is considered as strength in the context of pro-poor development. The outgrower

Fig. 10.5 Intercropping: jatropha and corn. (Mali Biocaburant 2011)

model involves several actors (small farmers, field coordinators, extension staff, local actors, collectors, etc.). Smallholder farmers are self-employed, whereas other farmers and collectors are employed on contractual basis. Extension staff and field coordinators are formally employed by the company. Labor is required for clearing the site, ploughing, pitting, planting, weeding, irrigating, spraying of crop protection chemicals, fertilizers, and pruning. As labor costs account for a high percentage of total costs, scale effects are unlikely when establishing a jatropha plantation on a larger scale. Labor requirements will increase almost linear with area size. Transportation costs could be reduced when transporting inputs or seeds, but this is a rather small portion of the total costs.

Jatropha production by outgrower models is undertaken by smallholder farmers working in the informal sector. Although the management of companies may be aware of health and safety regulations, compliance with regulations concerning appropriate use of agrochemicals, provision and use of protective gear, availability and accessibility to first aid services, working hours, wages and provisions for establishing a workers union may vary from one company to another. Since these companies do not have control over the outgrowers, their influence on working conditions is limited. The health and working conditions are applied to permanent workers in processing plants and seed collection systems only.

There have been ongoing debates on the impact of jatropha production on food security. Some believe that sustainable production of jatropha is possible without negative impacts on food security, solely depending on operation management. On the other hand, doubters argue that production of biofuels will threaten food supplies for the poor. However, the model of collecting jatropha seeds from outgrowers (smallholder farmers and contract farmers) does not have much effect on food security for smallholders, as jatropha is most commonly planted in hedges and in some cases intercropped with other local crops (maize, sweet potatoes, onions, and sunflower; Fig. 10.5).

Some biofuel companies in Africa which use outgrower models to process oil from jatropha do not own any land. Instead, they buy jatropha seeds produced or collected by local farmers according to contracts or outgrower arrangements. These companies are able to start producing biofuels earlier, avoiding delays and costs incurred in acquiring land. However, these companies may face other challenges, such as ensuring that enough biofuel feedstock at the right quality is supplied by local farmers in order to meet production targets. The smallholder farmers under this kind of arrangements, are not compensated for their lands because they do not lose rights of their lands. They can decide on the allocation of land for the production of crops and other (food) crops (Luoga et al. 2011).

Although women in Africa inherently have limited access to resources such as land, water, fertilizers, and pesticides, they have the right to collect, process, and sell seeds from family hedges, and keep the money earned. The government can allocate plots to women where they can plant jatropha. In general, often unequal opportunities and benefits for men and women headed households exist. Sometimes women extract oil which they use to make soap or sell to companies for various uses, thereby improving their income and livelihoods.

10.4.4 Independent, Small-Scale Farmers

Independent small-scale farmers may be organized in associations or cooperatives in order to locally produce, process, and use jatropha oil for the production of soap and energy. Under this model socio-economic impacts depend on the management setup and price of jatropha seeds. This model could be the most beneficial option for smallholder farmers in Africa, if well organized and managed.

Jatropha production by small-scale farmers has the potential to provide farmers and communities in Africa with extra income and improve access to energy services such as electricity, fuels for lighting, cooking for income, educational activities, and water pumping. Key issues need to be considered in the sustainable development of jatropha by small-scale, independent farmers based on experience from different villages in Tanzania, such as the village Leguruki in the vicinity of Arusha. In such villages, farmers intercrop jatropha with other crops, and significant economic opportunities have been realized. The communities have derived income from processing and use of jatropha oil for soap production, seed cake application as fertilizer and stationary engines for electricity, and motive power production.

Independent small-scale farmers are playing an important role in developing markets for jatropha seeds, soap, and energy produced from energy service platforms (ESP). Energy service platforms, also called multifunctional platforms (see Chap. 11, Fig. 11.2), are devices that are powered by an engine (e.g., oil, gas, power) and provide several small-scale services such as cereals grinding, pressing, cutting, etc. Energy service platforms owned by village enterprises or individuals are facilitating access to modern energy services to rural populations who previously lacked access to such services. Jatropha oil has thus contributed to small-scale power production in rural areas, substituting more expensive fossil fuels. New small and medium enterprises have emerged including, metal welding and soap production.

Ensuring that the economic and social benefits of biofuels are realized and sustained by independent and small-scale farmers requires improved knowledge of technologies and business management. It further requires support by competent local institution and governments to provide the necessary enabling environment.

In many African countries, small-scale jatropha models have shown positive results, providing access to energy services, increased income for local communities, higher agricultural productivity, improvement of women's working and living conditions, more efficient management of natural resources, and general quality of life improvements.

Further experiences have also shown that small-scale jatropha-growing models driven by local ownership (in which small-scale farmers produce fuel for their own use or community applications) appear likely to sustain benefits for rural communities. The transfer of technology, the building of technical and managerial capacity, improvements in farming practices, better farm inputs, and marketing will not only help rural communities to gain energy access but also increase food production, improve capacities to embark on income generating activities, add value to products, empower women, and protect soil from erosion.

Therefore, small-scale jatropha models have a large potential to provide modern energy services that contribute to increased employment and income opportunities, technological improvement, cleaner environment, energy security, gender equality and overall, enhanced economic and social well-being.

10.5 Environmental Impacts

A number of environmental impacts are usually associated with the production and use of biomass for biofuels, bioenergy, or biomaterials. These include impacts on human health (release of toxic substances, emission of photo-oxidants and ozone-depleting gases), on the quality of ecosystems (release of toxic substances, emission of acidifying and atrophying gases, land-use impacts on biodiversity, water, and soil) on climate change (global warming) and on resources (nonrenewable energy carriers and minerals).

Africa is facing serious interrelated environmental problems, including deforestation, soil erosion, water shortage and degraded water quality, and greenhouse gas emissions. Climate change is an important issue for all investors, as alongside high oil prices, and GHG mitigation is one of the main drivers for biofuels. Most investors in Africa have not yet carried out greenhouse gas assessments in order to calculate actual emission savings.

A jatropha tree absorbs around 8 kg of CO_2 every year. However, changes in land use for jatropha production can have dramatic effects on greenhouse gas emissions. When forest or grassland is converted to jatropha plantations, carbon stored in the soil is released into the atmosphere (Luoga et al. 2011).

Under the outgrower model, jatropha is principally produced through networks of small local farmers without associated land use change. The potential impact on biodiversity values will arise if natural habitats such as forests, woodlands, and indigenous grasslands are cleared. Significant areas of natural habitat also occur outside protected areas, which is important for biodiversity.

10.6 Conclusion

Global demands of biofuels are among the drivers for potential biofuel production in Africa. In addition, several African countries have been motivated to explore the opportunities of biofuels by concerns over unprecedented increases in fossil fuel prices and hence increasing import bills. Furthermore, biofuels may mitigate the problem of climate change through reduction of greenhouse gases, create employment markets for agricultural energy crops, and diversify rural economy.

African governments have been engaged in the promotion of biofuel investments, and many foreign companies have indicated interest and are in different stages of the investment process. While this is happening, few African countries have established suitable policies for governing investment decisions, a situation that has contributed to ad hoc investment arrangements creating threats for sustainable biofuels development.

This comparative analysis of different business models for jatropha development in Africa has outlined potential socio-economic impacts. The implementation of such business models may however vary from one to another African country. They can be integrated into local economies and adapted to the needs of different stakeholders, yielding a wide range of small, but crucial, social and economic benefits. Although large-scale production of jatropha seems not to be successful, other business models (involvement of small farmers) may well contribute to positive socio-economic development in African countries.

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Chapter 11
Socio-Economic Impacts of Jatropha Oil and Biodiesel in Mali

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Abstract The potential for oil and biodiesel from jatropha is of particular interest for Mali, as the country does not produce crude oil and the resources are currently devoted for the import of increasingly expensive and heavily subsidized fossil fuel products. In 2007, the government of Mali has adopted its National Strategy for the Development of Biofuels document (based on the National Energy Policy document and the Renewable Energy Strategy document) with the objective of replacing 20 % of diesel oil consumption with jatropha oil and biodiesel by 2022. This has led to the establishment of the National Agency for Biofuel Development (ANADEB) in 2009, in order to facilitate the implementation of the strategy and the elaboration of legislative rules. Several initiatives have been implemented by various actors in Mali to use jatropha oil and biodiesel for rural electrification and the transport sector. However, the contribution to the national energy supply is still very low. Meanwhile, jatropha oil and biodiesel have been heavily criticized for negatively impacting smallholder farmers in terms of food security and from being subjected to land grabbing from large corporate investors. In addition, criticism is related to the claimed reduced carbon emissions and to the economic feasibility and viability of jatropha oil and biodiesel production. This study will therefore highlight the opportunities and risks that jatropha oil and biodiesel present for a country like Mali in greening its economy, creating rural employment (both farm and nonfarm) and creating additional income. This is done by analyzing two different models of value chains, including a decentralized short jatropha value chain and a centralized long jatropha value chain. Both presented models involve smallholder farmers. The study therefore aims to contribute to increase knowledge of the literature pertaining to the socioeconomic impacts of jatropha oil and biodiesel value chains.

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Keywords Jatropha · Mali · Sustainability certification · Public perception

11.1 Introduction

Mali is a vast landlocked West African country with a population of 16.3 million inhabitants and is constantly ranking among the poorest countries in the world. Around 74 % of its population lives in the rural areas, while more than 50 % of the total population live below the poverty line of US$ 1.25 ppp (purchasing power parity) per day, relying heavily on barely mechanized agricultural activities for their livelihoods (UNDP 2013). While energy plays an important development role with the provision of energy services that can significantly improve livelihoods, the Malian energy mix is highly dominated by traditional biomass that is seldom used for productive uses, while most of the modern energy consumption is from imported fossil fuels. The production of biodiesel from jatropha seeds in Mali is therefore seen by many as a great opportunity to stimulate rural development, especially in the agricultural sector while greatly diversifying the country energy mix, and positively impact the economy by enhancing the jatropha oil and biodiesel value chain.

11.2 Case Study at the Local Level: Mali Biocarburant SA

Mali Biocarburant SA is located in the region, district, and municipality of Koulikoro about 57 km of East of Bamako. Information gathered from the case study was done through literature review and site visits.

Mali Biocarburant SA (MBSA) defines itself as being a pro-poor commercial enterprise (Lengkeek 2007). The company was founded in 2007 with the aim of producing jatropha-based biodiesel for the local and national market. As jatropha takes 3–4 years to reach maturity, the company started making biodiesel with imported palm oil.

Now, the company is being supplied with seeds from 4,500 local farmers grouped in a union (owning 20 % of the share of the company) and who cultivate jatropha intercropped with food and crops (e.g., with peanut, cotton, maize, sorghum). One of the key guiding principles of MBSA's approach is their reluctance to possess and operate large-scale monocrop jatropha plantations, but rather to focus on experimentation and seedling nurseries to provide adequate support (sound nursing and pruning techniques) to local farmers. In that respect, the company employs 30 field agents to promote intercropping (Fig. 11.1) and land reclamation activities,monitor closely fields, land-use changes through GPS technology, and agronomic production (improved and drought-resistant seeds).

The company is producing 2,000 l of biodiesel per day in a continuous process. It has a stocking capacity of 55,000 l. The biodiesel is sold at 0.79 €, while diesel is currently being sold at 0.93 €. Among the customers are car and diesel gen-set

Fig. 11.1 Intercropping of jatropha with cotton in Mali. (Source: D. Rutz, WIP)

Fig. 11.2 Multifunctional platform (MFP) at Mali Biocarburant SA (MBSA) in Mali. (Source: D. Rutz, WIP)

owners as well as small- and medium-scale industries. MBSA has been able to tap into the voluntary carbon market by promoting the carbon sequestered from established farmers' plantation and use the carbon revenues to further train and assist farmers. A number of farmers working with MBSA are women who greatly benefit from the additional income which contribute to their empowerment. In general, the households that use jatropha for intercropping have increased the revenues by either a minimum of 15 % in 5 years or an average of 76 €/ha. The press cake is currently used as a fertilizer for the plantation, but plans include the setup of biogas digesters with a mix of press cake and cow dung to produce biogas to run small-scale decentralized engines (multifunctional platforms, Fig. 11.2) in rural areas. Experimentation has already started on-site (Fig. 11.3) and should be expanded soon. Glycerine is used for soap production (Fig. 11.4) by women, further contributing to increase women revenues. The jatropha value chain is presented in Fig. 11.5

One of the major components to produce biodiesel (jatropha methyl ester) is methanol which is obtained from fossil sources and thus not produced in Mali. MBSA imports its entire methanol and, amidst the tax break, it is still quite expensive. On the other side, ethanol is produced in the country from sugarcane refineries

Fig. 11.3 Biogas plant at Mali Biocarburant SA (MBSA) in Mali. (Source: D. Rutz, WIP)

Fig. 11.4 Soap production at Mali Biocarburant SA in Mali. (Source: D. Rutz, WIP)

and the supply is expected to increase with ongoing public–private partnership projects in the sugarcane sector. This locally produced ethanol could be further processed in anhydrous ethanol and can be a good substitute to the imported methanol for the biodiesel conversion process. The company is currently experimenting the dehydration and use of ethanol onsite and assessing its economic feasibility.

11.3 Case Study at the Local Level: Garalo Bagani Yelen

The municipality of Garalo is located in the region of Sikasso, in the southernmost region of the country.

Garalo Bagani Yelen, which means translated Garalo Jatropha Lighting in Bambara language, is a project that resulted from the desire of the municipality of Garalo and its inhabitants to finally have access to electricity. The project was developed by Mali Folkecenter Nyetaa in partnership with AMADER (Malian Agency for

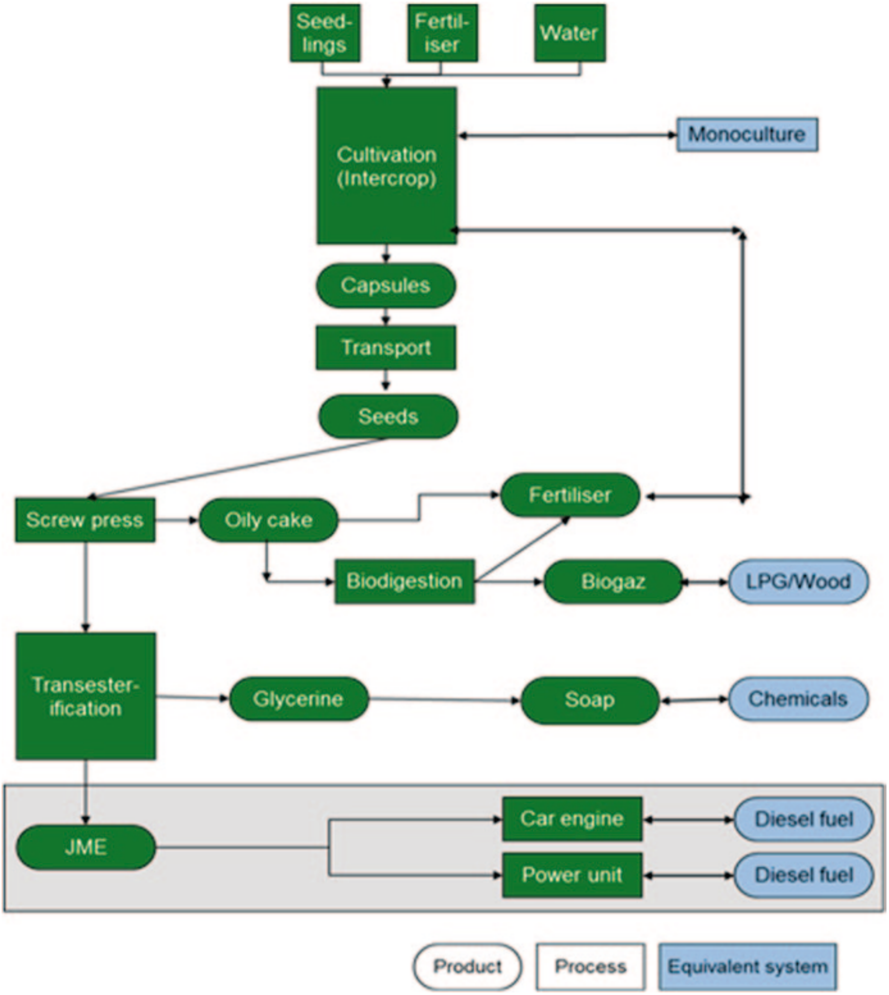

Fig. 11.5 Flowchart of the Mali Biocarburant SA value chain

Domestic Energy and Rural Electrification), ACCESS (a local rural energy service company), FACT Foundation, Stichting Het Groene Woudt, and Stichting DOEN (Dutch technical and financial partners).

The project started in 2006 (Fig. 11.6) with the objective of providing electricity to 10,000 inhabitants in the commune through a hybrid power station (using both jatropha diesel and oil). The system includes seed-oil extraction presses and filtration equipment. The installed capacity of the electric power system is 300 kW and is designed to serve around 400 connections of which most are village households and small businesses. Activities that have been carried out in Garalo in the production of jatropha included the setting up of a 2-ha nursery that produced 320,000 seedlings in

Fig. 11.6 Generator house of the project Garalo Bagani Yelen in Mali. (Source: R. Janssen, WIP)

2007, followed by 100,000 more in 2008 using organic fertilizers and well-prepared beds. The seedlings were transferred to farmers' field and were initially planted using a 3 m × 3 m spacing, but were later changed into 4 m × 4 m, 4 m × 5 m, and 5 m × 5 m plots to allow for adequate intercropping and for possible future mechanization of agriculture. For all fields, GPS coordinates were taken in order to have accurate record and to monitor the evolution of the various plantations (MFC Nyetaa 2008).

In 2008, the total planted area was 440 ha from which 80 ha was unsuccessful (82 % success rate) due to bushfire damages, bad maintenance of plants, and high density. Furthermore, 95 % of the 440 ha (418 ha) were planted by individual farmers (of which 6 % were owned by women) while the remaining 22 ha were collective farmers field of which 40 % (9 ha) were managed by women's group while the rest (13 ha) were managed by men's group. It is interesting to note that women-owned plantations are better managed than men's. About 27 % of the groups have put together financial accounting systems (largely women's groups) for managing income from the future sale of jatropha to the power plant.

However, jatropha is currently only marginally profitable for farmers in Garalo although the cost of labor for harvesting and dehusking the seeds was considered being lower than the selling price of 0.08 €/kg. Mali-Folkcenter Nyetaa and ACCESS are thus considering increasing the selling price to 0.11 €/kg to provide higher revenue to farmers. Furthermore, the main stakeholders are looking into the installation of dehusking hardware on the SJO-processing site to reduce farmer's labor cost. It is important to note, however, that yields have been lower than expected. Nevertheless, this is not related to the total yield of jatropha crops, as nearly all farmers did not carry out a full harvest in 2010. The highest yield harvested in Garalo was 800 kg/ha and the second highest was just 100 kg/ha. At 3 years old, the plants should be producing much higher yields according to the scientific literature (typically estimated at 1,500 kg/ha for an intercropped field). Another problem that farmers are facing is the threat of termites as they are, in general, not using pesticides to prevent attacks. Therefore, termites represent a threat to the viability of jatropha in Garalo (MFC Nyetaa 2007).

Due to this situation, it is important that significant improvements are made for the economic viability of the cultivation of jatropha before upscaling it nationally. Despite the production problems encountered, many farmers are supportive of the project, and this provides further opportunities to work with the farmers of Garalo to develop a model for jatropha production that is profitable and successful.

Regarding the power plant, the generator have been set up around the same time as agricultural activities started and have been running on diesel for 9 h a day (16:00 to 01:00). A full mechanical oil press, for pressing the jatropha seeds, with an oil filtration system was installed in 2010 with a maximum pressing capacity of 7 t/day. The currently used diesel (which represents 70–80% of ACCESS operating costs) will be progressively replaced with SJO as adequate amount of feedstock is supplied. The current price is set at 0.32 €/kWh by AMADER. As of September 2011, the number of connected clients amounted to 350, increasing from 230 in June 2008. More than 90% of the connected clients are households, while the remaining 10% is divided between micro and small-scale enterprises, health services, local government building, and places of worship. In addition, public lighting is provided and every client is charged a small publiclighting fee to cover the costs. Although the bill recovery rate is quite high with an average of 90%, it is often the case that they are collected in several installments (delay of up to 6 months) which can hinder operations. This is partly due to the fact that the major income-generating activity of households in the municipality is agriculture, characterized by seasonal income (with low to no disposable income at the end of the dry season). Therefore, there is a need to find new and innovative means of supporting households in diversifying their source of income, increase their yields (food or cash crop) or access to credits for bill payments, in order to maintain the operation. The jatropha value chain is presented in Fig. 11.7.

11.4 Sustainability Criteria and Certification of Biofuels in Mali

MFC is carrying out a project called "Mainstreaming Sustainability in the Biofuel Sector in Mali" in order to develop certification criteria for sustainable biofuel production in Mali. The project is funded by NL Agency and ANADEB (the Malian Biofuel Agency). ANADEB is also a strategic partner on the project, participating closely with MFC.

The project works with government institutions, the Chamber of Agriculture, the private sector (including with Mali Biocarburant—a Malian–Dutch Biodiesel joint venture), civil society (including the Malian National Jatropha Network of which MFC is the secretariat and the memberships include leading Malian research institutions), and farmers associations and cooperatives, as well as with other international bodies. Partners of this project coordinated by MFC are FACT Foundation from the Netherlands and WIP Renewable Energies from Germany. The expected results were:

- To develop sustainability criteria and a certification scheme to be adopted by ANADEB in order to lead to more sustainable biofuel production and added value for certified biofuels

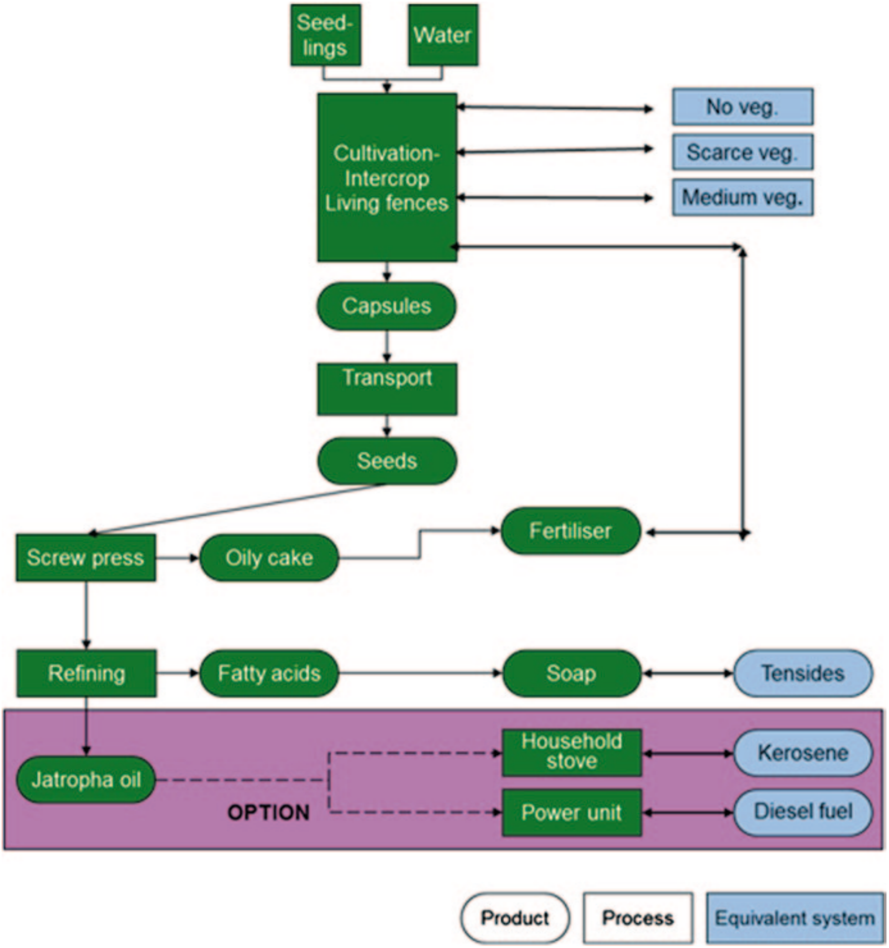

Fig. 11.7 Flowchart of the Garalo Bagani Yelen supply chain

- To reduce undesired effects of biofuels due to more sustainable practices being promoted and adopted, through legislative support and through the cooperation with policy makers
- The main project activities included:
- Development of sustainability criteria and certification scheme
- Reduce the undesired effects of biofuels
- Set up an interactive and participatory multi-stakeholder consultation process which leads to the development of Malian sustainability criteria relevant in the local context (taking inspiration from the Dutch-testing framework for sustainable biomass, and other international initiatives); adoption of the sustainability criteria by ANADEB; setting up a certification scheme at ANADEB

- Involve high-level decision makers from government (including ministries responsible for energy and water, agriculture, environment, land tenure, employment, economy and finance, industry and trade, women, children, and the family), parliamentary commissions on rural development, energy and water, environment, and trade, and will thus support wider policy development in Mali and the subregion

To date, the project has created a multistakeholder cross-sector working group on sustainability in the biofuel sector. This was made up of four subgroups: the parliamentary group, technical services of the state, private sector, and civil society. The project carried out the largest biofuel media campaign Mali has ever seen. The project developed sustainability principles, criteria, and indicators, and a certification commission has been put in place. The administration of the commission will be carried out by ANADEB. Certain governmental institutions, which have relevant expertise, will be associated with the certification of the commission's work as required.

The commission is currently being provided with the tools it needs to carry out its tasks in the future.

11.5 Public Perception of Biofuels in Mali

In 2011, MFC carried out a study on the evaluation of public perception (PP) on biofuel development in Mali (MFC 2011).

Public perception is considered by the actors of the domain as a prerequisite of biofuel and bio-product support throughout the world since it determines public acceptance, and therefore the demand in biofuel/bio-products.

It was recognized that there are big differences on the way experts and the public perceive the risks associated with environmental issues. Therefore, subjective decisions (personal and exclusive decisions of experts: environment protection, poverty alleviation) must take into account the opinion of people. There is a growing awareness of decision makers about the importance of taking public opinion into account when making a decision, and about the need to properly inform the public on the possible advantages and drawbacks of biofuel projects, so that their perception and opinion can be more favorable.

The methodology used to carry out this study consisted of:

- Exploitation of existing studies on biofuels: This consisted in making documentary and internet research to identify the actors who intervened in the different variables, the external influences and crises, the cultural parameters which influence public perception on biofuel use, as well as that of national media on biofuel issues.
- A field survey among a sample of 30 persons who are not experts in the domain of biofuel development in Mali. Some of the surveyed persons (24) were selected among the urban population of Bamako and in Garalo (village located in the south of Mali in the Bougouni according to their age, sex, level of study and occupation).

In general, the interviewed persons think that the development of renewable energies and of biofuels is good because of the uncountable advantages that they (biofuels) present for developing countries, in particular in Mali. They can contribute to job creation, generation of income, and improvement of the living conditions of the rural populations through, e.g., electricity production. Another important aspect of the development of biofuels is the environmental protection against the negative effects of climate change (reduction of greenhouse gas emissions effects which contribute to global warming).

Their large-scale development in Mali would not only allow to fight against the poverty of rural populations but also to reach energy independence for the country from oil products. Ninety-five percent of the interviewed age group of 31–45 years is for the development of biofuels and 5 % against the development of biofuels.

Despite this support to the development of biofuels, some interviewed persons expressed worries about the success of the domain because of the difficulties encountered by some biofuel projects already implemented (in the country or locally).

11.6 Conclusion

It is shown that jatropha production in Mali offers a great opportunity to create local supply of energy, create additional income to rural farmers, contribute to local development, increase women participation in the value chain and increase their income, while contributing to a pathway towards a green economy. Although the models currently being developed have not caused any land conflicts or food security issues, the development of sustainability criteria based on these models is necessary to avoid any future negative impacts that are warranted due to the growing interest of large corporation in the sector. In addition, the expected growing prices of fuels will make the jatropha market more and more attractive and competitive. On the production side, data on yields are sparse and inconsistent partly due to the fact that jatropha is not yet fully domesticated. This stresses the need for stronger agricultural research for jatropha. Finally, the government, through ANADEB, must put in place a robust monitoring mechanism and develop sustainability criteria to ensure the sustainable growth of the field from established best practices.

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Chapter 12
Socio-Economic Impacts of Bioethanol from Sugarcane in Brazil

Arnaldo Walter and Pedro Gerber Machado

Abstract The impacts of sugarcane and ethanol production in Brazil are widely discussed in all steps of its production. The rapid expansion, the possible indirect land use changes, and the socio-economic impacts are of great concern for different stakeholders. As any economic activity, ethanol production and sugarcane cultivation have many positive and negative socio-economic impacts such as employment and income generation, health issues, and migration. In this chapter, three geographical levels of impacts and aspects are discussed for Brazil: national, with an overview of the country and the main macroeconomic impacts; regional, focusing on the Northeast region; and local level with two case studies, Pindorama mill and São Francisco mill.

Keywords Ethanol · Sugar · Brazil · Case studies · Sugarcane

12.1 Introduction

After its introduction in the country and for over two centuries, sugarcane was Brazil's most important product and one of the main pillars of the economy. In the 1970s, the sugarcane sector initiated a long transformation: a large-scale ethanol production program ("Proalcool") was created by the government aiming at the production of anhydrous ethanol for blending with gasoline. With the second oil crisis, started in 1979, hydrous ethanol was introduced in the market and, since then, the sales of light vehicles, able to run just with ethanol, increased very fast.

With decreasing oil prices in the mid-1980s, ethanol started to lose its competitiveness. The incentives given by the government were reduced and in a second moment ethanol lost room in some regions due to the introduction of Natural Gas Vehicles (NGV) in the late 1990s. However, almost at the same time, with the deregulation of

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Fig. 12.1 Sugarcane workers in Brazil. (Source: D. Rutz, WIP)

the sugarcane industry and the rising prices of oil, ethanol became a feasible option again. Nonetheless, the most important driver for the revival of hydrous ethanol was the introduction of flex-fuel vehicles (FFV) in 2003. In Brazil, the technology allows the use of any fuel blend, varying from gasohol (a blend of anhydrous ethanol—18–25 %, volume basis—with conventional gasoline) to pure hydrated ethanol. The acceptance of this technology and the relative low prices of ethanol allowed a large increase of the sales of FFVs; currently, almost 90 % of the new light vehicles sold are FFVs.

Being an important economic activity for the country, as it contributes with 2 % of the total GDP, the sugarcane sector is interlaced between industry and agriculture, and its impacts are obviously related to both sides of the supply chain. Due to the number of economic operators and the heterogeneity within the supply chain, ensuring sustainability of ethanol production is, therefore, a highly complex task, which requires a wide view of the system and its peculiarities.

This chapter deals with socio-economic impacts of the sugarcane industry in Brazil. For many years the sector has been criticized mainly due to the large number of temporary workers (Fig. 12.1) and to the tough working conditions on sugarcane harvest. Improvements have been observed, but the critics are still strong, partially because of the lack of accurate information and also because of the tendency of generalizing the worst cases.

12.2 General Data

In 2011, 559.2 million t of sugarcane was harvested for sugar and ethanol production (EPE 2012) and this total required 9.6 Mha (UNICA 2012). The production of hydrated ethanol reached 13.9×10^3 m^3, while the production of anhydrous ethanol was 9.120×10^3 m^3. Altogether, there was a reduction of 18.1 % comparing with the results of 2010 (EPE 2012). This result was mainly due to the lack of sugarcane, partially because of small investments in the agriculture, and also due to weather

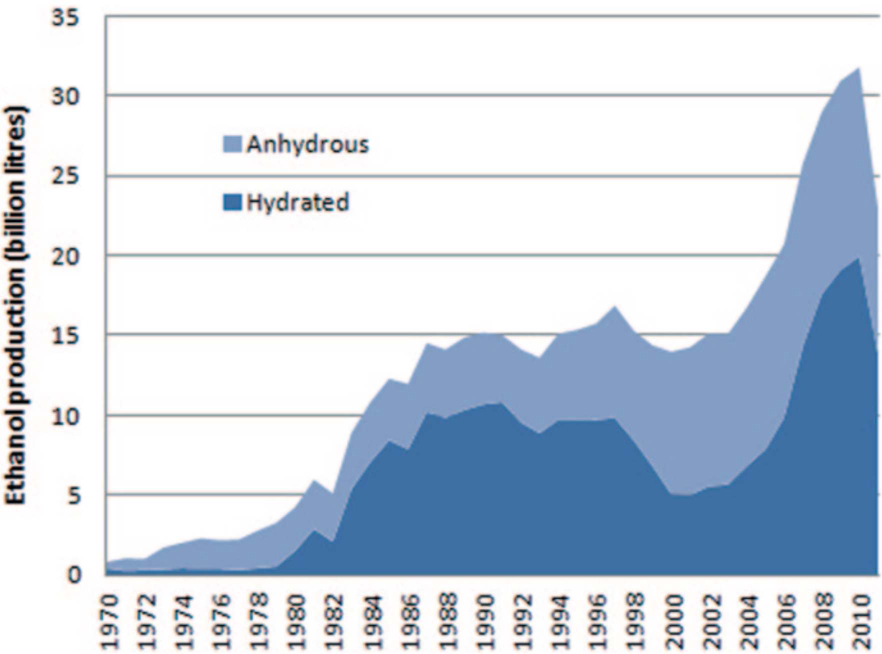

Fig. 12.2 Hydrated and anhydrous ethanol production—evolution 1970–2011. (Source: EPE 2012)

constraints. Figure 12.2 shows the evolution of ethanol production in the last four decades.

The exports of ethanol from Brazil were close to 2 million m^3 in 2011. Relatively to the year 2010, this volume increased only by 3%. On the other hand, in 2011, imports were 1.1 million m^3 of ethanol, 15 times more than 2010 (UNICA 2012). Atypical imports were due to the lower domestic production and exports were due to increasing demand in the USA for advanced ethanol (the Brazilian ethanol is the only one in a condition to fulfill the specifications).

As it is presented in Table 12.1, in 2010, 346 mills were located in the so-called Center-South region of Brazil. In 4 years, from 2006 to 2010, 98 new mills started operation in Center-South region.

In 2010, 246 mills were able to produce both ethanol and sugar, with some degree of flexibility between the two products (general sense, the production varies from 30 to 70% ethanol and, consequently, 70 to 30% sugar). In the same year, 163 mills were only able to produce ethanol (autonomous distilleries) and 17 mills were able to produce only sugar (MAPA 2011). The so-called "Brazilian model of ethanol production" refers to the combined production of sugar and ethanol, an option that brings some advantages to the producers, at least regarding risk reduction.

In 2011/2012, the bulk of sugarcane production (88%) occurred in the Center-South region and a small share in the North-Northeast region (12%, being more than 10% in the Northeast region). In the period 2000–2006, the production of sugarcane in states of the Amazon region was in average only 0.6% of the total. This

Table 12.1 Operating sugarcane mills in Brazil in 2010 and amount of sugarcane crushed (2011–2012). (Source: MAPA 2012; Conab 2012)

Region	State	Number of mills	Sugarcane crushed (1,000 t)
Center-South	Minas Gerais	40	49,741
	Espírito Santo	6	4,180
	Rio de Janeiro	7	2,174
	São Paulo	197	304,230
	Paraná	30	40,506
	RG do Sul	2	95
	Mato Grosso	9	13,154
	Mato Grosso do Sul	21	33,860
	Goiás	33	45,220
	Subtotal	346	493,160
North-Northeast	Alagoas	24	27,705
	Pernambuco	22	17,642
	Paraíba	9	6,723
	Bahia	4	2,557
	Maranhão	4	2,266
	Amazonas	1	287
	Piauí	1	992
	Tocantins	1	1,366
	Pará	1	666
	Rondônia	1	157
	Sergipe	6	2,548
	Ceará	3	120
	RG do Norte	4	2,973
	Subtotal	80	66,002
Brazil	Total	426	559,162

share has decreased to 0.2 % in the 2010/2011 harvest. In the state of São Paulo, the region with highest concentration of sugarcane mills—Ribeirão Preto—has the best conditions for this crop, considering soil quality, weather adequacy, rainfall, and topography. This region has a high concentration of sugarcane areas and land is relatively expensive there. In the state of São Paulo, the tendency is the installation of new producing units in the west side of the state, displacing pasture and, in a smaller extent, other traditional crops (e.g., orange).

An important characteristic of ethanol production in Brazil is that there is a high concentration of industrial capacity in large mills. The weighted average capacity in the Center-South region has been close to 2 million t of sugarcane crushed per year, and new mills tend to be even larger (about 3–4 million t/year).

12.3 Economics

The sugarcane industry has been settled in Brazil for centuries, since early colonization periods. This long presence in the country has given the knowledge and experience to create an important economic sector. After 2003, with the introduction of FFVs (Flex Fuel Vehicles), sugarcane production increased intensively due to the demand for ethanol. In 2008, the revenues for the mills were 4,562.7 million € due to sugarcane production and, for independent plantations, the revenue reached 3,658.4 million € (Neves et al. 2011). The industrial units earned 8.85 billion € with ethanol sales in 2008, both counting domestic and export markets.

The sugarcane industry generates wealth for other sectors of the economy as shown by Neves et al. (2011). The work done by the authors, using the methodology called Strategy Planning and Management of Agri-Industrial Systems, indicates that the sector generated 20.1 billion € in 2008, equivalent to 2 % of Brazilian Gross Domestic Product.

Ethanol and sugar are still the most significant products in terms of revenues, accounting for 8.9 billion € and 7 billion € in 2008, respectively. Bioelectricity generated 285 million € and it is expected to grow.

Figures 12.3 and 12.4 show the gross billing for different industries and their impacts on the production costs of the sugarcane sector.

In 2008, sugarcane cropping was responsible for 14 % of fertilizer sales in Brazil, with a consumption of 3.14 million t. As shown in Fig. 12.3, the expenses of fertilizers are among the largest in the agricultural phase.

With the increase in mechanized harvesting, the sales of new agricultural machines reached 981 units in 2008, i.e., a growth of 52 % compared to 2007. The sector bought 22 % of all harvesters sold in that year. Also in 2008, mechanized operations in sugarcane production and transportation from the field (to the mill) consumed almost 1 billion l of diesel oil and lubricants, according to Neves et al. (2011).

To quantify the billing of industrial equipment suppliers and companies that provide assembly services, the authors (Neves et al. 2011) considered the investments of the 29 industrial units that were built in 2008. The values shown in Fig. 12.4 represent the billings of these new units that started producing in 2008.

The GDP of the sugarcane sector was estimated for the Northeast region as well, using the country's average participation of the added value in the sugarcane, ethanol, and sugar production. The production value of the sector in the Northeast region in the year 2008, as well its added value, are presented in Fig. 12.5.

With a total GDP of 191 billion €, the sugarcane sector represented, in 2008, 0.76 % of the GDP of the Northeast region. Sugarcane contributed with 0.246 %, ethanol with 0.239 %, and sugar production with 0.276 %.

12.4 Social Aspects

12.4.1 Employment

There are two main sources of information regarding employment in Brazil: RAIS (instead) (Annual Social Information), and PNAD (National Survey by Household Sampling). RAIS is an administrative registration system that compiles yearly at

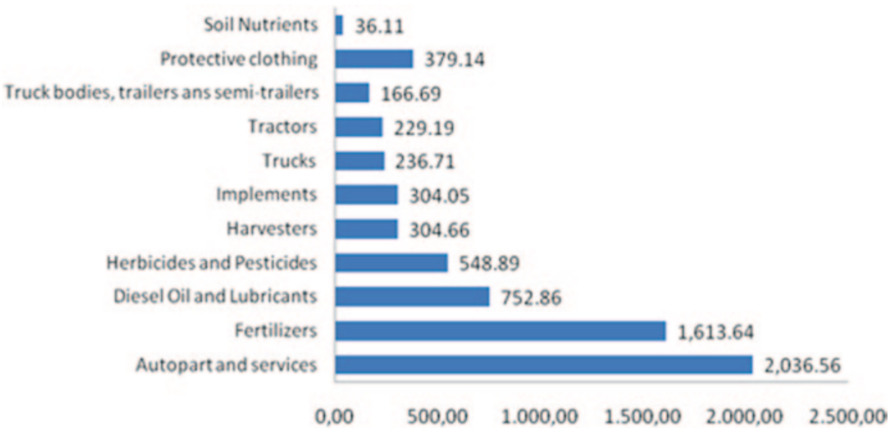

Fig. 12.3 Billings of agricultural inputs in 2008 (in million €). (Source: Neves et al. 2011)

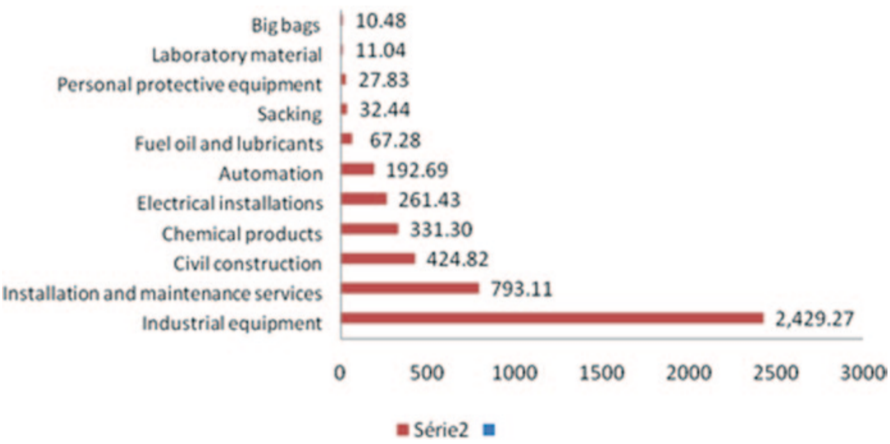

Fig. 12.4 Billing of industrial inputs in 2008 (in million €). (Source: Neves et al. 2011)

least 97% of all formal jobs. Every company has the obligation of reporting how many employees they have, as well as other social information, such as age, education level, length of service, and revenue; the results are published according to the occupational level, geographical regions, and economic sectors. The results also contain information on the number of jobs by size of establishment, payroll, and nationality of the employee.

PNAD, on the other hand, investigates general characteristics of the population, like education, work, income, and housing. It is based on a sample of the population and uses statistical methods. Estimates for the whole country are provided. When used in employment studies, it has the benefit of capturing the informal labor market.

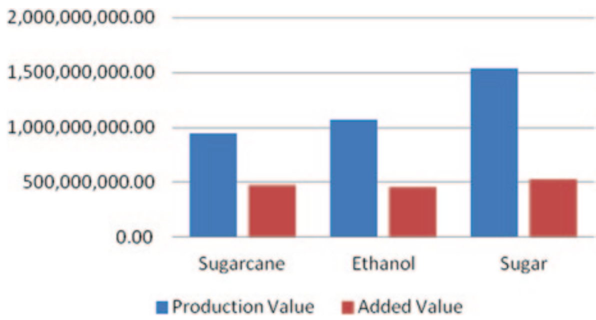

Fig. 12.5 Sugarcane chain's added values and production values in Brazilian currency in 2008 (exchange rate: 1 € for R$ 2.2)

Table 12.2 Number of employees in the sugarcane sector (formal and informal) in 2009. (Source: PNAD 2010)

	Total	%
Sugarcane farming	576,353	68.9
Sugar production	125,311	15.0
Ethanol production	135,058	16.1
Total	836,722	100

Both systems were used to estimate the number of jobs generated by the sugarcane sector. Under RAIS, the number of active employees (working at the moment data were registered) in the sugarcane sector in 2010 was more than 612,000 formal jobs, being 183,700 in the sugarcane fields. The ethanol industry had 111,300 active employees in the formal market. The number of terminated employment in the year is an important information, since it gives an insight on how dynamic the sector is. Terminations of contracts are very common due to the seasonal characteristics of sugarcane production. Table 12.2 shows the number of employees on the formal job market for the sugarcane sector, from 2007 to 2010; the data basis is RAIS.

In order to capture the information regarding informal jobs, PNAD's data set was also analyzed. As it can be concluded from a comparison between Tables 12.2 and 12.3, it can be estimated that the informal job market represented about 25 % of all employees in 2009.

According to PNAD, sugarcane farming activity employed over 576,000 people in 2009, while ethanol production employed over 135,000. This result includes the informal jobs.

The difference between the numbers of employees provided by both databases is clear. It is important to keep in mind that PNAD's data set result from a statistical analysis, done by interviewing a sample of the total population, while RAIS results from a direct compilation from the government, with information provided by the companies and employers themselves. PNAD is made with a sample of 399,000 people in different regions of Brazil, and then a weight factor is used to generalize the information to the whole population. Institutions used to mention the results by RAIS in order to give a figure of employees involved with sugarcane sector, e.g., about 1.2 million people by the end of 2010, but from this total only 613,000 were active employees at that moment and about 436,000 have been dismissed or had their contracts finished.

Based on econometric analysis it can be concluded that white workers are better paid, and incomes are higher as higher the educational level. In general, men receive more than women, and the employee working in ethanol production has a higher income than in sugar production. On average, the sugarcane employee is 35.4 years old and has 5.7 years of study. They work on average 46.7 h a week and have an income of 387.7 €/month (at the same time, the minimum wage in Brazil was 236.9 €). It is estimated that 68.8 % of the workforce is concentrated in the agricultural production, and 68 % are brown or black, and 90 % are men.

In the Northeast region, the formal job market in the sugarcane sector stayed almost constant from 2007 to 2010, as shown in Table 12.4; the variation in this period was only 2.4 %. The expansion of sugarcane cropping has not been in this region, due to the lack of good soils and also because of the constraints for mechanization (because of too steep slopes terrains).

In the sugarcane sector, in Northeast, workers are on average 34.6 years old, work 46 h a week, and have 3.7 years of education. The average income is 245.42 €. It is estimated that 80.5 % of the working force is brown or black, 83 % work in the agricultural side, and men represent 95 %. In 2009, the total number of employees for the sector in the region, including informal workers, was 310,722 active employees (PNAD 2010). The figures for workers at the sugarcane farming activity in Northeast are even worse: they have on average 3.3 years of education, earn 216.5 €/month and the average age is 34 years.

In the sugarcane sector, which includes the cultivation of sugarcane and the industrial production of ethanol and sugar, the participation of rural workers, especially cutters, represents approximately 68 % of the total.

12.4.2 Working Conditions

The main concerns regarding working conditions are related to the agricultural side of the supply chain, mainly when manual harvesting system is predominant. The main issues listed in different studies are: housing conditions, water provision during working hours, adequacy of tools, intoxication risk, personal protection equipment, inadequate rest time, transportation conditions, and quality of the meals.

As cutter's payment is directly linked to the amount of sugarcane harvested, many consider that working conditions are very inadequate and that workers are forced to work more. In fact, productivity has nearly doubled in 20 years, and there was no change of working tools (Alves 2006). Currently, the expected productivity is 10 t/day per cutter. However, it should be mentioned that this payment option has been imposed by the workers' union many years ago.

Forced labor is also a concern within the sector. According to the ILO's Convention 29 of 1930 (International Labour Organization), forced labor is defined as "all work or service exacted from any person under the menace of any penalty and for which has not offered himself voluntarily." In Brazil, there is a systematic procedure for verifying working conditions and reports are annually presented by the

Table 12.3 Active employees and employment terminations in 2007–2010 (formal jobs). (Source: RAIS 2010)

	Unjustified dismissal	End of employment contract	Resignation	Active employee	Other	Total
2007						
Sugarcane farming	134,898	97,512	50,891	181,847	32,522	497,670
Raw sugar production	105,748	86,896	37,883	295,188	39,183	564,898
Refined sugar	1,269	928	158	4,828	66	7,249
Ethanol production	42,073	31,446	18,428	90,331	8,616	190,894
Total	283,988	216,782	107,360	572,194	80,387	1,260,711
2008						
Sugarcane farming	138,378	73,994	51,694	188,036	29,560	481,662
Raw sugar production	117,763	87,640	42,601	296,708	16,580	561,292
Refined sugar	1,762	1,804	1,031	8,418	776	13,791
Ethanol production	52,132	33,034	23,238	107,300	10,809	226,513
Total	310,035	196,472	118,564	600,462	57,725	1,283,258
2009						
Sugarcane farming	115,364	64,898	35,544	191,306	17,915	425,027
Raw sugar production	115,167	76,017	31,399	314,435	17,603	554,621
Refined sugar	1,735	3,826	1,010	11,587	1,148	19,306
Ethanol production	48,183	28,654	16,049	111,883	8,548	213,317
Total	280,449	173,395	84,002	629,211	45,214	1,212,271
2010						
Sugarcane farming	118,071	63,392	32,741	183,742	22,114	420,060
Raw sugar production	104,595	70,291	33,620	310,206	17,201	535,913
Refined sugar	2,023	1,083	695	7,291	1,673	12,765
Ethanol production	46,796	30,646	16,156	111,310	8,200	213,108
Total	271,485	165,412	83,212	612,549	49,188	1,181,846

government. In case of the sugarcane industry, despite representing a small share of the reported cases across the country (7 % in 2009), these cases accounted for 31 % (1,911) of all workers involved in situations classified as slavery-like conditions. In São Paulo state, the largest producer of sugarcane, there was no single reported case of forced labor until 2009, but several labor irregularities were reported. The bulk of irregularities identified were related to the lack of rest after six consecutive hours of

Table 12.4 Active employees and terminations in the sector in the Northeast region 2007–2010. (Source: RAIS 2010)

	Unjustified dismissal	End of contract	Resignation	Active employee	Others	Total
2007						
Sugarcane farming	12,789	17,555	4,878	45,121	2,173	82,516
Raw sugar production	40,785	43,199	10,615	144,473	6,684	245,756
Refined sugar	753	807	52	3,433	32	5,077
Ethanol production	4,991	6,323	1,607	22,130	610	35,661
Total	59,318	67,884	17,152	215,157	9,499	369,010
2008						
Sugarcane farming	14,793	18,090	4,712	43,879	1,671	83,145
Raw sugar production	47,136	41,009	12,002	147,316	6,881	254,344
Refined sugar	1,254	1,425	722	7,205	300	10,906
Ethanol production	7,421	6,335	1,350	21,636	416	37,158
Total	70,604	66,859	18,786	220,036	9,268	385,553
2009						
Sugarcane farming	14,411	15,652	4,305	41,196	1,462	77,026
Raw sugar production	48,333	39,938	9,942	148,700	3,472	250,385
Refined sugar	1,285	3,499	858	9,764	801	16,207
Ethanol production	6,205	7,199	1,227	22,317	3,155	40,103
Total	70,234	66,288	16,332	221,977	8,890	383,721
2010						
Sugarcane farming	16,671	22,352	4,221	48,060	1,171	92,475
Raw sugar production	42,747	36,587	12,634	137,128	3,307	232,403
Refined sugar	1,207	981	517	5,783	1,204	9,692
Ethanol production	6,845	8,699	1,916	25,420	316	43,196
Total	67,470	68,619	19,288	216,391	5,998	377,766

work, excessive working hours along the day, failures on the records of employees, work on Sundays without authorization, and irregularities due to unhygienic toilets (Reporter Brasil 2010).

On the other hand, there are signs that companies are acting for improving working conditions and for enlarging the benefits given to the workers. Table 12.5 shows the benefits provided by sugarcane companies, based on a sample of 47 producing units.

Table 12.5 Benefits provided by sugarcane companies (2008). (Source: Adapted from Barbosa 2008)

Benefits	% of sample
Health insurance	95.7
Dental plan	93.5
Transportation	93.3
Group life insurance	91.5
Meal	87.0
Pharmacy AID	85.1
Hearing treatment	63.8
Christmas basket	59.1
Credit cooperative	37.8
Staple food	43.5
Education AID	35.6
Illness AID	20.0

The work of cutting cane depends basically on the strength, dexterity, and agility of the worker. This activity is of high risk for health, and Rocha (2007) indicates that the main diseases are linked to the execution of movements that require adoption of poor posture and to being exposed to adverse environmental conditions, such as solar radiation, intense heat, and large amounts of dust and soot. The work performed by the cutters exceeds the limits of tolerance of the musculoskeletal system and may cause diseases such as back pain, neck pain, tenosynovitis, tendonitis, bursitis, and arthritis. Many studies also indicate deaths in the cane fields, during or after the worker's activity (nine deaths in 2010, according to RAIS). Besides the deaths occurring in the cane fields, there are those not registered and occurring over a given time. Diseases such as cancer, caused by the use of poison sugarcane soot, respiratory illnesses, and those related with column impacted the workers also because their lack of financial resources (Mendonça 2007).

When it comes to accidents and occupational diseases, there are many concerns regarding sugarcane cultivation. In the late 1990s (between 1997 and 1999), 40 % (14,661) of the accident types (accidents resulting from the worker's activity) that occurred in agriculture in the state of São Paulo were in sugarcane cropping, being the share of occupational diseases (any disease peculiar to a particular activity) even higher (52 %). Considering the total work-related incidents in the state at that time, the cultivation of sugarcane was responsible for 28 % of the accidents and 38 % of the diseases. Fortunately, only 0.15 % of the total cases of accidents resulted in deaths and only 0.11 % caused permanent arrest (Teixeira and Freitas 2003).

When it comes to accidents, UNICA (Union of Industries of Cane Sugar) shows that in 2010 there were 6,075 accidents in the agricultural area and 2,552 in the industrial/management of its associated companies (a set of 88 plants for these data). According to the source, investments related to health and safety summed more than 39.5 million €. Putting in perspective, this represents 0.3 % of the sales of the producing units (UNICA 2011).

The number of retirements and deaths due to labor accidents and labor diseases in sugarcane production is displayed in Table 12.6. Although the numbers are relatively low, sugarcane is responsible for most deaths due to labor accidents in the

Table 12.6 Labor accidents and retirements in 2010. (Source: RAIS 2010)

	Death due to labor accident	Death due to working rout (residence–work place)	Death due to labor-related disease	Retirement due to labor accident	Retirement due to labor-related disease	Total
Sugarcane farming	9	0	0	11	20	40
	10.34%	0.00%	0.00%	8.21%	12.27%	9.80%
Grain farming	3	0	3	6	17	29
	3.45%	0.00%	42.86%	4.48%	10.43%	7.11%
Cotton and other fiber farming	1	2	0	0	1	4
	1.15%	11.76%	0.00%	0.00%	0.61%	0.98%
Tobacco farming	0	0	0	1	0	1
	0.00%	0.00%	0.00%	0.75%	0.00%	0.25%
Soy farming	12	0	0	10	6	28
	13.79%	0.00%	0.00%	7.46%	3.68%	6.86%
Other temporary crops	6	2	0	2	3	13
	6.90%	11.76%	0.00%	1.49%	1.84%	3.19%
Total agricultural activities, livestock, and related services	87	17	7	134	163	408
	100%	100%	100%	100%	100%	100%

agricultural sector, as well as the number of retirements due to labor-related diseases and accidents. This should also be related to the number of employees working at the farming process. Sugarcane, in 2010, according to RAIS, had 184,039 workers in the field, while cotton, soy, and tobacco had 14,241, 89,351, and 1,511 employees on the field respectively. So, the number of accidents is not only related to the dangers of the activity, but rather to the high density of human force in the sugarcane fields.

In addition to labor-related health problems, sugarcane burning also affects the health of people living in areas where burning is intense (Arbex et al. 2000). Epidemiological studies conducted in two counties in the state of São Paulo (Araraquara and Piracicaba), which are surrounded by sugarcane fields, show that respiratory morbidity increased significantly with the concentration of aerosol particles from sugarcane burning (Arbex et al. 2000; Arbex et al. 2007; Cançado et al. 2006). During the sugarcane burning season of 1995 in Araraquara, a study found a significant correlation between the daily number of patients who visited hospitals in the region for inhalation treatment due to respiratory diseases, and the mass of particle aerosols (Arbex et al. 2000). In a second study, conducted in the Piracicaba region, Cançado et al. (2006) found a significant correlation between PM2.5 (particulate matter ≤2.5 µm), PM10 (particulate matter ≤10 µm), and black carbon concentrations, and the number of children and elderly patients admitted to hospitals. According to their results, increases of 10 µg/m^3 of the PM2.5 concentration lead to an increase of 20 % in the number of hospital admissions. The emissions of particulate matter should reduce since the decrease in sugarcane burning started. In 2010, for example, 54 % of the total sugarcane was burned, and this number dropped to 44 % in 2011. The impacts of this reduction of sugarcane burning on health are yet to be studied.

Regarding education, UNICA (Sugarcane Industry Union) and its associates have promoted workers' retraining due to the growth of mechanized harvesting and to the lack of qualified working force. According to the source (UNICA 2011), in 2 years almost 5 million € in agriculture and more than 5.9 million € were invested in the industrial area; putting in perspective, this represents 0.09 % of total declared income of associates for the year 2009.

12.4.3 Land Use and Land Competition

An important issue regarding bioenergy production is the competition for land, especially when it comes to land for food production. The area cropped with sugarcane in 2011 accounted for 1.1 % of the total area of Brazil, or 3.3 % of the total area currently available for agriculture and livestock. However, at least in theory, its expansion throughout the country can generate conflicts with other food crops and livestock.

According to Ortiz (2007), the land market is an important component in the expansion of monocultures with consequent pressure on small and medium landowners. In that sense, the expansion of sugarcane is facilitated by a weakly ordered land market, both legally and socially, which leads to positive effects on production costs, while concentrates land ownership and prevents the practical uses by family farms. Since the increase in sugar industry's production is related to the expansion of cultivation in new areas, this leads to a reconfiguration of the geographic space and a pressure on livelihoods and rural activities.

A reasonable share of the supply of sugarcane in Brazil is due to small producers, with an average production range from 1,000 to 6,000 t and an average area of 60 ha. This is due to the high levels of land leasing in the sector. For Ortiz (2007), the land lease is the foundation to the expansion of sugarcane plantations and triggers a change in the complex types of production, the availability of jobs, in the migration to cities, food supply, and the possibility of demarcating land for agrarian reform.

In the state of Mato Grosso do Sul, land conflicts grew by 87.5 % between 2003 and 2005, rising from 16 to 30 conflicts. The author points out that during the year 2004, 24 occupations were performed, with 15 of these in municipalities where new sugarcane plantations are being designed (Ortiz 2007).

Studies based on satellite images covering the Center-South region (close to 90 % of the sugarcane production) show that between 2000 and 2010 sugarcane expansion occurred mostly over pastures (69.7 %), followed by annual crops (25 %),

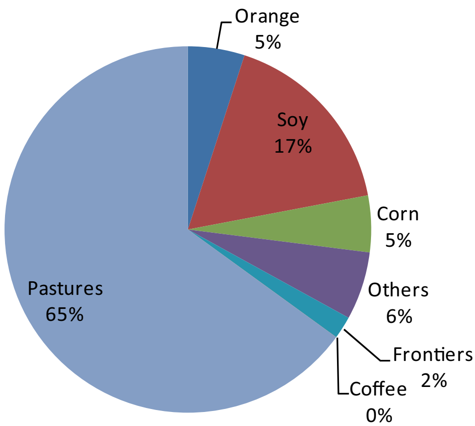

Fig. 12.6 Change in crops in the fields of sugarcane expansion. (Data source: MAPA 2009)

citrus (1.3 %), forest (0.6 %), and sugarcane land under crop rotation (3.4 %). These results are close to those presented by the Ministry of Agriculture and the National Supply Company (see Fig. 12.6) that shows that the expansion occurred mainly over pasture lands, due to increase in livestock productivity.

Nevertheless, when specific years are considered, the conclusions can be different. For instance, a study from *Reporter Brasil* (Reporter Brasil 2009), also based on the same satellite database previously mentioned, but just for the year 2008, shows that the sugarcane expansion in some states took place over other crops such as the case in Goiás (75 %), Minas Gerais (65 %), and Mato Grosso (57 %).

12.5 Local Level Case Studies

At the local level the system boundary is a local area from, for instance, a farmer, a company, an association, or project level. The local area refers to the area where the biomass feedstock (including by-products) is produced and converted into the final or intermediate product. In the context of the case studies developed during the Global-Bio-Pact project, two cases were selected and investigated in Brazil: the São Francisco Mill and the Pindorama Mill.

São Francisco Mill was selected since it has a different model of production. It is located north of São Paulo state and is the largest organic sugarcane producer in the world. The hypothesis to be explored was that the differences between regular and organic sugarcane production should also correspond to different socio-economic and environmental impacts. It belongs to Balbo group.

On the other hand, Pindorama Mill was selected since it is a cooperative. This managerial system is not very common in Brazil, and Pindorama is the only cooperative in the sugarcane business in the Northeast region. Pindorama is situated in Alagoas, one of the poorest states in Brazil. The location of both mills is presented in Fig. 12.7.

Fig. 12.7 Geographical position of the two case studies considered

12.5.1 Case Study at the Local Level: São Francisco Mill

São Francisco mill is located 356 km away from the capital, São Paulo. The total sugarcane production area is 7,500 ha in the São Francisco mill, plus 6,000 ha in Santo Antônio mill. According to UNICA (2009), São Francisco mill and its suppliers produced 1,291,223 t of sugarcane in 2009, and the mill alone produced 83,941 t of sugar. In this sense, the mill is a small to medium unit considering Brazilian averages.

When São Francisco was established, the main objective was the development of a self-sustaining production system of sugarcane. After a decade of research, from 1987 to 1997, the São Francisco unit received the certificate of organic farming. Organic production does not allow the use of chemical fertilizers or pesticides. The control of pests is biological and the cane is cut raw. Special mechanical harvesters deposit straw and green leaves to the soil, optimizing the use of industrial organic wastes as sources of nutrients. There is practice of green fertilizing in a system of crop rotation.

The production system developed by the Balbo group allowed harvesting cane without burning. The harvesters, while they take away the cane, promote the deposition of green leaves in the soil, creating mulch that protects it from erosion and heat stroke. The soil also receives liquid and solid organic waste from the industry. As the production cycle of a sugarcane field is approximately 6 years, during which they get five crops, the soil is ploughed only every 6 or 7 years. Furthermore, machines and vehicles have mats and high flotation tires to minimize soil compaction. All these techniques help maintaining soil's fertility, creating a favorable environment for the action of beneficial microorganisms and the infiltration of air and water, essential for plant development. According to the mill, the combination of required practices (e.g., the biological control of pests and diseases and green manure in crop rotation with legumes and other crops) and the proper management of weeds, and the creation of islands of biodiversity in the midst of culture ensure the balanced coexistence and harmony between the farmer and nature.

Besides all the agreed practice of organic agriculture, biodynamic farmers (part of the mill's production is also biodynamic) also use:

- Lunar calendar based on astronomy
- Biodynamic preparations

The calendar suggests the most appropriate time for planting, processing, fertilization, cutting, and harvesting, according to the position of the moon and planets. The biodynamic preparations are homeopathic compounds made with medicinal herbs, minerals, and manure. They undergo a special process of fermentation and under the influences of the rhythm of the earth and the sun; these preparations are applied directly on the ground and on plants, helping the development of roots and fruit quality.

From sugarcane and organic industrial processes, Native (the brand behind the São Francisco mill) produces organic alcohol, which can be applied in industries such as cosmetics and pharmaceuticals, for example. Native also produces sugar and exports 85 % of its production, being 90 % to Europe and USA and 10 % to Asia, especially Japan.

São Francisco mill produces about 1.4 million t of cane per year, as said, in total 13,500 ha. Recently, the total production was 85,000 t of sugar and 65,000 l of ethanol. From the total amount of ethanol, 14,000 l are hydrated organic.

The total number of employees during the harvest season is about 4,000 people, divided into the agricultural, industrial, and administrative sectors.

In 2009, Balbo group's organic sugar and ethanol division received the Ecosocial seal. Conceded by IBD (Biodynamic Institute), it establishes minimum social and environmental criteria to be completely accomplished, as well as actions for enhancing the performance regarding these aspects.

To receive the Ecosocial seal, all employees must be under the CLT regime, which is the main legislative provision related to the Brazilian labor law. The temporary workers (mainly those who work on the harvest) are hired under a "harvest contract," with a specific duration of 180 days. These rural workers are protected by NR–06, a regulatory standard for personal safety equipment (known

Table 12.7 Expenditures with social care and benefits - São Francisco mill (2009)

Item	Expenditure (in 1,000 €)	%
2009 payments (wages)	28,856.59	70.23
Total vacation	3,182.13	7.74
Social security contribution	2,800.15	6.81
13th salary	2,623.33	6.38
Private pension	1,551.20	3.78
In traffic hours payments	939.31	2.29
Maternity leave, paternity leave, and other leaves	3.67	0.01
Health insurance	1,031.61	2.51
Pharmacy aid	93.51	0.23
Dental care	8.22	0.02
Total	41,089.71	100

as EPI, in Portuguese), and are paid considering "traveling hour," which means they start getting paid the moment they get into the workers' bus.

The social projects conducted by São Francisco mill are divided in two areas: those to the employees and their families, and those targeted to the external community, under a 50-km distance from the mill.

The company has a profit-sharing program, based on a productivity incentive that aims to establish a form of recognition of the company to its employees for the effort expended in meeting or exceeding corporate goals. (see Table 12.7)

In the context of the Global-Bio-Pact project, it was not possible to do an accurate survey on the other mills located in the same region. In this sense, it is not possible to state if São Francisco mill has a better performance from a social point of view than the other sugarcane companies in the same region. On the other hand, considering the average figures of the whole sugarcane sector, in Brazil, it is possible to state that the São Francisco mill presents better results. This is probably related with the fact that the production and exports of organic sugar is very important for the company and exports are only possible with certified production. The certification schemes require a better performance (than the average) from a social point of view.

In this regard, the previous hypothesis was confirmed, that is, the focus on the production of organic sugar results better results from a social point of view than the average figures of the sugarcane sector.

12.5.2 Case Study at Local Level: Pindorama Mill

Pindorama is a cooperative of agricultural farmers, created in 1956 by a Swiss citizen and located 120 km away from Maceio, that is Alagoas' capital. In the 1950s, there was a great exodus in the Northeast. People went to look for work in São Paulo and Paraná, mainly in coffee plantations due to lack of opportunities in that region. It was in 1953 when Henri Bertholet, who had arrived in Brazil in 1949 and was based in Guarapuava (PR) (South region), was invited by the Brazilian government to

Table 12.8 Disaggregation of the total sugar and ethanol costs provided by the financial department at Pindorama mill

	Contribution to total costs (%)
Raw material (sugarcane)	69.86
Labor	7.62
Direct materials	1.75
Industrial process	7.99
Harvest of sugarcane	8.59
Operation and maintenance	3.97
Other	0.22

join a working group in order to colonize the northeast, retaining the rural workers in their natural habitat. He accepted the invitation, and when arrived at that region identified the lands that belonged to a local family and that was home to a bankrupt project financed by a state-owned bank, Bertholet proposed the federal government to take the land on account of debt, developing a project that resulted the creation of the Cooperative Pindorama. In the period 1953–1956, he worked to organize the cooperative, with the recruitment of the first settlers and division and delivery of lots.

As a cooperative, it is formed by 1,160 small producers, who are the owners and the only providers of raw materials. The total cultivated area for fruits and sugarcane is 32,000 ha. The size of the lots range from 9 to 25 ha. Today, Pindorama is a major producer in the region, being among the 100 largest tax contributors in Alagoas, reaching in 2009 revenues of R$ 125 million.

Initially, its main product was passion fruit and it slowly moved into juice production. Pindorama diversified their products: ethanol since 1982 and sugar since 2003. They also cultivate other fruits for juice production. The 2009/2010 production of sugarcane was 608,000 t, resulting in 32,549 t of sugar and 35.6 million l of ethanol. The production in the last harvest season was expected to be 900,000 t, with 50 % designated to ethanol production and 50 % to sugar production.

Ethanol is sold to big companies like Petrobras, Ipiranga, and Shell. About 15–20 % of the sugar is exported. The expected sugar production is of 40,000 t and ethanol production is expected to be 45 million l for the 2010/2011 harvest period.

Currently, Pindorama's productivity is estimated at 70 t/ha of cane (5,000 t/day) which is quite high due to the rains. The average yield in the Northeast region is 55 t/ha. A 20 % growth in productivity is expected in the next 4 years.

The disaggregation of the total sugarcane and ethanol costs at Pindorama mill are shown in Table 12.8.

Pindorama has a total of 1,823 employees. From the total, more than 50 % are fixed employees and the others temporary workers, working 8 h a day (from 7 am to 4 pm). In the mill sector, there are 250 workers, divided in 3 shifts of 8 h each. From all the cane cutters, 56 % have less than 8 years of education. For the other 44 %, there is no information.

According to the company, Pindorama makes a big effort to provide social benefits to their employees, associates, and their families. The so-called CETRUP (Centro de Treinamento Rural de Pindorama), offers professional training to local people. They have educational projects such as reading and computer classes, as well as sewing, handcraft, and silk screen printing classes. A group of approximately 45–50 local seamstresses make and provide the uniforms for all the employees in

Table 12.9 Price paid per t of cane cut. (Source: FETAG 2010)

Sugarcane cut	
Burned cane, minimum price for 4 t	R$ 4.35 (1.89 €)
Burned cane, minimum price for 4–8 t	R$ 4.60 (2.00 €)

Pindorama which includes individual protection equipment. An additional project in Pindorama includes a vegetable garden run by locals where the products are for own consumption. Another important project is the pepper garden. The participants are mostly young students, who can sell their production every week for R$ 500. The participants in the social programs receive psychological support if needed and receive also education for regular school. Most of the local people enjoying these benefits have a high chance to stay working at the cooperative.

The cooperative Pindorama is an example for a good land reform in the country. To reach its goals of social inclusion, the cooperative develops, aside its partners, projects that seek education, professional capacity, and employment and income growth.

The sugarcane cutters are provided with fresh water, bathroom facilities, shadow, tables and chairs, and two snacks during the working hours. The workers are brought to the field by special buses. They also have 1 h of lunch break. The cutters have a leader, who controls the amount of sugarcane they cut each day. The average harvesting per man is 8 t/day, sometimes reaching 10 t/day. The amount of sugarcane cut influences the cutters salary. They are all guaranteed with a basic salary of R$ 557 per month (242.1 €) but if the cutter's productivity is high, its salary would be also higher. The current tariffs paid for the amount of sugarcane cut for Alagoas region is given in Table 12.9. Pindorama mill has life insurance to all workers including the temporary workers. Fifteen accidents with leave of absence were registered in 2009/2010 harvest period, being 11 among rural workers and 4 in the industrial site.

As for the regional context, it is possible to compare Pindorama with other sugarcane business in the region. Coruripe mill, for example, is the largest industrial sugarcane unit located in Northeast region and is nearby the Pindorama mill: in 2012, Pindorama crushed 924,000 t of sugarcane, while Coruripe crushed about 3 million t, i.e., Coruripe is about three times larger than Pindorama. In the context of the Global-Bio-Pact project it was possible to visit both mills.

In general, Coruripe has more environmental and social programs than Pindorama, and this can be understood by its largest economic power. The main issues are addressed by Pindorama, but also in general sense, everything is simpler there in comparison to Coruripe mill.

In the Pindorama case, the largest advantage is for sugarcane producers, as they are associated to the cooperative. In regard to the workers, it was not possible to notice any advantage in comparison to other mills in the same regions and with the Coruripe mill. However, it is fair to state that no specific problem was noticed.

In this regard, the previous hypothesis was partially confirmed, that is, the ownership by a cooperative brings some advantage, from a social point of view, along the supply chain. The impact in the municipality and surrounds is partially shadowed by the fact that there are other mills in the region, and one of them is the largest in Northeast Brazil.

12.6 Conclusions

The social impacts of large-scale ethanol production in Brazil are a controversial issue. Due to the size of the industry and the large number of stakeholders, it is very easy to identify good and bad examples. Two consensual points are, first, that improvements are noticed and, second, that there is still a lot to do in order to have all main problems solved.

Working conditions are very tough in the sugarcane supply chain, mainly in the harvest stage. Mechanization is advancing very fast and in few years the number of sugarcane cutters will be extremely reduced. In general, working conditions are similar or even better in the sugarcane sector in comparison to other agricultural sectors.

In the context of the Global-Bio-Pact project, two case studies were investigated: one considering a sugarcane mill located in state of São Paulo, that is the richest area in the country, and one considering a mill located in state of Alagoas, that is one of the poorest regions in Brazil. The importance of sugarcane activities is clear in both cases, mainly because both studied regions depend a lot on the sugarcane industry. However, a simple comparison is not possible, because the differences between the two states is very large which can be noticed when single indicators are compared (for instance, wages and benefits given).

The two case studies were chosen based on two hypotheses that are verified. In the case of São Francisco mill, that produces organic sugar and has its production certified, social impacts are larger than in the sector as whole, in average terms. In this sense it can be concluded that sustainability initiatives and certification schemes can have a positive impact as long as environmental and social aspects are considered. In the case of Pindorama mill, that is a cooperative of farmers, at least suppliers of sugarcane have more benefits comparing with the conventional situation in which small farms rent the land or work as outgrowers of large companies.

It seems that certified production is a tendency in Brazil, as many sugarcane companies want to reach international markets of sugar and ethanol. On the other hand, there are few cooperatives in the agricultural sector in Brazil, and even less in the sugarcane industry. In this sense, the experience and the results of Pindorama mill should be disseminated.

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Chapter 13
Socio-Economic Effects of the Sugarcane-to-Ethanol Production Chain in Costa Rica

Abigail Fallot and Adriana Cárdenas

Abstract Climatic conditions are favorable in Costa Rica to high-yielding biomass feedstock such as sugarcane and African palm. Sustainability and certification are important and current issues in Costa Rica, a country hosting biodiversity hot spots, touristic activities and dynamic agro exporting businesses. Geographical characteristics (central volcanic mountain range, coastal areas on both western and eastern fringes) and active forest and biodiversity conservation policies make large-scale production schemes impossible or, more accurately, "large-scale" does not hold the same meaning in Costa Rica as larger South American countries such as Brazil or Argentina. The land where sugarcane is grown cannot increase much without competing with other agricultural (mainly coffee) and nonagricultural land uses. This chapter describes socio-economic impacts of ethanol production from sugarcane in Costa Rica.

Keywords Costa Rica · Sugarcane · Ethanol · Molasses · Case studies

13.1 Introduction

Sustainability and certification are important and current issues in Costa Rica, a country hosting biodiversity hot spots, touristic activities, and dynamic agro-exporting businesses. The country is therefore quite proactive in sustainability standards, engaged in several environmental and social certification procedures, such as FSC (forestry), Rainforest Alliance (coffee), CST (tourism), and, already for sugarcane ethanol, the ISCC (International Sustainability and Carbon Certification).

Although climate conditions are favorable for high-yielding biomass feedstock such as sugarcane and African palm, geographical characteristics such as central volcanic mountain ranges (Fig. 13.1) and coastal areas on both western and eastern fringes, as well as active forest and biodiversity conservation policies make large-scale production schemes impossible. More accurately, "large-scale" does not hold

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Fig. 13.1 Sugarcane field in front of an ash cloud from a volcano in Costa Rica. (Source: D. Rutz, WIP)

the same meaning in Costa Rica as in larger South American countries such as Brazil or Argentina.

The land where sugarcane is grown, 53,000–64,000 ha according to latest FAOSTAT data (2009–2011), cannot increase much without competing with other agricultural (mainly coffee) and nonagricultural land uses. Decisions on land use must be considered within comparative outlooks, taking into account not only differences of performance (e.g., yields, net benefits), but also complementarities between land uses (calendar of activities, market diversification, and climate sensitivity, among others).

Costa Rica is dehydrating imported Brazilian ethanol, which is later exported to the USA with tariff exemption. Its capacity for that matter amounts to 97 million l. Ethanol can also be produced out of locally grown sugarcane in two distilling plants in the country, of respective 16 and 20 million l capacities (Acuña 2012). However, ethanol production has not started yet on an important and regular basis, because relative prices of sugar and ethanol do not provide adequate incentives. Current production relate to specific foreign orders for neutral alcohols. Therefore, the evaluation of the socio-economic impacts of ethanol production is based on very specific data and represents a rather ex ante evaluation of those impacts that could be expected from the development of ethanol production in Costa Rica if the national biofuel program aiming at substituting 10% of national fuel consumption were to be implemented.

Given the small size of Costa Rica (51,100 km^2) and the limited volumes of sugarcane ethanol production, only two assessments were made: one at the national level and one at company level.

13.2 The Framework for a Nascent Industry

Located in the Central American Isthmus, Costa Rica's 5.1 million ha shares a border with Nicaragua to the north and with Panama to the south and comprises 1,228 km of coastline and over 100 volcanic cones, of which several are major volcanoes.

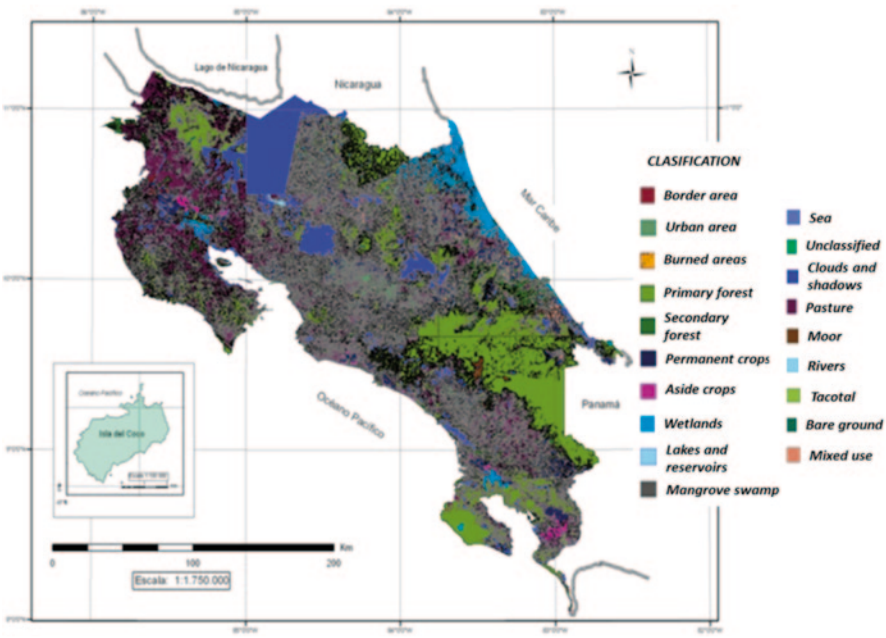

Fig. 13.2 Land uses in Costa Rica. (Source: PNUD-IMN-MINAET 2009)

The Central and Talamanca mountain ranges shape the spine of the country and separate the Pacific and Caribbean watersheds. The forest area is approximately 2.5 million ha, and the agricultural area is of 505,000 ha, 46 % of which is dedicated to crops and the rest to livestock (SEPSA 2009; Fig. 13.2).

13.2.1 Economic Indicators and Policy Framework

As developing country of the upper middle income category, Costa Rica has relatively high economic indicators compared to its neighbors. 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 labor force of 2.09 million.

Though relatively low, poverty levels have not been reduced recently. Fiscal and trade deficits are growing. The gross domestic product is estimated at US$ 35 billion for 2010, 25 billion € (BCCR 2011; CINDE 2009). Per capita basis, GDP is then reaching US$ 7,000 (5,000 €) on a nominal basis, US$ 11,000 (7,860 €) on a purchasing power parity (PPP) basis, approximately the same level as Belarus. Poverty is growing in Costa Rica, where 21.3 % of the population is living below the poverty line, including 6 % in extreme poverty (Fig. 13.3). There are higher levels of poverty and it is more disperse in rural areas (26.3 %) than in urban areas (18.3 %) where poverty affects specific sectors of the population (INEC 2010; Céspedes and Jiménez 2009).

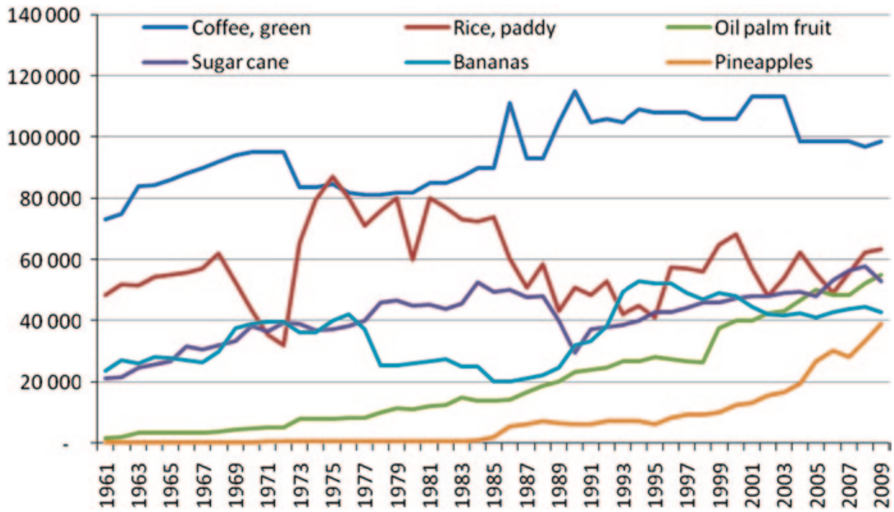

Fig. 13.3 Evolution of crop areas for some of Costa Rica's main crops. (Own elaboration with data from FAOSTAT 2011)

Costa Rica's economy depends heavily on tourism, agriculture, and electronics exports (Table 13.1). 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.

Costa Rica is a presidential representative democratic republic, with a multiparty system. Executive power is exercised by the president and his cabinet, the president being head of both the state and the government. Major international treaties, namely on human rights and on environment, have been ratified in Costa Rica.

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.

13.2.2 Population

Costa Rica's population is approximately 4.6 million. Annual population growth rate is estimated at 1.4%. Fertility rate is 1.8, one of the lowest of Latin America. Immigration to Costa Rica (mostly from Nicaragua and Colombia) is three to four times higher than emigration (to the USA, principally). The most densely populated region is the Central Valley, where economic activity is concentrated. Life expectancy, 79.1 years, is the highest of Latin America. The literacy rate of 95% is among the highest, also at the world level for developing countries (INCAE 2010; PNUD 2009). Average annual income per household is estimated at CRC 804,336,

Table 13.1 Costa Rican GDP (gross domestic product) composition. (Source: MAG 2010; SEPSA 2009)

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

approximately 1,150 €. One third of households are led by a woman (33.7 %); 41 % of these households are in extreme poverty.

13.2.3 The Agricultural Sector

The main agricultural land uses are coffee (99,000 ha in 2009), followed by rice (63), palm oil (55), and sugarcane (53) (Fig. 13.3).

In terms of production volume, sugarcane (4.2 million t) is the largest, followed by bananas (2.12 million t), pineapples (1.72 million t), cow milk (0.92 million t), cassava (0.42 million t), oranges, fresh fruits, and rice. Regarding value, pineapples come first (US$ 325 million), then bananas (US$ 296 million), cow milk (US$ 237 million), cattle meat (US$ 182 million), chicken meat (US$ 124 million), coffee (US$ 88 million), sugarcane (US$ 86 million), palm oil (US$ 59), pork (US$ 53 million), rice (US$ 52 million), and orange (US$ 49 million). The country exports mainly bananas (US$ 703 million in 2009), pineapples (US$ 575 million), and coffee (US$ 337 million).

13.2.4 Landownership Concentration

Properties with more than 500 ha represent 1 % of holdings and 36 % of registered land (Leonard, quoted by CADETI 2004). The majority of the medium and smallholders own land is on hillsides and of forest aptitude (CADETI 2004). Though high relative to European standards, land concentration in Costa Rica is among the lowest of Latin America and the Caribbean. The general trend is the decreasing share of smallholders the increasing share of large firms in main agricultural productions. Farmworkers are increasingly becoming employees of these farms.

13.2.5 The Energy Sector

Costa Rica is not exploiting any fossil energy sources, at least for the time being. Energy consumption has been constantly increasing (Fig. 13.4).

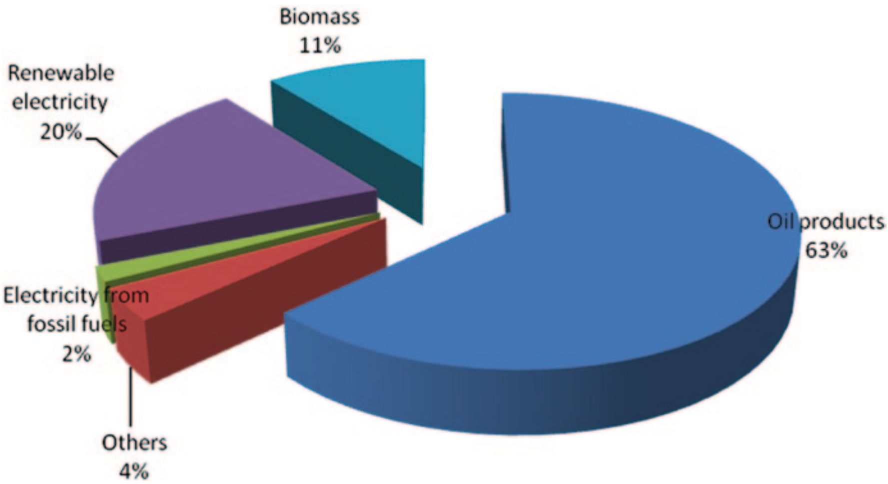

Fig. 13.4 Structure of energy consumption in Costa Rica in 2009. (Source: MINAET 2010)

Most of the 9,503,622 GWh generated in 2009 (Orozco et al. 2009) came from hydroelectric plants (76.4 %), with biomass accounting for only 0.7 %, kept small by low sale prices offered to independent electricity producers. It could be higher given the large potential of pineapple and sugarcane harvest residues (Milhau and Fallot 2011).

Oil is imported in its entirety, at some 21.5 million barrels, generating an oil bill of approximately 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.

13.3 The Sugarcane-to-Ethanol Supply Chain in Costa Rica

Although ethanol is produced in Costa Rica from sugarcane already since 1918, the sugarcane-to-ethanol supply chain is not fully established yet. Paraphrasing and updating IIED (2007), alcohol as carburant is still not part of the energy matrix of the country despite the fact that in the country alcohol has been produced for 31 years and exported for 25 years. Therefore, it needs to be considered 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 (Fig. 13.5).

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,

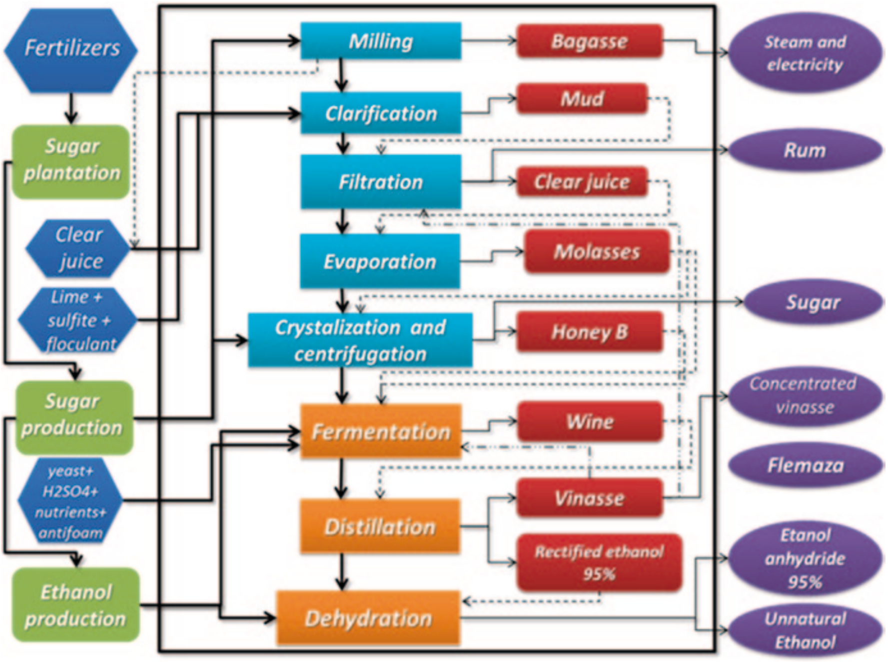

Fig. 13.5 Flowchart of the supply chain of sugarcane in Costa Rica (2011)

planting and replanting; plantation maintenance: maintenance of furrows, pest and disease management, weeding, fertilizing, hastening maturation; harvesting: cutting (either manually or mechanically), loading (either manually or mechanically), and 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, crystallization 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 harbor terminals (in Morales, some 100 km from Guanacaste's main sugar plants) and exportation through LAICA. For the national fuel market, it entails 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.

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.

Table 13.2 Key characteristics of the sugar–ethanol system in Costa Rica (inputs, labor requirement)

Stage	Inputs	Labor
Sugarcane production	Fertilizers Herbicides Maturing agent Fuel for agricultural machines	Seed and seedling management, planting Harvesting (50 % of workforce) Loading and transport (truck driving)
Sugarcane transformation	Water Sulfite 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

At current production levels, two of the three production and supply facilities 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 (Table 13.2).

Sugarcane is planted for 6 years and harvested every year. After 6 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.

Before and during planting, herbicides (Fig. 13.6) and fertilizers (organic and inorganic) are applied, including vinasses from the sugar and ethanol production processes. Fertilizers are applied during plant growth. Harvesting time is controlled by the use of maturing agents, shortening the time required to reach the desired level of sugar content.

Activities are partly mechanized. The level of mechanization depends mainly on how steep the land is 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 US$ 20 million worth) has been done by 2 of the 16 sugar plants only, located quite close from the harbor terminal where ethanol is exported. Molasses are bought by these two plants. However, there are other market opportunities for molasses, in the food industry namely.

Fig. 13.6 Spraying of pesticides in a sugarcane field in Costa Rica. (Source: D. Rutz, WIP)

13.3.1 Actors in the Costa Rican Sugarcane Supply Chain

The public–private sugarcane producer association LAICA is most influential, as an intermediary between public authorities and producers as well as between international markets and producers, negotiating production quotas and prices for sugar and ethanol. It establishes quality standards, manages ethanol imports, dehydration, and reexports, and provides research efforts and technical assistance all along the supply chain. It is well integrated into international research networks, for example, the BIALEMA network (Producción de biocombustibles e impactos sobre los alimentos la energía y el medio ambiente) on biofuels (www.icidca.cu/Red/QueEs.htm) (Table 13.3).

The public firm RECOPE has a monopoly on refinery and distribution of oil and oil products, and ACEC, which groups gas station owners, has a crucial role in determining the acceptability of biofuels by consumers. ACEC has been pleading for better incentives at the distribution level, arguing the need for specific adaptation of tanks and tubes to ethanol, which in turn planted doubts in fuel consumers as to whether the product was safe for their car motors.

The public tariff authority ARESEP influences production and distribution choices, such as the use of molasses or juice, cogeneration from bagasse for internal use or for the network, as well as ethanol exports or sales to international markets.

13.3.2 Case Study at the Local Level: Central Azucarera Tempisque S.A

Central Azucarera Tempisque S.A. (CATSA) was chosen as it appeared more open to providing data, although orders of magnitude are similar to both ethanol plants in Costa Rica. It can be estimated 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 10,000–25,000 ha).

Table 13.3 Actors in the Costa Rican sugarcane supply chain

Phase	Actor	Role in the supply chain
Sugarcane production	Independent farmers (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, supports commercialization
	Sugarcane Federation of Chambers	Represents the sugarcane sector in general, LAICA in particular
Industrial production (sugar and ethanol)	Sugar plants, also non-independent sugarcane producers	Receive sugarcane deliveries from smallholders, process to sugar and ethanol (in two plants in the country)
	Sugarcane chamber	Organization of sugar plants
	Industrial Sugarcane League (LAICA)	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)	Refine, transport, and distributes 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)	Develop existing sources of energy in the country and provide electricity and communication services
Regulation	Public Service Regulating Authority (ARESEP)	Determines prices and taxes on public services and basic goods including sugar and fuels
	Ministry of Agriculture and Livestock (MAG)	Promotes integration and development in the agricultural productive sector and related institutions
	Ministry of Environment, Energy and Telecommunications (MINAET)	Governing entity in the energy sector

LAICA liga agrícola industrial de la caña de azúcar, *RECOPE* refinadora costarricense de petróleo

CATSA began commercial alcohol production in 1980, using Brazilian equipment. It was ISO 9001 certified in 2001 and fulfills the requisites of ISO 9001:2008. Since December 2010, CATSA is also ISCC certified in order to maintain access to the German and other European markets (Fig. 13.7).

Sugarcane is produced on CATSA's own land and additionally provided by 1,049 independent producers, whose supply represents 27 % of the sugarcane processed in CATSA. Prior to sugarcane plantations, the land was destined mainly for pastures.

Fig. 13.7 Flowchart of the ethanol supply chain of Central Azucarera Tempisque S.A. (CATSA)

Applied agrochemicals include fertilizer (CaCO3; 10–30–10; Nutran 35.5 % N 15–3–31); pesticides (Diuxon 80 % SC; 2.4 D 60 %; Hexazizona); and Roundup as a ripening agent.

Without accounting for a recent (2010–2011) decline, average sugarcane yield reaches 87.4 t/ha at CATSA's farm. During harvesting time, CATSA employs approximately 1,210 people, 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, 490 people are employed.

13.4 The Socio-Economics of Sugarcane Ethanol Production

13.4.1 Economics

Sugarcane production generates 1.4 % of the PIB. Costa Rica has a long history of sugarcane production, with continuously improved material and well-developed technical assistance and international cooperation.

Table 13.4 Estimated sugarcane production costs in Costa Rica (2011)

Year	Yield (kg/ha)	Expenses per hectare (€/ha)					
		Field preparation and maintenance	Planting	Transplanting	Fertilizer application	Pesticides application	Transport
0	–	171.43	304.29	190.00	361.71	–	–
1	85	–	–	–	369.83	243.05	255
2	95	45.60	–	–	369.83	243.05	285
3	85	45.60	–	–	369.83	243.05	255
4	75	45.60	–	–	369.83	243.05	255
5	60	45.60	–	–	129.91	243.05	180
Total years 0 to 5	–	353.83	304.29	190.00	1,970.94	1,215.25	1,230
Year 6 = Year 0	–	171.43	304.29	190.00	361.71	–	–
Year 7 = year 1	85	–	–	–	369.83	243.05	255

The macroeconomic effects of feedstock conversion are not very visible, because there are only two distilleries in the country. For the time being, CATSA estimates its production costs at 0.27 €/l. At this production cost level, oil price must rise above US$ 90 per barrel for ethanol production to generate positive added value.

Given that CATSA staff was not in a position to provide numbers for all the variables of interest for the Global-Bio-Pact project, three steps were applied: (1) getting all possible data directly from CATSA; (2) deducting missing data on the agricultural phase by interviewing other sugarcane producers; and (3) sending the results to interlocutors at CATSA to get their feedback (Table 13.4, 13.5, 13.6 and 13.7) .

13.4.2 Employment Generation

Employment in this sector is not specific to the sugarcane-to-ethanol supply chain (sugar and ethanol production), nor to sugarcane itself: other agricultural activities complement it (such as rice in Guanacaste or coffee in other zones).

Work is mainly seasonal during 4 months. Agricultural employment at CATSA rises from 430 to 1,150 people. Given that CATSA cultivates around 6,500 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).

Employment relies on participation from migrant workers from Nicaragua, namely to cut sugarcane. During the 4-month harvest season, CATSA brings about 300 workers from Nicaragua, following legal procedures. Their monthly wage is about 211 €. In other farms of the region, participation of Nicaraguan workers is

Table 13.5 Estimated labor requirements per hectare for sugarcane production in Costa Rica (2011)

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

[a] 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] Total harvesting hours were obtained from producer data and own calculations; the number of cut sugarcane t/ha was multiplied by the number of working hours/day (7) and divided by the average daily volume of sugarcane cut by workers (4 t/day)

[c] Total time estimated, accounting for the rates in Table 13.6

Table 13.6 Estimated time (in hours) per activity (2011)

Activity	Estimated time (h)
Sugarcane loading into the harvester	3.0
From the harvester to the farm where sugarcane is loaded in a truck	0.5
Harvester capacity™: 3	
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	0.66
Average distance from the farm to the plant (km): 20	
Total truck capacity™: 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

higher than at CATSA, where the local workforce focuses on more technical tasks, such as transportation, machine, and equipment maintenance.

Employment depends on the mechanization degree of activities. CATSA estimates that one mechanic harvester substitutes for 250 field-workers. About 90%

Table 13.7 Wages in the sugarcane production system in Costa Rica (2011)

	Staff number		Average wage US$/month
Agricultural division			
Off-season	35	Executives	2,500–3,000
	150	Technicians	1,500–1,800
		Machine operator	700–1,000
		Field-worker	600–700
Harvest season	35	Executives	2,500–3,000
	800	Technicians	1,500–1,800
		Machine operators	700–1,000
		Harvester operator	500–600
Administrative and industrial division			
Off-season	25	Executives	2,500–3,000
	280	Technicians	1,500–1,800
		Others	700–1,000
Harvest season	25	Executives	2,500–3,000
	350	Technicians	1,500–1,800
		Others	700–1,000

of its harvest is mechanized. At CATSA, agricultural activities represent 66% of the employment. The remaining 34% combine industrial and administrative employment. Given the high level of automation of the sugar and ethanol production processes, employment at the sugar-to-ethanol stage is mainly for maintenance, control, and supervision, employing only six people.

13.4.3 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 is a solidarity association, controlled by the employer, providing multiple social benefits to permanent employees. CATSA complies with national labor regulation, and has therefore obtained ISCC certification.

Working in sugarcane fields is physically very demanding. Occasional workers' contracts are characterized by their flexibility and precariousness. Workers are often hired indirectly through an intermediary employer, which can dilute employer responsibilities (Cerdas Vega 2007). In addition, wages are paid by tonnes or by linear meter of sugarcane harvested. During the sugarcane-to-ethanol conversion, two activities require special care: handling sulfuric acid and loading fuel. During feedstock conversion, river and other bodies of water must be protected from the spreading of vinasses.

13.4.4 Gender Issues

There are few women working in the sugarcane-to-ethanol supply chain in Costa Rica (CATSA staff is 10 % women). Given the harsh working conditions of feedstock production, the low percentage of women in the fields might not be an issue. Given the increasing number of women graduating as engineers, an indicator of gender equality could be, e.g., the percentage of women engineers in sugar and ethanol plants in relation to women graduating as engineers in the country, for instance. For the time being, women are underrepresented, which can also be explained by the low attraction the Guanacaste province holds for young people who studied in the Central Valley.

13.5 Environmental Impacts of Sugarcane-to-Ethanol Conversion

Although Costa Rica is so small and as it appears to be entirely in the tropical wet climate zone, the 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. CATSA operates mainly on inceptisols and vertisols, which may be considered under the "high activity clay soils" category. Land use factor (F_{LU}), management factor (F_{MG}), and input factors (F_I) for land use on 01/01/2008 and today are 0.48, 1.15, and 1, respectively.

13.6 Conclusion

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 implemented 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 and processing sugarcane, producing sugar and molasses which they sometimes transform to ethanol exported mainly to the European Union. National ethanol consumption is limited to one region and comes from hydrated ethanol imported from Brazil and dehydrated in Costa Rica.

There is only one zone favorable to relatively large-scale production and supply of sugarcane for ethanol, the northwestern Guanacaste province, where a few large farms coexist with smallholders.

In this province with relatively low population density and high poverty rates, sugarcane production has been offering since long the possibility to keep part of the population from migrating to the main cities. However, it does not appear that the sector can take the province out of poverty. Opportunities offered by sugarcane production are limited by land prices rising with tourism development and higher value-added food crops or wood plantations. In the rest of the country, the complementarities of sugarcane production with other agricultural productions (such as coffee and dairy farms) are key to the sustainability of sugarcane cultivation.

Regarding sugarcane transformation to ethanol, it comes after sugar production and using bagasse to provide process heat. The context (low electricity selling prices to the network and high electrification rate) is not favorable to yield optimization in the conversion of sugarcane to ethanol.

Regarding environmental impacts, the main issues are related, upstream, to the burning of sugarcane before harvesting even with mechanization, given the low profitability of residue conversion for the time being and, downstream, to the spreading of vinasses, given that some soils are saturated. Further developments of the sugarcane-to-ethanol supply chain rely mainly on better incentives to optimize production and conversion processes.

Negative impacts of sugarcane production and transformation to ethanol that would constitute an opposition to the implementation of such incentives were not identified. However, the positive impacts might not be significant enough to justify a specific effort in this sector.

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Chapter 14
Socio-Economic Impacts of a Lignocellulosic Ethanol Refinery in Canada

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Abstract There has been a strong public debate on the sustainability of feedstock used in the production of biofuels. Some of the main concerns have been the impacts of biomass production on food security, the local economy, and working conditions in feedstock production and conversion chains. This chapter assesses the socio-economic impacts of lignocellulosic biomass production and conversion, using case studies from a lignocellulosic biorefinery and indicators from a hypothetical thermochemical biorefinery in British Columbia (BC), Canada. The production of second-generation products, like lignin, ethanol, pyrolysis oil, and upgraded products using forest residues and pulp wood, can generate economic benefits and employment in the forestry sector that suffers from the declining demand for paper and timber. These impacts are important on national and regional levels, but even more on a local level. Villages and communities are often highly dependent on the nearby forests, paper mills, or saw mills, and the decline of these sectors will have significant impacts on the local economy. On a microeconomic scale, for each biorefinery, the challenge is to produce sufficient added value materials at economical costs.

Keywords Canada · Second-generation biofuels · Ethanol · Pyrolysis oil · Lignocellulose biomass

14.1 Introduction

A strong public debate on the sustainability of biomass used for energy emerged in the last few years. This debate focused mainly on negative social and environmental impacts. In consequence, several initiatives were set-up, which are engaged

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in developing tools to ensure sustainability of biofuels. One option to ensure the sustainability of biofuels is the application of certification systems. The main aim of the Global-Bio-Pact project is the improvement of global sustainability certification systems for biomass production, conversion systems and trade in order to prevent negative socio-economic impacts and to promote positive ones. Thereby, emphasis is placed on a detailed assessment of the socio-economic impacts of feedstock production and a variety of biomass conversion chains.

The present report presents the Global-Bio-Pact Case Study for second generation biofuels and products from lignocellulosic material in Canada. Since the impacts of the production of biofuels and bio-products depend on the investigated scale, different levels were investigated in all Global-Bio-Pact Case Studies, including the national, regional, and local/company/project level. In each Case Study country of the Global-Bio-Pact project the following assessments were made:

- One study at national level
- One study at regional level
- Two studies at local level

The case study about second generation technologies, specific technologies has been selected based on an initial draft report on current and future industrial and small-scale conversion chains (Vis 2010). According to this report, two general types of technologies were selected:

- The lignocellulosic biorefinery (with ethanol production from cellulosic biomass)
- Thermochemical biorefinery (with pyrolysis and upgrading of pyrolysis oil in existing refineries)

Both conversion technologies utilize lignocellulosic biomass (e.g. straw, miscanthus, wood, husks) which is widely available and—if produced from residues—does not compete for land for food and feed. The case of pyrolysis introduces the concept of the use of both decentralized (pyrolysis oil) and centralized (upgraded products) production in one biorefinery concept. Given that the other case studies focused on agricultural commodities, this paper focused mainly on woody biomass from forestry feedstock as case study. Subsequently, Canada was selected as the focus country for this case study in view of the country's forest resources and the fact that the second generation technology is gradually advancing in the country.

14.2 Country Context of the Case Study

Canada is the second largest country in the world extending from the Atlantic Ocean in the east to the Pacific Ocean in the west with the Arctic Ocean to the north. The country covers an area of 9,984,670 km² (CIA World Fact-book 2011). The climate of the country varies from temperate in the south to subarctic and arctic in the north. There are 15 terrestrial ecozones ranging from coastal rainforests in British

Columbia to sparse and slow growing forests in the Arctic tree line (Arseneau and Chiu 2003). As one of the countries with the largest forest estates in the world, Canada has about 397.3 million ha of forests, other wooded lands and lands with tree cover which represents 10 % of the world's total forests and 30 % of world's boreal forests. This forested area, comprising mainly of boreal forests (80 %) has been fairly constant within the past decades (FAO 2009) and currently covers up to 54 % of the country's land mass. The country is one of the leading exporters of forest products globally, with the USA being the major export destination and receiving over 70 % of exports (Tree Canada 2011). The forestry industry continues to be a major player in the country, accounting for a fifth of Canada's exports and 1.9 % of GDP in 2008.

About 67,600,000 ha of land is set aside for agriculture of which 45,100,000 ha is arable with 7,050,000 being for permanent crops (FAOSTAT 2011). Grains, oil seeds and livestock are the major agricultural commodities. As a result of shifts from an agricultural to an industrial economy, agriculture now accounts for less than 1 % of GDP.

14.2.1 Forestry Sector

Canada is a net exporter of wood products with a trade surplus of $ 14.4 billion in 2009. Being the world's largest wood exporter, Canada netted about $ 30.2 billion in forest product exports in 2008, which generated 273,700 direct jobs and supported some 300 forest-based communities (Poon 2009). Lumber currently accounts for more than half of Canada's wood exports. Other exported wood products include pallets, railway ties and engineered wood products (Poon 2009). Canada leads globally as the country with the largest area of third party certified forests (over 142.9 million ha as at December, 2009 representing over 40 % of the global certified forest area) and also as the country with the largest proportion of its managed forests certified (Tikina et al. 2010). The forests of Canada comprise mainly of softwoods (68 %), mixed wood (16 %) and hardwoods (17 %) with spruce (53 %), poplar (12 %) and pine (9 %) being the predominant tree species. The total growing stock as at 2009 was 32,983 million m^3 of which an Annual Allowable Cut (AAC) of 208 million m^3 was allowed for year 2008. Annually, less than 1 % of the country's forests are harvested and approximately 90 % of the forest products are harvested in old growth and primary forests under management (Forestwatch 2011).

14.2.2 Land Ownership Concentration

In Canada, land ownership is generally held by the government, native groups, corporate entities and individuals. A major portion of the forests are held in trust by federal and provincial governments. These are referred to as Crown Lands. However, with the exception of a section of southern Quebec, all of Canada is subject to

Table 14.1 Mill residue production—sawmills (Canada Report on Bioenergy 2010)

Production year	2004	2005	2006	2007	2008	2009	2010	2011
Lumber (million m^3)	83.5	82.9	78.2	71.8	58.7	45.1	52.6	65.0
Mill residues (million m^3)	21.2	21.1	19.9	18.3	14.9	11.5	13.4	16.5

Aboriginal title. Native groups historically negotiated treaties in which they traded tenure to the land for annuities and some legal exemptions and privileges. Of the 397.3 million ha of forest lands in Canada, 93 % is publicly owned. Of this, 77 % is under provincial or territorial jurisdiction whilst 16 % is under federal purview. The remaining 7 % is on private property owned by over 450,000 landowners (NRC 2011). The provinces and territories manage their own natural resources including forests except on federal lands such as First Nations Reserves and National Parks. An estimated 1,000 forest operations are owned by First Nations.

14.2.3 The Lignocellulosic Biomass Supply Chain

The cellulosic bioliquid industry is emerging, with little reliable data on feedstock demands and supply. Because the industry depends mainly on co-products and by-products from various wood processing operations, it is difficult to quantify the actual demand and supplies attributable to cellulosic bioliquids alone. Nevertheless, data on logging residues, mill residues and the pulp and paper market may be useful indicators.

The Canadian timber sector which in previous years produced excess quantities of logging and milling residues was one of the worst hit sectors during the global financial crisis from 2006. With the USA housing market being the major buyer of Canadian timber, the rapid decrease in the construction of new houses in the USA had a significant impact on sawmilling in Canada and consequently reduced the production of milling residues from 83.5 million m^3 in 2004 to 45 million m^3 in 2009 (Table 14.1). The drop in lumber production wiped out surpluses of mill residue by 2009.

At the same period that available milling residues were declining in Canada, the production and export of wood pellets (which relied heavily on milling waste as input materials) in the country was growing at a fast pace. Several large new biomass projects were built in anticipation of access to mill residue. The national pellet production capacity grew from 500,000 t in 2002 to 2.1 million t in 2009 making Canada the 4th largest in the world. However, the reduced availability of milling residues due to the economic downturn and lower lumber productions has left the industry with little feedstock and led to a decline in wood pellet production in the country in 2008. Consequently, pellet producers have had to resort to harvest debris and non-commercial round wood which now account for about 70 % of the feedstock. Currently, all provinces with vibrant forestry industries are examining the option of allowing harvest wastes to be exploited for energy purposes. Long term contracts for standing non-commercial wood are being awarded in Ontario to fledgling biomass projects that can support forest based employment for local communities and have First Nation involvement. Additionally, there is a considerable volume of standing timber that can be used for biomass including non-commercial timber and wood impacted by fire, insects, disease, wind throws, etc. However, this may not always be economical as the wood has to bear the cost of harvesting. Costs of extraction of biomass from the forest can vary greatly depending on landscape, distance to roadside, technology used, labor, and even moisture content of the slash (Canada Report on Bioenergy 2010).

14.3 Regional Context: British Columbia

British Columbia (BC) is one of the most important forestry provinces in Canada in terms of resource availability and forest industry. Though it is only the fourth largest province in the country, it has the biggest forest estate covering an area of 57,910,000 ha which represents close to two-thirds of the land area of the province. The topography and climate of BC divide the province into two distinct forest regions: coastal forests and interior forests. The interior forests, made up mainly of spruce and lodgepole pines account for over 70 % of timber harvests while the remaining 30 % come from the hemlock dominated forests of the coastal areas. The forests contain approximately 11 billion cubic meters of wood, half of which is located on lands available for harvesting. Currently, there is about 22 million ha of timber harvesting land base (THLB) in BC. THLB are publicly owned lands on which timber harvesting is both feasible and permitted. Some 94 % of the forest is owned by the Province of British Columbia. For management purposes, the forest resources are divided into units known as timber supply areas and tree farm licenses. Timber harvesting in these units is delegated to private operators under various license agreements. Harvesting rights issued to private interests confer varying rights and responsibilities. In all cases, forest managers are expected to implement sustainable management practices to ensure the continued maintenance of the forest resource. The British Columbia's Forest and Range Practices Act specifies the requirements for maintaining high levels of environmental protection and outlines the requirements for soil conservation, reforestation of logged areas, the protection of riparian areas, biodiversity etc. Under this Act, forest companies are required to develop forest stewardship plans outlining how they will meet the objectives set by government for soil, timber, wildlife, water, fish, biodiversity and cultural heritage resources.

There is also an increasing involvement of First Nations in the forest based economy and since 2002 BC has entered into interim measures agreements with 158 First Nations to provide access to 39 million m^3 of timber and over $ 230 million in forest revenues. The forests of BC continue to be an important source of employment accounting for 7 % of the province's employment in 2007. According to the State of BC's Forests report (2010), forest based industries provide lucrative remuneration with average income being up to 12 % greater than other industries.

Forestry is a major contributor to the economy of BC, accounting for at least some 15 % of the province's economy. BC produces more than one fifth of Canada's softwood lumber supplies each year. The combined annual harvest of the country comes from less than 200,000 ha of land which represents less than 1 % of the working forests in the area. As with the rest of Canada, the forestry industry in BC has been adversely impacted by the USA housing crisis and sawmill production in the region has declined in the past half-decade with lumber production falling from 41,050 m^3 in 2006 to 22,975 m^3 in 2009.

However, the industry is expected to gradually recover from the downturn and production figures in 2010 have shown signs of improvement. The sawmill production coupled with the increased capacity of cogeneration facilities have ensured that locally produced sawmill residues have been wiped off. However, there may be alternative sources of woody biomass from logging waste and salvaged trees for use in various energy applications.

Spreading through the forests of Western Canada since 2006 is the mountain pine beetle (*Dendroctonus ponderosae*) which had attacked up to 13 million ha of pine forests as at 2009 and is expected to kill up to 80 % of all the pine trees in BC. As at 2007, more than 530 million m^3 of wood had been lost and it has been predicted that about one billion m^3 would be lost by 2018. BC's attempt to tackle the situation also involved the salvage logging of millions of trees to minimize the damage and prevent the spread of the insect. Mountain pine beetle killed timber could be a temporary source of biomass that will be available for the next 20years.

14.4 Case Study at the Local Level

14.4.1 Description of the Project Location of Tembec

Considering the dynamics of wood based feedstock supply for possible use in lignocellulosic bioliquid production, this paper focused on the forest management operations of one of the largest forestry industries in the British Columbia area. Tembec is a leading integrated forest products company, with operations in North America and France. With some 4,300 employees, it operates over 30 pulp, paper and wood product manufacturing units, and produces silvi-chemicals from by-products of its pulping process as well as specialty chemicals. Tembec markets its products worldwide and has sales offices in Canada, the United States, China, Korea and Japan. The Company also manages forest lands in four Canadian provinces in accordance with sustainable development principles and has committed to obtaining Forest Stewardship Council (FSC) certification for all its forests. In BC, Tembec's forestry operations started in 1999 when the company acquired its initial forest operations from the Crestbrook Forest Industries in the Kootenay region. Currently, Tembec's operations in BC also include a Bleached Chemical Thermomechanical Pulp mill in the north east of BC. For the case study, Tembec's forest management operations in the Kootenay area were assessed. Kootenay is located in the south-eastern corner of BC.

In 2007, most of Tembec's forest management tenures in Kootenay were certified. However, in the following years an assortment of additional temporary non-renewable licenses was added to the company by their owners (including First Nations, businesses and private owners) to be managed. This assessment only focused on the certified management units under Tembec's Kootenay operations.

14.4.2 Description of the Lignol Technology

Lignol Innovations Ltd. (Lignol) is a company based in Burnaby, a suburb of Vancouver, BC, Canada. The organization was founded in 2000 and in 2002 Lignol acquired the Alcell technology including intellectual property, marketing data, project files and a pilot plant from UPM-Kymmene Canada and Industry Canada. This process was developed by the University of Pennsylvania, General Electric and Repap Enterprises Inc between 1973 and 1997. Lignol has developed the Alcell technology further during the years. Now, the technology is an integrated cellulose-to-ethanol process for biorefining ethanol (fuel alcohol), pure lignin and other valuable co-products from readily available biomass. With this process Lignol delivers an alternative to the current dominant production of ethanol—the fermentation of grain.

Currently Lignol owns a fully-integrated pilot plant where the process is tested and developed further. This development has led the company into the use of enzymes, which can be used to make valuable products from biomass. In the near future, Lignol wants to construct a commercial demonstration plant, to test the technology further and to show that it can be a viable investment. The organization also looks into other options besides the Alcell technology, such as pulp mill conversion to alternative energy options (Lignol Innovations 2011a, b).

The Alcell technology, which is used by Lignol, employs an organosolv process. With this process biomass pre-treatment and lignin/hemicellulose removal are combined in one process step. The two main products from this entire process are lignin and ethanol. These are produced from lignocellulosic material—often wood, straw and stover—which contains 10–12 % lignin for some short annual plants and up to 30 % and more for some coniferous wood types.

Within the organosolv process the input biomass is treated with an aqueous organic solvent—in this case ethanol (ethyl alcohol) and water—at temperatures in the range of 180–200 °C. This is necessary to open up the tight structure of the woody fiber to expose cellulose more for enzymatic attack. Two products remain from this organosolv delignification, namely the solid mass (cellulose) and "black liquor" containing the other elements of the input and the remaining alcohol and water. The cellulose mass is transformed into alcohol by enzymatic saccharification, fermentation and distillation in the presence of enzymes and yeast.

The black liquor is treated in another process called lignin precipitation. In this process most of the lignin is removed from the black liquor. The black liquor is then transformed into yellow liquor which is distilled to retrieve the alcohol, furfural and other extractives. Using enzymes a few other steps can be performed to extract

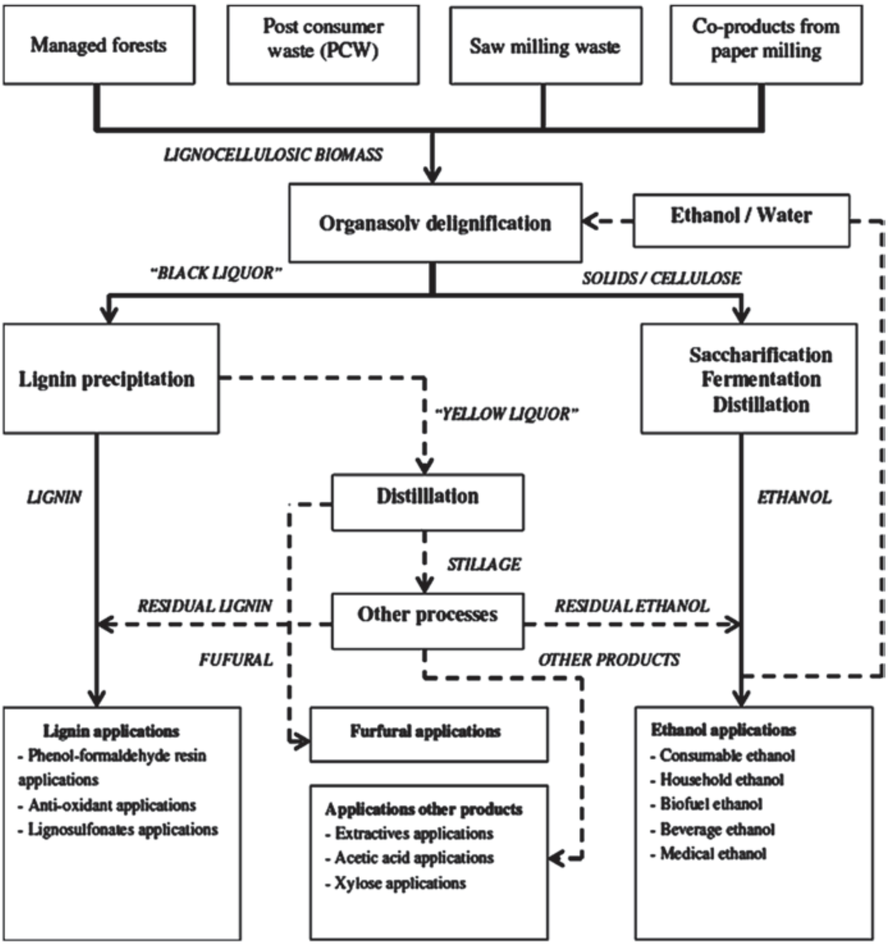

Fig. 14.1 Flowchart of the Lignol process (Source: Pye et al. 2007: adjusted by BTG)

more products and the remaining lignin fraction (Pye et al. 2007). A visual representation of the supply chain can be found in Fig. 14.1.

The demonstration plant of Lignol is planned to have an input of 200 to 300 t of dry biomass a day. However, the actual amount still needs to be determined.

14.4.3 Flowchart of the Supply Chain

The major forest based feedstock used by Lignol at its pilot plant in Burnaby is typical pulping chips obtained from debarked whole log chippings and chips from lumber mill residues such as slabs and trim ends of logs. These conventional wood chips have been supplied in the past by pulp mill operators throughout North America. Currently Lignol does not have any long term supply arrangements as it is yet to finalize the location of its commercial biorefinery plant. Other non-forestry feedstock that have been tested by Lignol include corn stover, straw, bagasse and oil palm empty fruit bunches.

For a hypothetical commercial plant that would be situated in BC, typical forestry feedstock would come from the sources described below:

Mill residues: This generally refers to wood waste from sawmills and woodwork shops that are collected and transported to processing facilities. This includes slabs, shavings, sawdust, trimmings, end pieces of wood, non-commercial logs and log cores. Until recently these were incinerated in BC in beehive burners at the sawmill site.

Across Canada, the main feedstock for bioenergy production in the broader sense has been from mill residues, and the primary use has been in cogeneration plants for the production of heat and power.

Logging residues: This refers to the residual biomass from logging and pre-commercial thinning operation. Materials used include logging tops, culls and stumps. Also, damaged, rotten/dead, undersized and non-commercial trees removed from woodlots may be used.

With the current low availability of mill residue surpluses, forestry and energy companies are looking to logging residues as a feedstock source (Canada Bioenergy Report 2010). Additionally, salvage operations after disturbances could produce a source of biomass. Fires burn approximately 2 million ha of forests per year, while pests severely damage or kill another 16 million ha in Canada. The use of salvaged logs is currently particularly relevant to the province of BC because of the mountain pine beetle epidemic. However, the availability of these infested trees for use as a biomass feedstock may be limited in some cases due to possible high costs associated with accessing, extraction and haulage.

Post-consumer waste (PCW) woody biomass: This refers to post-industrial wood waste and all urban wood wastes. Urban wood residues are also currently being used as feedstock, and their deployment in bioenergy systems could rise if it can be secured clean and at low costs. Currently, Enerkem has a commercial demonstration plant in Westbury, Quebec where 'negative cost' used electricity poles are being utilized to produce cellulosic ethanol, methanol and acetates.

Purposely grown stands: These are stands grown specifically for biomass production and commercial thinning dedicated to cellulosic biomass. In view of the significant cost of forest management and the costs associated with lignocellulosic bioliquid conversion chains, it is usually not considered economical to manage forests mainly for the production of bioliquids alone.

Early Lignol biorefineries would be small compared to modern pulp mills and would probably be sized to process 600 to 900 t/day of wood (50 % moisture), while later biorefineries might be sized to process 2,000 t/day of wood at 50 % moisture. Forestry operations, whether they are owned by Lignol or by contractors, would involve cutting and delimbing the tree. In the ***short wood*** system, the tree would be cut down, topped, delimbed and the round wood (logs) would be skidded to the nearest logging road, cut into truck bed lengths and then transported to public roadside stacking areas. Larger logging trucks would then transport the logs to the biorefinery where they would be weighed, debarked and chipped. The chips would be either sent directly to the digester/extractor or dumped onto chip piles to create an inventory or reserve of chips. Some newer and cheaper systems are now being used in the pulping industry. These are *tree length systems* and *full tree systems*. In both systems trees are cut and topped, but in the tree length system the delimbed tree length log is hauled directly to the mill without length reduction. In the whole tree system, the topped tree is stacked onto truck beds and transported to the mill where it is chipped in its entirety but quality chips are recovered from a chip screening and classification system. The remaining residues are used as fuel in a hog fuel boiler. Saw mill chips are hauled to the mill by rail or truck, weighed and moisture content assayed and then added to the chip pile for reclaim.

14.4.4 Products of the Lignol Process

One of the main products of the Lignol process is ethanol, which accounts for around 22–23 % of total input. This percentage depends on the cellulose content of the input. The worldwide ethanol market is still in development and grows slowly every year. In 2010 the total production reached 85,800 million l of ethanol. The projected production for 2011 is even larger with 88,700 million l of ethanol. This amount saves around one million barrels of crude oil a day (The Bioenergy Site 2011). The Canadian production is also on the increase and reached 10,300 barrels a day or 1,637,700 l in 2008. Canada is the fourth largest producer of ethanol in 2008 (Canadian Centre for Energy Information 2010).

Due to the relatively low price for a gallon of ethanol[1], the sales of high value lignin is essential for Lignol's business case. Around 80–85 % of the lignin from the input can be retrieved in the process. This accounts for around 20 % of the biomass input of the installation. One of the most important applications of this lignin is the replacement of phenol-formaldehyde (PF) resin applications. PF is produced by reacting phenol and formaldehyde in the presence of an acid or alkaline catalyst. Since phenol is now produced almost exclusively from benzene instead of from coking operations, increases in crude oil prices cause a significant rise in the cost of raw materials and a consequent increase in the prices for phenolic resins. The manner of substituting lignin for PF-resins can vary from a simple blending of dry powder lignin with dry powder phenolic resin to the use of organosolv lignin as a primary phenolic component during the manufacture of the resin.

The lignin from the biorefinery can also serve as an anti-oxidant, for instance in animal feed supplements, rubber products and the lubricant industry. It could also

[1] The current ethanol price is fluctuating around US$ 2.40 a gallon.

be used in markets currently served by lignosulfonates, i.e. in concrete admixtures, dye dispersants, asphalt emulsifiers, agricultural applications, and as dispersants for herbicides, pesticides and fungicides (Kamm et al. 2006, pp. 181–199). With the ethanol and lignin around 40 % of the input is actually used. After the distillation step a stillage component (solids) remains which accounts for 20 % of the installation's input. The remainder of the input exits the process as CO_2 in the fermentation stage where it is produced in almost the same amount as the ethanol. Also, some water is produced in the process. It is still unknown which products are economically feasible to extract from this process and it should be determined with further research and development. Examples of other products are acetic acid and xylose.

14.4.5 Pyrolysis Process of BTG

The Biomass Technology Group BV (BTG) is a private company, which specializes in the conversion of biomass into biofuels and bio-energy. BTG focuses on biomass energy technologies including thermal and biological conversion. In addition, BTG developed the fast pyrolysis technology further which was initially invented at the University of Twente. In 2007 BTG established BTG Bioliquids BV (BTG-BTL). This company deals with the worldwide commercial implementation of the fast pyrolysis technology. BTG has its own pilot plant located at the BTG headquarters in Enschede and has constructed a commercial scale pyrolysis plant in Malaysia (2 t/hour).

For the analysis of socio-economic impacts, a hypothetical pyrolysis factory in BC was assumed. The case will be based on the fast pyrolysis technology of BTG and information is used from the project (5 t/hour) which is currently developed by BTG and BTG-BTL in Hengelo, The Netherlands (The EMPYRO project). The EMPYRO project will have a capacity of 25 MW_{th}. For Canada this project is scaled-up to 50 MW_{th}. The input of the plant will then equal 240 t of dry biomass a day (80,000 t/year dry biomass).

When the wood enters the production site it first needs pre-treatment. The pyrolysis process requires biomass with a particle size smaller than 6 mm and a moisture content of 10 % for optimal production. Therefore, the wood is shredded and dried beforehand. When this is done, the biomass is fed into a rotating cone reactor where it is heated by hot sand—and in the absence of air—converted to gas, oil vapor and char. The gas and char are combusted and used to reheat the cooled sand. The reheated sand is returned in the process. The excess energy is used to produce steam that steam can be used directly in a production process—for example to dry the biomass—or transformed by a generator to electricity. Electricity can be directly used in the production process or delivered to the electricity grid.

The oil vapor is cooled and condensed in a condenser to pyrolysis oil. The pyrolysis oil has a lower heating value between 15 and 19 GJ/t. The conversion efficiency of the plant is about 65 % on mass basis based on dry wood.

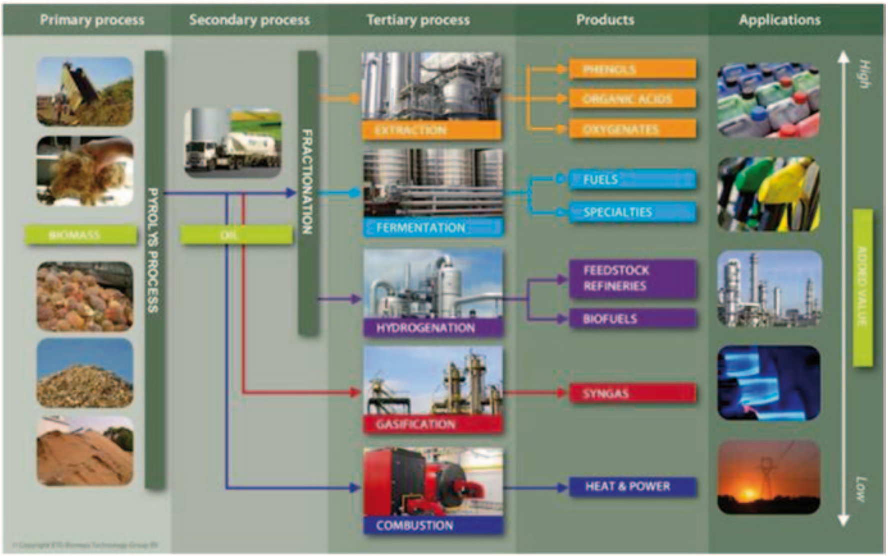

Fig. 14.2 Applications of pyrolysis oil (Source: BTG 2010)

14.4.6 Products of the BTG Process

This pyrolysis oil has multiple applications (Fig. 14.2). The pyrolysis oil can, for example, be separated in two fractions: an oil fraction and an aqueous fraction. From this aqueous fraction products with chemical applications can be derived. An example is acetic acid. The pyrolysis oil itself can also be burned in boilers or gas turbines to produce heat and electricity directly. In the future it can become possible to use the pyrolysis oil as a second generation fuel in diesel engines or for automotive fuels. Currently, pyrolysis oil is mainly used in boiler applications to replace domestic fuel oil.

14.5 Socio-Economic Impacts of the Lignocellulose Biomass Chain

14.5.1 Macroeconomics in the Lignocellulosic Biomass Chain in Canada

Given that currently, there is no well-defined market for lignocellulosic biomass, this chapter evaluates indicators in the forestry industry in general. It should however be noted that most of the wood products that will end up being used as lignocellulosic biofuels would probably be from residues from the industry rather than from purposely grown stands. The forestry sector made a significant contribution of 1.7 % to the country's GDP in 2009. The forest management and logging industry alone accounted for some $ 3.571 billion while the entire sector (including the pulp industry and the wood manufacturing sector) accounted for a total of $ 19.887 billion. According to the State of Canada's Forest report (2010), the forestry sector constitutes about 50 % of the economic base for about 200 communities in Canada generating some 238,200 direct jobs and $10.3 billion in salaries in 2008.

For the pyrolysis case, the theoretical potential of the technology can be sketched by assuming that all 913 paper and pulp mills established in Canada would host a pyrolysis plant. This would result in a total investment of almost € 20 billion. The plants will generate more than € 110 billion of revenue in ten years' time. In the same period, the total profit is estimated to be over € 18.5 billion. This type of potentials could also be reached by assuming Lignol plants would be installed at each paper and pulp mill.

14.5.2 Macroeconomics in the Lignocellulosic Biomass Chain in British Columbia

As this study focuses on the use of woody biomass for bioliquid production, the forest industry in BC is used to provide economic indicators for the production of feedstock. Given that there is no exclusive industry for producing lignocellulosic biomass and that by-products and co-products from the production of other forest goods are used as feedstock, the assessment from this point onwards focuses on the general forestry industry, and the associated socio-economic indicators. The forests of BC provide a variety of products generating substantial private and public revenues. The forestry sector in the province accounts for over 7 % of employment and 15 % of all economic activity in the province when indirect and induced economic activity are considered (State of BC Forest 2010). The forest sector is the major employer in rural areas. In 2009, BC forest products accounted for 30 % of BC's total exports, and BC forest industry shipments accounted for 26 % of BC total manufacturing shipments. Due to its reliance on the export market, the forestry sector tends to be susceptible to changes in international markets and trade restrictions. Though these indicators represent the forestry industry in its entirety and most of the products accounted for by the figures here are high grade wood products. There is nevertheless an opportunity to produce significant amounts of feedstock for woody bioliquids from the residues generated from forestry and processing activities.

According to the 2010 State of Canada's forests, there was 62.1 million Canadian C$ of new investments in Canada's forestry and logging industry in 2009. In 2008, a total of C$ 858 million in wages and salaries was paid in BC's forestry and logging industry. Revenue generated by the forestry and logging industry alone in 2008 amounted to C$ 4.4 billion. Harvested volume amounted to 61.8 million m^3

while the value of domestic exports in primary wood products was C$ 464 million. The use of wood biomass to produce electricity, heat and bio-products represents a significant opportunity in BC as it has an abundance of underutilized wood in the form of sawmill residues, logging debris, and timber killed by the mountain pine beetle.

The theoretical value for BC of the technology can be determined by assuming that all 94 paper and pulp mills in the province host a pyrolysis installation. The total investments and result equals almost € 2 billion over a 10 years' period.

14.5.3 Employment Generation

According to the LFS (2009), forest industries provided up to 52,000 direct jobs in BC in 2009. The forestry industry is a major employer in the province, and though forest based employment has declined from some 100,000 to 142,000 jobs in the 1970s to current levels due to the sharp decline in demand and prices of forest products since the 2007s, the industry nevertheless continues to be a major employer in the region. Data from the State of BC forests, 2010 indicate that in 2008, direct jobs in the forest sector provided some 4.6 % of employment in the province whilst they provided some 6.8 % of jobs, together with indirect jobs. The province has traditionally been dependent on the forest industry and many First Nations are dependent on forest based employment.

Though the province's economy has grown and become more diversified with overall provincial dependence on forests decreasing, there are still many areas that depend primarily on forest employment, whereby a high proportion of incomes are obtained from forest employment. According to the state of BC forests, 2010, forest based industries tend to pay very well and the average incomes tend to be around 12 % higher than that of all industries. In 2005, direct and indirect forest labor incomes yielded a total of some C$ 6.75 billion or 8.2 % of the provincial labor income from all industries.

A distinction can be made between jobs actually created in operating the conversion plants[2] and jobs supporting the production process. In operating one plant, 11 jobs are created for persons with a technical degree from college. These operators work in 3 shifts of 8 hours a day. In addition, 2 persons are present on the plant during normal working hours. These are the jobs of maintenance engineer and a technician. For the supporting activities 3 jobs are created- a plant manager, a production assistant and an administrative assistant.

The conversion plants also create indirect jobs. Often a plant needs a technology manager, a safety officer and some human resource services. In addition, the product created by the plant (ethanol, lignin or pyrolysis oil) should be transported to the customer. Around 6 jobs may be created in addition 35 temporary jobs are created in

[2] Estimation BTG on job generation from second generation plants like pyrolysis plant or Lignol plant.

constructing the plant. To summarize, each plant can create 16 direct jobs, 6 indirect jobs and 35 temporary jobs (internal information of Lignol and BTG).

14.5.4 Working Conditions

One of the core principles of Tembec's Sustainable Forest Management Plan is to comply with all provincial and federal legislations. These include guidance on health and safety, working hours, employee benefits and staff working conditions in general. Additionally, employees have the right to collective bargaining, there are appropriate grievance resolution mechanisms and staff representation to the company. The company also has a Human Resource Participation Policy that aims at empowering its staff and integrating their concerns into planning and decision making processes. As a matter of priority, the company ensures that all its employees are well trained not only to execute their duties efficiently, but also on necessary health and safety and working practices. Each staff of the company is entitled to forty hours of training per annum, as a corporate policy. The company hopes to review this upwards to sixty hours. The company has an internal time-table for delivering this and staff is paid their normal rates during the training periods.

14.6 Evaluation of Measurable Units and Indicators

14.6.1 Relevance of Impacts

The production of second generation products like lignin, ethanol, pyrolysis oil and upgraded products using forest residues and pulp wood can generate economic benefits and employment in the forestry sector that suffers from the declining demand for paper and timber. These impacts are important on national and regional level, but even more on a local level. Villages and communities are often highly dependent on the nearby paper or saw mill and the decline of these sectors have hit these communities hard. On micro-economic scale, for each biorefinery, the challenge is to produce sufficient added value materials at low costs. For instance, ethanol is produced elsewhere in bulk and ethanol prices are comparatively low. Some fractions have high added value but are only available as small shares of the total output. These fractions are often similar but not equal to their fossil substitutes, meaning that marketing can be challenging. Furthermore, the complexity of the process increases the costs. For these reasons it is difficult to predict when the widespread dissemination of biorefineries will take place with the estimated economic and employment impacts on regional and national level. Working conditions are not likely to deviate from the existing practices in the forestry sector (biomass supply) and chemical industry (biomass conversion). In both sectors, health and safety are important issues that need to be taken care of by following and implementing the regulations that are in place.

Food issues are limited to the use of forest products like maple syrup, mushrooms and berries. Impacts seem to be limited, but can occur in case of land use conflicts. Land use conflicts are a relevant topic in Canada with its population of First Nations. These conflicts are tried to be solved through treaties on province level.

The forestry sector and processing industries typically employ male workers. Field work in the forestry sector is physically demanding, while offices have a 50 % share of female employees. The wage gap between male and female workers is decreasing in Canada, but still exists.

14.6.2 Determination of Thresholds

For economic issues, the determination of thresholds does not seem to be useful. Investors use thresholds on the Internal Rate of Return (IRR), Net Present Value (NPV), payback time and perceived risks before making an investment decision, but there is no reason to provide specific thresholds in the frame of this case study.

In the Employment Standards of BC various thresholds for labor conditions can be found, related to minimum wage, minimum daily pay, meal breaks, paydays, overtime, deductions, statuary holidays, annual vacations, leave from work, employment of young people and disputes, etc.

Related to safety issues, safety records are kept, but it is hard to provide thresholds: each accident is simply one too much. Regarding gender issues, some countries have minimum shares of women present in the board, but most countries don't. Of course, wage gaps between women and men are not acceptable on company level, but are however found in statistics.

14.6.3 Impact Mitigation Options

The production of renewable biofuels and bio-products is perceived as an environmentally friendly and green activity. Generally, this green image also raises expectations related to socio-economic conditions. Working conditions in the biomass supply sector should meet all relevant standards. Biomass supply is expected to be extracted from forests that are managed sustainably, and meet standards like the Forest Stewardship Council (FSC) or Programme for the Endorsement of Forest Certification Schemes (PEFC). The company should have an active policy on equal treatment and payment of women and encourage their participation.

14.6.4 Impacts and Biomass Certification

Existing biomass certification schemes do not cover biomass conversion. The biomass production and supply is covered by forest certification schemes. There are a number of possible certification systems that are available for forest management.

The most widely used systems are the FSC and the PEFC certification schemes. In 2001, Tembec committed to certification under the Forest Stewardship Council as a step towards improving its operational activities and assuring its client base about the sustainability of their forestry operations. In 2008, the company achieved FSC certification for all its forestry operations (an area totaling more than 9.7 million ha across Canada. Additionally, all of the company's pulp and paper, solid wood and chemical operations achieved FSC Chain of Custody Certification. The company continues to pursue FSC certification for new areas that come under its management. As an FSC certified entity, there is the requirement for the company to ensure that its operations are socially acceptable, environmentally sound and economically viable. To meet its certification requirements, the company has carried out a number of assessments (including High Conservation Value Assessments) to identify the impacts of its operations on the surrounding environment and communities. Various stakeholders including First Nations and experts have been involved in the identification of social and environmental values and in the prescription of appropriate management interventions as well as the monitoring of these interventions.

Following its commitments under certification, the company has also moved to implement grievance and dispute resolution mechanisms as well as introduce various policies aimed at eliminating discrimination and ensuring fair treatment and representation of worker interests.

14.7 Conclusion

This report presents the Global-Bio-Pact Case Study for second generation biofuels and products from lignocellulosic material in Canada. Two different technologies were selected as cases: lignin and ethanol production with the Lignol process and pyrolysis oil production with the BTG process. Although these technologies are different, their socio-economic impacts are very similar. The biomass supply chain is similar: both technologies can use pulp wood, forest residues, saw mill residues, waste wood, etc. Especially when biomass is extracted from forests, socio-economic issues like land ownership and conflicts are relevant. The conversion side has also many similar characteristics: both processes are in the demonstration phase, have the challenge to sell new bio-products with potentially high added value, but with the challenge of selling these products in a fossil dominated market. Also their factories will have a quite similar general outline and need of technical and operational personnel. Working conditions, health and gender issues are expected to be similar to those found in the forestry sector (biomass supply) and the chemical industry (biomass conversion). The processes are expected to have environmental benefits and the products will be marketed as being 'green'. This image as green = good, needs to be supported by proper measures to ensure that proper socio-economic conditions in the field of labor conditions, health and gender equality, etc. are created and sustained.

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Chapter 15
Biogas from Organic Waste in African Cities

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Abstract In comparison to bioenergy systems that are based on dedicated energy crops or parts of it, the use of waste materials and residues has received considerably less attention to date, especially with a view to sustainability concerns. This, however, may change in the future, as the competition for organic materials increases. Nevertheless, today one of the main challenges for the twenty-first century is the sustainable management and reuse of waste. This applies to developing, emerging, and developed countries. The focus of using waste for bioenergy production is usually on sustainable waste management, whereas the energy production is seen as a positive side effect. This chapter provides an overview on the different waste treatment options for bioenergy production in Africa and more specifically in three cities in Africa: Addis Ababa (Ethiopia), Arusha (Tanzania), and Johannesburg (South Africa). It shows the urgent need to invest in technologies in urban areas of Africa in order to improve especially health issues. The production of bioenergy is the most promising option to stimulate this investment, as it creates new business and job opportunities.

Keywords Biogas · Anaerobic digestion · Africa · Cities · Composting

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15.1 Introduction

One of the main large challenges for the twenty-first century is the sustainable management and reuse of waste. This applies to developing, emerging, and developed countries. Due to its important developments and legal framework conditions, some general aspects of waste management in Europe are described in the following sections, before the focus of this chapter is placed on Africa.

Although considerable achievements were made in several European countries, a major environmental challenge in Europe still remains in the field of sustainable waste management. Several policies and legislations were introduced in Europe in order to set the rules for sustainable waste management, such as the Landfill Directive 1999/31/EC (EC 1999) and the Waste Framework Directive 2008/98/EC (EC 2008).

The objective of the Landfill Directive is to prevent or reduce as far as possible negative effects on the environment from the landfilling of waste, by introducing stringent technical requirements for waste and landfills. The Directive is intended to prevent or reduce the adverse effects of the landfill of waste on the environment, in particular on surface water, groundwater, soil, air, and human health. It defines "biodegradable waste" as "any waste that is capable of undergoing anaerobic or aerobic decomposition, such as food and garden waste, and paper and paperboard." It obliges Member States to reduce the amount of biodegradable landfilled waste to 35 % of 1995 levels by 2016.

The Waste Framework Directive lays down measures to protect the environment and human health by preventing or reducing the adverse impacts of the generation and management of waste and by reducing overall impacts of resource use and improving the efficiency of such use. A core content of the directive is the application of the following waste hierarchy as a priority order in waste prevention and management legislation and policy:

- Prevention
- Preparing for reuse
- Recycling
- Other recovery, e.g., energy recovery
- Disposal

The directive defines "biowaste" as "biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants." Article 22 on biowaste of the directive asks Member States to take measures to encourage:

- The separate collection of biowaste with a view to the composting and digestion of biowaste
- The treatment of biowaste in a way that fulfills a high level of environmental protection
- The use of environmentally safe materials produced from biowaste

The directive highlights the importance in accordance with the waste hierarchy, and for the purpose of reduction of greenhouse gas emissions originating from waste disposal on landfills, to facilitate the separate collection and proper treatment of biowaste in order to produce environmentally safe compost and other biowaste based materials.

The problem of many European countries is that still much waste is landfilled and not recycled, nor used for energy production. More details about the European legislation and an approach on how to overcome the waste problem with biogas/biomethane production in five European cities is described by Rutz et al. (2013).

In contrast to the waste management and policies in many European countries, which calls for urgent improvements, the waste management in many African countries is less well managed. Suitable policies are only partially in place or not enforced. Often, informal practices characterize the sector and the waste is dumped on uncontrolled, open dumping sites. Even proper landfilling, that shall be phased out in Europe in the coming years, is rarely applied in African countries. According to the UNIDO review report on waste management, poor waste management practices, in particular the widespread dumping of wastes in water bodies and uncontrolled dump sites, aggravates the problems of generally low sanitation levels across the African continent (Mwesigye et al. 2009).

This poses a large potential for using waste for different purposes. The methane generation potential, derived from MSW (Municipal Solid Waste) produced by African urban areas (403 million inhabitants in 2010), has been calculated by Motola et al. (2013 draft version) and is estimated as 22.560 M m^3/year in volume and 807.641 TJ/year in energy. If all the potential calculated in this study is exploited and converted to power and assuming an efficiency of 40 % of the conversion *process*, the theoretical electricity potential is 92 TW_{el}/year, which is about 14 % of Africa's power production in 2010.

Despite being currently insufficiently exploited in Africa, urban organic waste (MSW and Agro-Industrial waste) is a potential feedstock for many value-added products for local economies. Organic wastes can be used for anaerobic digestion and related biotechnological processes, such as composting and vermiculture. Thereby, biodegradable wastes are converted into useful bioproducts, including biofuels, fertilizer (e.g., for urban farming), and animal feed. The core challenge of African countries in the waste sector is the management and valorization of biowaste in urban areas. This is an increasing concern in rapidly expanding urban areas in Africa due to rural exodus and migration to cities. While addressing this problem, a contribution to the fulfillment of the following Millennium Development Goals (MDG) can be made:

- MDG 1) Eradicating extreme poverty and hunger
- MDG 6) Combating HIV/AIDS, malaria, and other diseases
- MDG 7) Ensuring environmental sustainability

By improving the management of biowastes in developing countries, their potential adverse impacts on human and animal health can be reduced, the environment protected, and the economy stimulated. In order to demonstrate the impacts, examples of three rapidly expanding African cities are described in Sect. 15.3: Addis Ababa (Ethiopia), Arusha (Tanzania), and Johannesburg (South Africa). The differences of the three cities in climate, social framework, waste management, and different poverty/income levels allow for a comparative analysis.

15.2 Technical Solutions for Waste Management in African Cities

The simultaneous energetic use of organic urban waste, such as municipal solid waste (MSW) and catering/food waste (FW), and the creation of a closed nutrient cycle are only possible in anaerobic digestion (AD) biogas plants. The setup of AD waste treatment plants is developing very rapidly in many countries, such as in Europe (e.g., Germany). These plants are usually technically very sophisticated due to strict legal framework conditions and high profitability expectations. Therefore, these AD plants are usually larger plants of in average about 450 kW_{el}.

In Africa, AD is far less developed, especially for waste treatment (Rutz and Janssen 2012). The framework conditions are very different, technologies are available only to a limited extent, there exists a lack of capacity and financing resources, and project developers are confronted with many other technical and nontechnical barriers. However, AD for treating urban organic waste has many advantages and could be readily implemented in African cities, if the process is adapted to local framework conditions and nontechnical issues are considered.

AD facilities may be much smaller in African cities and need to involve a rather simple technology. Maintenance needs to be easy and special equipment that is not available on African markets has to be avoided. AD facilities must also be affordable by individuals, city communities, NGOs, or by the African waste management sector. Some issues are even easier to address in African cities, such as lower legal requirements. Furthermore, higher temperatures in African favor the AD process without additional heating system (in Europe climate is too cold for AD without heating systems).

Table 15.1 demonstrates in a simplified way the different use and treatment methods of organic urban waste in Africa. It includes some details on the current status of the application/technology as well as the advantages and disadvantages.

The table, highlighting the negative health and environmental impacts of the current waste system in most African cities, clearly stresses the advantages of AD, composting, and vermiculture. The following sections provide short definitions on these advanced processes:

- **Anaerobic digestion** (AD) is a series of processes in which several microorganisms break down biodegradable (organic) material in the absence of oxygen. The resulting output is biogas (mixture of different gases: 50–75 % CH_4, 25–50 % CO_2, 0–10 % N_2, 0–3 % H_2S, 0–2 % O_2) which can be used for heating, cooling, light, electricity, and transport. The other important output is digestate which can be used as fertilizer, e.g., for urban farming.

Table 15.1 Comparison of different waste applications and technologies in Africa and their (dis-)advantages

Waste application/technology	Current status in Africa	Advantages	Disadvantages
Uncontrolled dumping/combustion	Applied in many African cities by individuals	Simple, cheap	Serious negative health impacts through pathogens, air pollution, and water pollution; no valorization possible
Open landfill/dumping	The overwhelming majority of landfills in Africa are open dumps/landfills without leachate or gas recovery systems. Several are located in ecological or hydrological sensitive areas	Simple, cheap	Serious negative health impacts through pathogens and water pollution; landfills are often sited based on considerations of access to collection vehicles rather than hydrological or public health considerations. Waste collecting system is needed
Covered landfill (with landfill gas recovery)	In the last years some countries, including e.g., Egypt and South Africa, have considered policy changes to promote upgraded landfills for their major cities	Environmental impacts can be considerably reduced; valorization only possible if landfill gas is recovered	Sophisticated waste management is needed; it is related to higher costs
Controlled incineration in power plants	Only very few plants are in operation in Africa	Energy recovery possible	Very high investments needed. No nutrient recovery possible
Composting and vermiculture	Composting is made for agricultural wastes in rural areas. Industrial composting activities are very little. Vermiculture is also only applied in some very few examples	Rather simple process. Only low investment costs are needed. Can be also applied at small-scale and decentralized. Creation of microenterprises possible. Closed nutrient cycle	Only applicable to the organic fraction. Source separated collection system is needed. No energy recovery possible
Anaerobic digestion	AD is so far mainly applied on household level in rural areas or related to dedicated waste streams of the agro-industry	Only low investment costs are needed. Can also be applied at small-scale and decentralized. Creation of microenterprises possible. Closed nutrient cycle. Energy production possible for cooking, light, electricity, or transport. Contributes to improve environmental and health issues	Only applicable to the organic fraction. Source separated collection system is needed. Not implemented yet at large-scale due to the lack of processes adapted to local African framework conditions

- **Composting** is the decomposition of biodegradable (organic) material by aerobic bacteria. They decompose the inputs by using oxygen into heat, carbon dioxide, and ammonium. The ammonium is further converted by bacteria into plant-nourishing nitrites and nitrates through the process of nitrification. Also fungi and macro organisms like worms contribute to the decomposition of the material.
- **Vermiculture** is a special form of composting by utilizing various species of worms, usually red wigglers, white worms, and earthworms to create high quality bedding materials, and vermicast. Vermicast, also known as worm castings, worm humus or worm manure, is the end-product of the breakdown of organic matter by a species of earthworm. Containing water-soluble nutrients, vermicompost is an excellent, nutrient-rich organic fertilizer and soil conditioner.

The application of these technologies have impacts on socio-economic aspects on a local level, including on working conditions, local revenues, job creation (especially low skilled jobs), human and environmental health issues, and on micro-scale waste collectors (i.e., scavengers).

15.3 The Situation in African Cities

The treatment of urban organic wastes constitutes one of the largest environmental and social problems of expanding African cities in the twenty-first century. African cities are characterized by rapid expansions due to rural exodus and migration to urban areas. In many cases, this creates serious threats and pressure to the urban infrastructure, which has difficulties to keep pace with the growth. One of the major infrastructural challenges is sustainable waste management.

The infrastructure and land-use planning in African cities (including for waste management) is not coping with the growth of urban areas (around 3.5 % annually, highest in the world) and this is particularly problematic in the slum areas which constitute a large part of many cities and towns in Africa (Mwesigye et al. 2009).

Large fractions of urban wastes are characterized by very high amounts of organic material, including household waste, agricultural waste (due to urban farming), industrial waste, and wastewaters. Organic urban wastes have considerable potential as a source of renewable bioenergy, but currently only constitute serious environmental pollution problems affecting human health in many African cities. These organic wastes are generally suitable as feedstock for biotechnological processes and specifically for AD which could contribute as technology to:

- Manage organic waste streams in cities
- Avoid urban pollution and reduce pathogens constituting a major health risk
- Recycle highly valuable nutrients which are often lacking in African agriculture
- Generate renewable energy
- Increase new business and job creation opportunities

However, the AD process is complex and requires dedicated technology and knowledge to keep it stable and efficient. A large advantage is that biogas can be produced at different scales, from small/simple scale to large/sophisticated scale, depending on the main objectives (e.g., energy production, waste treatment), feedstock material, and available financial resources. The use of urban waste for AD, especially urban household waste, is a large challenge for African cities, due to for instance, weak waste treatment infrastructure, inhomogeneity of feedstock, and impurities in the waste.

So far, most African biogas projects and programs have focused on dedicated wastes from agriculture or on biogas production at household level in rural areas (e.g., Biogas for Better Life Africa[1], Africa Biogas Partnership Programme-ABPP[2], Tanzania Domestic Biogas Programme[3]). Progress is needed in order to develop AD and related biotechnological processes for converting biodegradable wastes in urban areas of Africa into useful bioproducts, including biofuels, and animal feed through the improvement of urban farming by high-quality digestate as fertilizer.

Thus, in most African countries there is urgent need to improve waste management and sustainable energy supply in urban areas. In the following section, the situations of three African cities are described: Addis Ababa (Ethiopia), Arusha (Tanzania), and Johannesburg (South Africa).

The differences of the three cities in climate, social framework, waste management, and different poverty/income levels allow for an interesting comparative analysis. For instance, in Johannesburg waste management systems are more sophisticated and AD technology and financing sources more abundant than in Addis Ababa or Arusha. This has some impact on technology selection. Currently, the use of biogas in Addis Ababa and Arusha is more feasible for smaller systems such as for cooking and small applications whereas in Johannesburg it may be as sophisticated as upgrading to biomethane quality for transport use.

15.3.1 Addis Ababa, Ethiopia

Addis Ababa was established in 1887. It is a rapidly growing city with a total land area of about 546 km^2 and a population of over 2.9 million. Poor solid waste management is an issue of major concern of the city. According to the Addis Ababa Sanitation, Beautification and Park Development Sectoral Plan (SBPDA 2004), about 65 % of the solid waste generated by the city is collected and disposed at the dumping site. Hence, this dumping site, with an area of 36 ha, has been filled so far with about 10 million t of waste in the past 46 years. The volume of solid waste generated in the city is increasing drastically as a result of the rapid population growth. The city has no dedicated plan for solid waste management, and it lacks necessary

[1] http://www.biogasafrica.org

[2] http://www.snvworld.org/en/ourwork/Pages/Africa_Biogas_Partnership_Programme.aspx

[3] www.biogas-tanzania.org

Fig. 15.1 Waste collectors in Addis Ababa. (Source: D. Rutz, WIP)

infrastructure. The primary and secondary collection schemes for solid waste are not well organized and are characterized by poor efficiency (Fig 15.1).

According to Addis Ababa Health Bureau (1997), the major sources of solid waste were residential (76 %), commercial (15 %), street sweepings (6 %) and the remaining 3 % from other sources. Food left over, kitchen waste, and spoiled vegetables constitute the major residential and commercial waste. The official solid waste generation rate data generated from Gordon dating back to 1995, being about 15 years old (SBPDA 2004). According to this reference, it was about 252 g/capita/day. Recently, the IGNIS project investigated the waste generation rate for different sources and has obtained very close figures to the data from Gordon (IGNIS 2010). Hence, the daily generation rate is estimated to be about 730 t. The biodegradable component is estimated to be higher than 70 %. It is characterized by very high moisture content (Tsegaye 2007).

Hence, the organic fraction of the city waste has a very high potential for anaerobic digestion and for composting. However, there are limited experiences for biotechnical treatment in the city. Some individuals, NGOs, and the city's Environmental Protection Authority have been constructing biogas plants and composting facilities. The biogas production is thus currently very limited and only includes the treatment of human and animal wastes. The practices are lacking efficiency, experience, and knowledge about biogas production and utilization. In the IGNIS project, small-scale research was carried out to investigate biogas potential of food left-over and other organic waste mixtures in a 15 m^3 digester. However, experience is not yet mature to optimize the biogas plant.

Key challenges in Addis Ababa

- The increasing volume of waste, which is attributed to the large growth of the city population, is a major concern since current waste disposal sites are not capable to accommodate these wastes properly. The existing open disposal site is an open dumping field overflowing to the nearby highway. Due to land scarcity in the city, a sanitary landfill will be set up in the neighboring administrative regional state which is about 30 km away from the city. However, also this landfill also will not be large enough to dump all waste.

- There is neither appropriate treatment nor disposal methods regarding the solid wastes being dumped on the dumping sites, particularly considering the adverse GHG impact of dumped waste.
- Waste collection does not include waste separation. The characteristics and composition of the (organic) waste is not very well investigated. There is only knowledge and awareness to sustainably manage the waste (skilled personnel, technology, and others).
- A large portion (70 %) of the waste in Addis Ababa is biodegradable and would be suitable for AD, but is currently disposed uncontrolled.
- Some experience on AD exists. However, biogas production is largely limited to the treatment of animal and toilet wastes. Slight changes of the feedstock characteristics usually result in rapid changes in gas production and disturbances in AD. There is currently lack of research on the use of MSW in AD processes in Addis Ababa.

15.3.2 Arusha, Tanzania

Arusha is a city in northern Tanzania. It is the capital of the Arusha Region, which claims a population of 1,288,088, including 281,608 for the Arusha District (2002 census). Refuse generated is estimated at an average of 410 t/day and an average daily rate of 0.8 kg/capita. The amount of *solid* waste currently generated from household source only in Arusha city is 254 t/day or 0.48 kg/capita/day, which is within the range of 0.4–0.64 kg/capita/day for developing countries as reported by the World Bank. The refuse generation in Arusha City comes from different sources as follows: commercials/trade activities 39 %, markets 18 %, households (domestic) 18 %, industries 2 %, street vendors/pedestrians 2 %, institutions 0.5 %, and construction waste materials 3.5 %. Only 160–220 t, which counts for approximately 40 %, are collected and disposed. The remaining 60 % is not collected due to limited financial resources required for purchasing enough refuse collection trucks and other equipment resulting in serious environmental pollution especially at garbage collection centers (Fig. 15.2).

Solid wastes from households consist of degradable food wastes, leaves, and dead animals as well as nondegradable wastes such as plastics, bottles, nylon, medical/hospital wastes, industries and commercial waste. The most visible wastes produced by urban dwellers in Arusha are organic domestic waste, plastics, and general packaging materials. About 70 % of the household waste is organic. A large quantity of organic waste is littering the town and surrounding water streams, or is put on cumulative refuse piles in collection points and along road ditches. Much of the non-collected waste consists predominantly of plastics and comes directly from commercial centers and households.

Arusha has favorable climatic and weather conditions which favor urban farming, especially dairy livestock keeping that produces large amounts of cow dung which could be potentially used as energy source. Solid waste collection and disposal in

Fig. 15.2 Waste collection at the central market in Arusha. (Source: D. Rutz, WIP)

Arusha is involving franchises (private firms) and community based organizations (CBOs). Collection includes street sweeping, refuse bins, plastic bags, communal and other household containers.

Key challenges in Arusha

- A key challenge regarding waste management for the city of Arusha is mainly the volume of waste being generated, which increases at a faster rate than the ability of the agencies to improve waste collecting infrastructures. There is a lack of financial and technical resources to manage this growth. Therefore, waste management in the city of Arusha is characterized by lack of source sorting, inefficient collection methods, insufficient coverage of the collection system, insufficient storage, and improper disposal of waste. There is no proper landfill operation. This is evidenced by the accumulating wastes and illegal dumps that can be observed in the streets. Thus, these wastes create major public health problems as well as cause water pollution and greenhouse gas emissions.
- Arusha city has very few trucks to remove waste from communal bins and other public generation and collection points to Muriet dump site. Only about 40 % of waste is collected. The rest, mostly cow dung, is either being burnt in-situ, left along the road, or disposed in rivers. Open dumping is common practice in Arusha City. Communal waste collection bins are not enough and where available, people are not trained to use them. Scavengers put fire on communal waste bins to extract metals from waste.
- Most cow dung of urban farming is dumped, wasting valuable nutrients. It is common practice in Arusha that residents practice urban farming through keeping dairy cattle in their household, which produces large amounts of cow dung. This is not managed by solid waste management systems, presenting a huge potential for AD.
- The composition of the waste is characterized by high levels of impurities, large moisture content, large amount of organic waste (70 %) in the urban waste fraction, as well as large quantities of dust and dirt (street sweepings, etc.).

Fig. 15.3 Biogas cooking stove supplying a canteen close to Arusha (Diligent biogas plant). (Source: D. Rutz, WIP)

- Traditional AD processes which exist in developing countries have several drawbacks. Depending on the technology, the drawbacks include extremely low treatment efficiency, problems of odor, health issues, and long retention time, as well as other operational and technical problems. Furthermore, the biogas technologies of existing plants concentrate mainly on energy production and less consideration is given to waste reduction. In the greater Arusha area, only very few AD plants exist. A major application of biogas is the use as cooking fuel (Fig. 15.3).

15.3.3 Johannesburg, South Africa

The Gauteng Province (including the cities Johannesburg, Pretoria, and Ekurhuleni) in South Africa is the largest mega-city in Africa as measured in terms of economic activity, and generates most waste per person in South Africa (2.44 m^3/year/person). This waste is disposed to 25 landfill sites across the province. In addition, a large number of closed landfill sites exist. Separation of municipal waste is limited. A number of landfill gas capturing projects at some of the landfill sites have started since 2005. These projects, for the most part, flare landfill gas with the intention of earning income through Clean Development Mechanism (CDM) credits. No biogas generation through anaerobic digestion is currently conducted at any of the landfill sites in Gauteng.

The City of Johannesburg, one of the largest metropolitan municipalities within the province, generates municipal waste which requires the equivalent of 1.7 M m^3/year. This waste is primarily disposed at five landfill sites, including Robinson Deep, Limbro Park (full and closed in 2010), Goudkoppies, Marie Louise, and Ennerdale. The City of Johannesburg is the leading Metropolitan Municipality in the province with respect to waste separation and landfill gas beneficiation. At one closed landfill site in the province, the Sebenza site at the Ekurhuleni Metropolitan Municipality,

Fig. 15.4 Filling station of NOVO for upgrades landfill gas plant at the Sebenza landfill site. (Source: Hugo A., NOVO)

landfill gas is captured, cleaned, and compressed and used to refill vehicles belonging to the Ekurhuleni Metropolitan Municipality and minibus taxis (Fig. 15.4). This project has been developed as a pilot project by the private company Novo Energy (Pty) Ltd, in cooperation with the Ekurhuleni Metropolitan Municipality.

Key challenges in Johannesburg

- Waste collection in Johannesburg is relatively advanced in comparison to Addis Ababa and Arusha. However, source separation is still insufficient. This is required to ensure that sufficient quantities of the suitable feedstock are available.
- Appropriate biogas generation equipment needs to be identified, which can produce biogas with a defined quality for various applications, such as upgrading and use in the transport sector.
- The AD technology needs to be demonstrated in order to generate credibility in South Africa and to phase out landfilling in the long term.
- The economic and financial feasibility of the biogas generation technology, and it applications, needs to be assessed under South African policy, legal, and economic conditions.

15.4 Socio-Economic Impacts

In general, proper waste management has many positive impacts on the environment and on humans. In addition, biogas production from waste generates energy and high quality fertilizer. Due to the positive impacts of the "feedstock" production step, biogas from waste is very different to the use of dedicated energy crops, which are presented elsewhere in this book. Although there are many positive impacts during the feedstock production step of energy crops, there are several negative impacts and challenges to be overcome. In contrast to this, the use of waste for bioenergy production can be regarded per se as positive. The positive impacts of using waste for bioenergy are also recognized, e.g., by European policies (EC 2012).

Despite the positive impacts, changes of systems such as from poorly managed waste systems to well-managed systems, may also have spontaneous negative impacts for some individuals. Waste pickers, also called scavengers, are person who collect reusable or recyclable materials thrown away by others to sell or for personal consumption. Waste picking is a phenomenon of mainly developing countries due to urbanization. It is usually an informal sector. People living from the informal waste sector may lose their basis for income, shelter, and food. However, these impacts are minor in comparison to the overall positive impacts of well managed waste systems, and solutions to avoid these negative impacts can be easily identified, such as the set-up of social programs, in which employment is generated for the people of the informal sector.

15.5 Conclusion

Although biogas production from waste has multiple positive impacts, the realization of good waste management practices in Africa is rarely in place. This is due to the fact that the gap between waste management policy and legislation and actual waste management practices is widening, due to ongoing capacity constraints or nonexistence of waste management facilities for the different waste streams (Mwesigye et al. 2009). Furthermore, there are gaps in know-how and capacity and finally of investment.

The existing waste management structures in Europe often pose a barrier to the introduction of new technologies as stakeholders in the waste sector tend to use the "old" technologies as long as possible. In contrast, the low level of waste management structures in Africa presents a large opportunity to streamline investments in the direction of creating sustainable waste management practices, such as anaerobic digestion. However, there is an urgent need to enable large amounts of investment in waste management in Africa.

The examples and comparisons of the three cities in Ethiopia, Tanzania, and South Africa have shown differences in development of the waste sector. This highlights the need for individual approaches.

Due to the positive impacts of using waste for energy (biogas) production, nowadays heavily criticized bioenergy, especially in developing countries, could get a new and very positive image.

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Chapter 16
Analysis of Socio-Economic Indicators on Different Bioenergy Case Studies

Janske van Eijck and André P. C. Faaij

Abstract Socio-economic indicators are not fully developed and operational while this is an important aspect of sustainability. Seven case studies were analyzed within the Global-Bio-Pact project covering seven countries and five feedstock types. The 100 indicators that are identified are analyzed and evaluated to derive valuable lessons and recommendations. From this analysis it becomes clear that it is essential to look at impacts on different levels: national, regional, and local. This is because, e.g., impacts on a local level are not always reflected in macroeconomic indicators and vice versa. Background indicators, e.g., GDP in a region or the level of unemployment, do not necessarily link directly to bioenergy impacts but can provide a snapshot of the setting in which bioenergy projects operate. This can identify potential important areas of concern (with negative or positive impacts) beforehand. There is a trade-off between accuracy of the data and practicability. This can vary per country and per feedstock depending on data availability. More (accurate) data collection is required on all levels (national, regional, and local). Furthermore, more methodologies, based on quantitative data, have to be developed to gain better insight in socio-economic impacts on the long term.

Keywords Socio-economic indicators · Employment · Food security · Land rights · Working conditions · Gender issues

16.1 Introduction

Worldwide production and trade in bioenergy has increased exponentially during the last few years. Biodiesel production rose from less than 30 PJ in 2000 to 572 PJ in 2009 and ethanol production from 340 PJ in 2000 to 1,540 PJ in 2009 (Lamers et al. 2011). However, a strong public debate on sustainability aspects for

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bioenergy emerged in the last few years. This debate focused mainly on negative social and environmental impacts. As a consequence, several initiatives are set up that are engaged in developing methodologies and tools to ensure the sustainability of biofuels. One option to ensure the sustainability of biofuels is the application of certification systems that use indicators which can be useful to share and compare information (Diaz-Chavez 2010). There is globally an increased focus on the development of sustainability certification schemes (van Dam et al. 2008; van Dam et al. 2010; Vissers et al. 2011). However, most of the existing sustainability certification schemes are not yet fully operational, although sustainable bioenergy production is required, e.g., by the European Renewable Energy Directive (RED, European Commission 2011).

More than 100 indicators (social, economic, and environmental) were already identified by Lewandowski and Faaij (2006) and around 67 sustainability certification initiatives by van Dam et al. (2010). Vissers et al. (2011) furthermore compared 18 certification schemes that were suitable for biofuels for energy purposes. But there is a lack of unity and consensus among the different certification schemes (Vissers et al. 2011). There is a need for further harmonization of the various certification schemes to come to a more uniform certification system (Janssen and Rutz 2011; van Dam and Junginger 2011). But also, criteria and indicators may sometimes be too general, vague, and leave room for different interpretations (Lewandowski and Faaij 2006).

Furthermore, it appears that most of the sustainability certification schemes mainly considered environmental principles, even though there are serious concerns about socio-economic impacts of bioenergy production activities (van Dam et al. 2010). More recently, certification schemes have been developed that also include socio-economic aspects. Examples of sustainability certification systems that include socio-economic aspects are the *Sustainability Indicators for Bioenergy*, developed by the Global Bioenergy Partnership (GBEP 2011), the *Principles and Criteria for Sustainable Biofuel Production*, developed by the Roundtable of Sustainable Biofuels (RSB 2010), and the *NTA8080* (Netherlands Technical Agreement), developed by the Nederlands Normalisatie-institute (Dutch Normalization Institute; NEN 2011). But some of the indicators in these schemes are not based on quantitative indicators, often on compliance indicators and most schemes are not yet fully operational or field tested.

There is also a need to develop more suitable methodologies, to measure impacts of biofuel production under specific circumstances, such as for a specific region (Smeets et al. 2008). Examples of studies quantifying the impacts of bioenergy production are those by Arndt et al. (2009) and Herreras Martinez et al. (2013), who, respectively, use a CGE analysis and an input/output analysis. However, these methods require a thorough understanding of modeling techniques and are time consuming. There is a trade-off between the accuracy of sustainability indicators and the practicability (taking into account time and financial constraints). Furthermore, the applicability in developing countries, where (reliable) data is often lacking, and obtaining field data is tiresome due to cultural, infrastructural, and other barriers, can be different than in high developed countries (van Eijck et al. in press;

van Eijck et al. 2012), while developing countries have a large potential for bioenergy feedstock supply (van der Hilst et al. 2011; Wicke et al. 2011).

A core activity of Global-Bio-Pact was the description of socio-economic impacts in different countries and continents in order to collect practical experience about socio-economic impacts of bio-products and biofuels under different environmental, legal, social, and economical framework conditions. The results of these surveys are described in different case studies. In this chapter, the indicators that were identified by the case studies are analyzed and evaluated to be able to identify practicability issues and current knowledge gaps. Section 16.2 shows the case studies and the areas of concern that are included in the analysis. In Sect. 16.3, the indicators that came out of the case study report analysis are evaluated. Section 16.4 finally covers the recommendations.

16.2 Methodology

16.2.1 Case Studies

In order to generate data on the ground, seven in-depth case studies covering seven countries on three different continents and five different feedstock types, were investigated on socio-economic impacts in the framework of Global-Bio-Pact. The impacts are assessed on different levels, including the national, regional, and local/company/project level (see Table 16.1 and Fig. 16.1). In the case studies the following assessments were made:

- One study at national level
- One study at regional level
- Two studies at local, company, or project level

The case studies at the national level were selected in order to balance the geographical distribution (Africa, Latin America, Asia, Europe, North America), feedstock sources (soy, palm oil, jatropha, sugarcane, lignocellulosic feedstock), conversion technologies (e.g., fermentation, pressing, transesterification, hydrolysis, gasification), and products (biodiesel, pure plant oil, ethanol, bio-products, second generation technologies).

16.2.2 Overview Areas of Concern

The following areas of concern or themes were addressed:

- Economics (macro, regional, and local level)
- Employment generation
- Food issues

Table 16.1 Feedstock types that are included in the case studies, including country, region, and village or company on which the Global-Bio-Pact case studies were based

Feedstock type	Case study country	Region	Project/village/company	Source/case study report
Soy	Argentina	National and regional Buenos Aires, Santa Fe, Cordoba	Viluco S.A., Frias Roldán	Sbarra and Hilbert (2011)
Palm oil	Indonesia	North and Central Sumatra	Aek Raso Plantation and palm oil mill, Desa Asam jawa and Harapan Makmur	Wright (2011)
Jatropha	Mali	Koulikouro	Mali Biocarburant SA, Garalo Bagani Yeelen	Burrel et al. (2011)
	Tanzania	Kisarawe Arusha	Leguruki Village	Sawe et al. (2011)
Sugarcane	Costa Rica	Guanacaste, Turrialba	Central Azucarera Tempiswue S.A. CATSA	Cárdenas and Fallot (2011)
	Brazil	Sao Paulo, Northeast Brazil	São Fransisco Mill and Pindorama Mill	Gerber Machado and Walter (2011)
Second generation	Canada	Vancouver, BC		Sleen et al. (2011)

Fig. 16.1 Case study countries of the Global-Bio-Pact project

Table 16.2 Overview of indicator theme and relative significance indicated by the Global-Bio-Pact case study reports

Indicator theme	Number of indicators identified	Indicator significance[a]	Indicator significance[a]	Indicator significance[a]
		high	low	no indication
Macroeconomic	7	5	6	4
Regional economic	10	0	8	5
Microeconomic	14	9	3	6
Employment generation	14	16	12	n.a.
Food issues	4	4	5	6
Land use competition	16	7	2	9
Working conditions	12	19	5	n.a.
Health issues	11	6	8	n.a.
Gender issues	12	10	8	n.a.

[a] Some indicators are identified by multiple case study reports, therefore indicator significance total can be more than number of indicators identified

- Land use competition and conflicts
- Working conditions
- Health issues
- Gender issues

The case study reports also indicated the relative importance of the different indicators (based on the opinion of the author of the case study report; Table 16.2).

Especially, employment generation and working conditions were considered to be important by the case study authors. In the next section (16.3) the indicators are evaluated. It is described whether the indicators that the case studies identified accurately describe the main theme, considering the sometimes limited amount of time and data, or that additional information or analyses are required.

16.3 Analysis of the Indicators

16.3.1 Economic Indicators

Within the economic indicators, macro, regional, and local indicators are differentiated. Furthermore a difference is made between background indicators that describe the general background of the nation or region and impact indicators that are directed specifically towards the impact of the biofuel activity (Table 16.3).

All economic indicators are quantitative indicators. The macro and regional economic indicators rely on statistical analysis or input/output analysis and require statistical data availability. Usually most of the indicators are collected by national bodies. The methodology that is applied to the majority of local indicators is by means of interviews or company records, which means data collection partly depends on information provided by companies. Only the NPV, which can be calculated on project level, is more objective, although even this methodology relies on data that is obtained from companies or projects.

The different level-indicators are further evaluated below.

National (Macro) Level The majority of the macroeconomic background indicators are used and collected by global organizations such as Food and Agriculture Organization (FAO), United Nations Development Programme (UNDP), and the World Bank. Statistical data that are presented by sector such as the sector-GDP contribution, number of jobs per sector, etc., is normally collected by national bodies, but since the bioenergy sector is relatively new, this sector is often not disaggregated. Therefore, some indicators such as investment in the bioenergy sector and number of jobs in the bioenergy sector are currently difficult to gather in some countries. For example, Canada was the only country of the Global-Bio-Pact case studies that was able to provide information on investments in the bioenergy sector.

Besides methodologies that are based on statistics, there are other methodologies e.g., using Input/Output (I/O) tables. An I/O analysis per country or region (see Herreras Martinez et al. 2013), can provide information on the specific impact by a sector and can also take future projections into account. However, I/O tables are needed per country to be able to make such an analysis as well as capabilities to perform the analyses. A General Equilibrium Model (CGE) can provide even more detailed information, but this requires technological capabilities at the organizations that perform the analyses.

In general, the background statistical indicators are relatively easy and quick to obtain and give a snapshot idea of the state of the economy of a country. The impact of the biofuel sector on the national economy requires additional data (especially a disaggregation of the biofuel sector) or modeling efforts.

Table 16.3 Economic indicators on national (macro), regional, and local (micro) level, identified by the Global-Bio-Pact case studies, excluding employment creation

No.	Economic indicators	Qn Ql	Measurement method
1A	*Macroeconomic indicators*		
	Background indicators		
–	GDP (€ or $)	Qn	Statistical data
–	GDP/capita (€ or $)	Qn	Statistical data
–	GINI coefficient	Qn	Statistical data
–	People below poverty line of US $ 2/day (%)	Qn	Statistical data
–	Human Development Index (HDI)	Qn	Statistical data
	Impact/ specific indicators		
a.1	Sector contribution to GDP (%)	Qn	Statistical data or input/ output analysis
a.2	Sector contribution to agricultural GDP (%)	Qn	Statistical data
a.3	Value of the sector (by revenue or turnover generated by the sector (€ or $)	Qn	Statistical data
a.4	Products exported (t or l)	Qn	Statistical data
a.5	Investments in the sector (€ or $)	Qn	Statistical data
a.6	Total investment in bioenergy infrastructure over the past decade (€ or $)	Qn	Statistical data
a.7	Value of industrial inputs (€ or $)	Qn	Statistical data
B	*Regional economic indicators*		
	Background indicators		
–	GRDP (€ or $)	Qn	Statistical data
–	Regional per capita income as percentage of national per capita income (%)	Qn	Statistical analysis
–	Regional GINI index compared to national GINI index		
b.1	Bioenergy sector contribution to GRDP (%)	Qn	Statistical analysis or input/ output analysis
b.2	Contribution of bioenergy product exports to total exports (%)	Qn	Statistical analysis
b.3	Turnover of the sector in the region (€ or $)	Qn	Statistical analysis
b.4	Investments in the sector in the region (€ or $)	Qn	Statistical analysis
b.5	Regional sector employment as part of total employment	Qn	Statistical analysis
b.6	Regional sector turnover as part of total turnover (%)	Qn	Statistical analysis
b.7	Volume of bioenergy production by large plantations and smallholders	Qn	Statistical analysis
b.8	Share of income for large companies and smallholders	Qn	Statistical analysis
b.9	Amount of revenue collected from bioenergy sector (€ or $)	Qn	Statistical analysis
b.10	Total number of jobs generated in the region by bioenergy sector (no. of jobs)	Qn	Statistical analysis or Input/ output analysis
C	*Local-economic indicators*		
c.1	Net present value (NPV) (€ or $)	Qn	Cost benefit analysis (CBA)
c.2	Internal rate of return (IRR) (%)	Qn	Interviews, CBA
c.3	Contribution of feedstock sales to household income (% or absolute value)	Qn	Smallholder records and interviews

Table 16.3 (continued)

No.	Economic indicators	Qn Ql	Measurement method
c.4	Cost of feedstock production ($/GJ) compared to other alternatives	Qn	Company records and interviews
c.5	Cost of feedstock conversion ($/GJ) compared to other alternatives	Qn	Company records and interviews
c.6	Total project investments (€ or $)	Qn	Interviews
c.7	Turnover of the company (€ or $)		
c.8	Labor requirements (jobs/ha)	Qn	
c.9	Labor costs ($/t or liter)	Qn	Literature/ interviews
c.10	Wage levels at the bioenergy company	Qn	
c.11	Feedstock price (€ or $)	Qn	Literature/ interviews
c.12	Product selling prices (€ or $)	Qn	Literature/ interviews
c.13	Total profit by project	Qn	Interviews
c.14	Revenue per ha from bioenergy crop compared to revenues of other crops ($/ha)	Qn	literature and/or interviews

Qn quantitative, *Ql* qualitative

Regional Level The regional impact of the biofuel sector in the case study countries is difficult to assess. General regional differences, such as the per capita income in a region compared to the national average give an idea of the relative level of development of a region compared to the national average, but this does not give information about the impact of biofuels. Two indicators seem to give a good overview of the regional impact by the biofuel sector:

- The percentage bioenergy contribution to GRDP gives a quick (if statistical data is available) first order idea of the importance of a certain sector in the region. It is also possible to obtain the potential contribution of the sector, if this impact is modeled. However, more detailed information would be required to assess differences in this sector, such as average wages, employment, technology investment, etc. The total amount of investment in the region could provide information on possible expansion of the sector.
- The total number of jobs generated in the region by the biofuel sector only provides information if this figure can be compared to a national average or to total unemployment figures of the region. Combining these indicators would provide information on possible migration of laborers, and with average wages to identify the impact on household level.

For both indicators often no statistical data is recorded. Only in five case studies data for these indicators was obtained. In that case an input/output analysis is necessary to obtain values for these indicators.

Local (Micro) Level As the impacts on a local scale are project specific, the micro-economic indicators have to be assessed for each project. If a business plan is publicly made available, acquiring the internal rate of return (IRR) or NPV of a project is relatively easy. However, in reality the exact cost figures might be different from the planned ones, and obtaining this type of data is very time consuming (van Eijck et al., in press).

The revenue per ha for a certain bioenergy crop (indicator c.14) can give a good indication of potential profits for farmers or plantation companies, especially if compared to other crops.

Wage levels and product selling prices relate directly to a certain business model and projected profits.

The distribution of profits is an important theme. Wage levels, minimum wages, possibly gender disaggregated wage data but also the ratio of profits that stay in a country or goes abroad, could assist in assessing the distribution.

The contribution of the bioenergy project to household income is also important, although this does not give information about other (potentially more profitable) income opportunities (or the lack thereof).

16.3.2 Employment Indicators

There are 3 background indicators identified and 14 impact indicators as shown in Table 16.4.

In ex ante impact assessments employment generation is often an important parameter; while in certification systems there is usually no criterion for the number of jobs to be created; the working conditions and (minimum) wage levels have to be considered (discussed in other sections). It can be a challenge to measure minimum wage levels, e.g., for contract workers that are paid by unit. Important other questions are: Can they live from their wage? Do they have the possibility to bargain? Do they get a contract?

Interesting is to observe that indicators need to be specified well: there could be a difference between the number of workers and the number of jobs. Also, the categories of educational levels vary between the case studies (unskilled, semiskilled, skilled labor versus more detailed educational level indications).

16.3.3 Food Security

Table 16.5 shows the indicators on food security that are identified.

Most of the indicators depend on (available) statistical data. Figure 16.2 shows the results for the indicator undernourishment for the case study countries. The data for this indicator is collected by FAO. General trend lines can easily be observed, but they are not necessarily related to bioenergy developments.

Some indicators already combine a lot of information such as the indicator "Food security index score." However, not many governments collect the data for this indicator. Together with other indicators that are mentioned by the case studies, for example, the percentage of undernourished people, these indicators can give background information on the status of food security in a country. The link to bioenergy developments and their impact is however still not accurately shown. Only

Table 16.4 Overview of employment indicators as identified by the Global-Bio-Pact case study reports

No.	Employment indicators	Qn/Ql	Measurement method
	Background indicators		
–	Total labor force (no)	Qn	Statistical data
–	Unemployment ratio (%)	Qn	Statistical data
–	Average minimum wage ($/day or month)	Qn	Statistical data
2.1	Employment generation on national level (sector; no. of jobs)	Qn	Statistical data or input/output analysis
2.2	Employment generation on regional level	Qn	Statistics, literature (if available)
2.3	Employment generation on local level	Qn	Company records and interviews
2.4	Ratio of fixed contract: casual/daily workers	Qn	Company records and interviews
2.5	Percentage of informal jobs, total jobs generated included informal		
2.6	Wage levels (including casual workers) compared to minimum wages	Qn	Company records and interviews
2.7	Income earned by smallholders ($/ha or t)	Qn	Interviews, literature
2.8	Educational level required	Qn	Company records and interviews
2.9	Job growth rate	Qn	Statistics
2.10	Average age of employees	Qn	Sector level labor statistics
2.11	Participation of different races	Qn	Sector level labor statistics
2.12	Wages at farm/company compared to wages in traditional activities (like charcoal making, food production)	Qn	Interviews and analysis
2.13	Wage levels sufficient to buy food and other household needs?	Qn?	Interviews and analysis
2.14	Person-days used in the biofuel activities by family labor at local level Threshold: Sufficient time left to grow own food (in case wages too low to buy all food)	Qn	Interviews and analysis

Ql qualitative, *Qn* quantitative

if there is a food deficit in the country or region where the bioenergy is produced, it is clear that the issue becomes more pressing.

Household-level food expenditures data can be obtained by interviews, if this measure can be repeated it will become a performance indicator and in an area with biofuel development, part of this effect could possibly be liked to biofuel activities. Other performance indicators that can provide more information on the development of for example a region: yield developments of the five main staple crops (GBEP 2011).

Other indicators could be: previous land use (is agricultural land that was used for the cultivation of food crops converted into biofuel feedstock cultivation), food expenditures over time. A more qualitative, but important measure is the perception of the local communities themselves, if they feel food insecure. This can be addressed in interviews or surveys.

Up to today there is no clear indicator for food security, since the concept food security is very complex and links to many different issues. Food security indexes

Table 16.5 Overview of food security related indicators as identified by the Global-Bio-Pact case study reports

No.	Indicator description	Ql/Qn	Measurement method
3	Food security		
	Background indicators		
–	Food security index score	Qn	Statistics
–	Conversion rates of food producing land	Qn	Statistics
–	Poverty rates	Qn	Statistics
–	% of household income spent on food	Qn	Statistics
–	Prevalence of undernourishment [%]	Qn	Statistics
–	Calories per capita	Qn	Statistics
–	Quantity and type of food missing at the local community	Ql	Interviews/surveys
–	Population that is food insecure [%]	Qn	Statistics
–	Main staple crop production in the country (and price development)	Qn	Statistics
	Impact indicators		
3.1	Protection programs	Ql	Interviews
3.2	Providing alternative for current practices	Ql	Literature
3.3	Number of people that became food insecure due to bioenergy production	Qn	Interviews/surveys and statistics
3.4	Δ in household income spent on food	Qn	Interviews/surveys and statistics

Ql qualitative, *Qn* quantitative

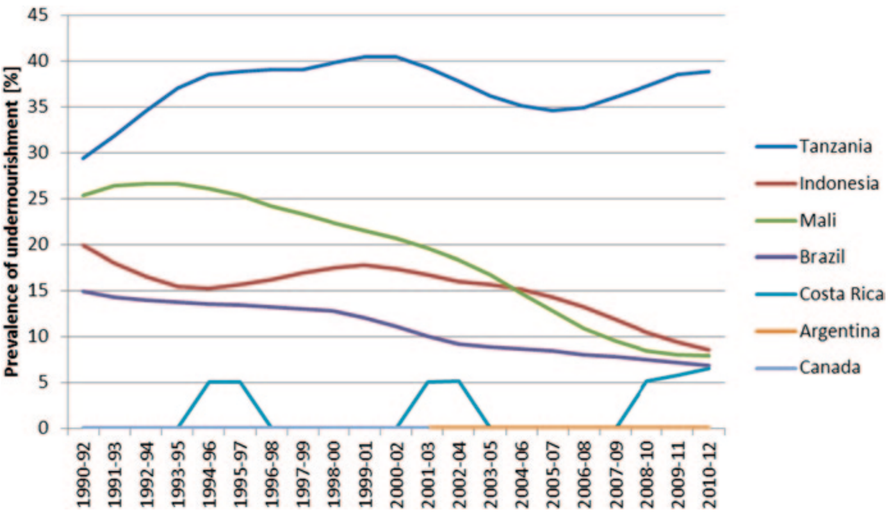

Fig. 16.2 Results for indicator "prevalence of undernourishment" based on Statistics Division of the Food and Agriculture Organization. (FAOSTAT 2012)

are at the moment the best available indicators, combined with the more qualitative indicator whether people feel food secure, identified by the case studies.

Table 16.6 Overview of land right related indicators as identified by the Global-Bio-Pact case study reports

No.	Indicator description	Qn Ql	Measurement method
4	Land use competition and conflicts		
4.1	The extent to which land acquisition followed the correct legal process	Ql	Company records and community interviews
4.2	The extent to which community land rights are determined and mapped	Ql	Company records and community interviews
4.3	The extent to which the principles of FPIC are followed in dealings with local communities and indigenous peoples, including when handling disputes	Ql	Company records and community interviews
4.4	Number of conflicts due to biofuels expansion	Qn	–
4.5	Expansion area over other cops	Qn	–
4.6	Compensation payments	Qn	
4.7	Language of contracts	Ql	
4.8	Availability documentation for local communities	Ql	
4.9	Lost rights to land	Ql	Interviews
4.10	Coherent land ownership structure	Ql	Literature
4.11	Availability of treaties on land use issues with native local stakeholders	Ql	Interviews
4.12	Hectares of land suitable for bioenergy production	Qn	National statistics
4.13	Hectares under public land	Qn	National statistics
4.14	Hectares under bioenergy cultivation	Qn	National statistics
4.15	Development of land prices	Qn	National statistics
4.16	Area under bioenergy production as percentage of total planted area	Qn	National statistics

Ql qualitative, *Qn* quantitative

16.3.4 Land Use Competition and Conflicts

Table 16.6 shows the indicators that are identified by the case study reports on land use competition and conflicts.

There are many indicators identified, and many of them are considered of high importance by the case studies. This indicates that this theme is important. Some of the data for the indicators can be obtained from national statistics, such as the development of land prices and total cultivation area of bioenergy (relative to total area available for example). Other indicators are more qualitative such as lost rights to land (difficult to quantify) and the extent to which land acquisition followed the correct legal process. The data for these last two indicators have to be obtained from interviews with various stakeholders.

For most of the indicators no data was obtained. This shows that it is difficult or time consuming to obtain the data.

Problems with land acquisition are often due to preexisting weak institutional frameworks. Therefore it is difficult to assess whether land acquisition processes followed the correct legal path. Through interviews with various stakeholders, information can be obtained on how the process was executed; if there are national

Table 16.7 Overview of working conditions related indicators (verifiers) as identified by the Global-Bio-Pact case study reports

No.	Working condition indicators	Qn/Ql	Measurement method
5.1	Maximum number of hours of work per day	Qn	Workers' contracts, company records, and interviews
5.2	Right to collective bargaining/respecting trade unions	Ql	Company records and interviews NGO monitoring records
5.3	Extent to which child labor laws/minimum age are complied with	Qn	Company records and interviews NGO monitoring records
5.4	Number of work related accidents	Qn	Company records and interviews
5.5	Level of provision of operational safety and health systems, training, and protective equipment	Ql	Company records and interviews
5.6	Extent to which legal requirements for social security and accident insurance are complied with	Ql	Company records and interviews
5.7	Number of unjustified dismissals/end of contracts/resignations	Qn	Sector level labor statistics
5.8	Mode of transport to the fields	Ql	Company records and interviews
5.9	Right of training/education	Ql	Company records and interviews
5.10	Possibilities of retirement pension	Ql	Company records and interviews
5.11	Rights of casual workers (social security, medical assistance) compared to fully employed workers	Ql	Interviews
5.12	Right to understand the employment contract	Ql	Interviews, language employment contract versus language employee

NGO non-governmental organization, *Ql* qualitative, *Qn* quantitative

bodies that keep data on land conflicts this could enhance data collection. Communities often want to see development in their area; however, they should be compensated for any loss of land access. Checking whether there is any provision for returning land access rights in case of bankruptcy could reduce the risk.

16.3.5 Working Conditions

Table 16.7 shows an overview of the indicators (verifiers) related to the working conditions and identified in the case studies.

Some of the identified indicators check compliance such as "possibilities of retirement pension" or "right of training," these compliance indicators are in fact verifiers (Woods and Diaz-Chavez 2007).

The right to collective bargaining and to be a member of a trade union is widely accepted as an important indicator. Furthermore many indicators are relevant for one country but less for another country. For instance, the indicator regarding compliance with child labor laws was not used by all case study countries since it is not a significant issue in part of these countries. Possibilities or retirement pension is only relevant in countries that have a pension system. Some indicators are difficult to measure; for instance the number of work related accidents is not always recorded, and the interviewed company owner might have its reservations towards answering this question. Regarding collective bargaining, it can be useful to distinguish between the firm's own employee association and third party trade unions.

Working conditions are an important topic in many existing certification systems. Bargaining, free access to trade unions, and occupational safety and health (OSH) are important.

Since working conditions are so important, this group of indicators has been developed in much detail. It is observed that the measurement method is very important. Interviews with company owners can easily result in biased outcomes, stressing the importance of professional third party auditing including interviews with workers.

16.3.6 Health Issues

Table 16.8 shows the indictors (or verifiers) regarding health issues.

Biomass supply in both the agricultural and forest sector has potential health risks. Many of the risks are already known, since biofuels/bio-products are actually another application of a product of existing activities in the agricultural or forest sector. Since these risks are known and health and safety measures usually described in (national) law, it is possible to check compliance with these regulations, rather than to work out indicators in further detail. This way existing regulations are enforced.

The main health issues are accidents and occupational diseases. The most severe indicators are deaths and retirement due to labor accidents or labor related diseases. Other indicators are related to potential causes of long term health effects: like noise and dust emission levels etc. However, whether preventive health policies are in place or not could be checked and can be regarded as an important verifier. National labor laws normally also cover these aspects, but monitoring and control are often neglected.

In Brazil, statistics on accidents and deaths were available on sector level, providing useful insights. On company level, it can be difficult to obtain correct information from the involved companies, as the number of accidents of work related health issues is clearly not good advertisement. It is also difficult to define a threshold for the number of accidents. The observation whether a company has a record system for accidents in place, is a (compliance) indicator of the companies' awareness and attention for this issue and can be included in a certification system.

Another observation is that company records of accidents are sometimes absent. Furthermore, it is observed that health risks are mainly focused on company level impacts. Health impacts related to environmental impacts, for instance by air, soil, and water pollution could be included as well.

Table 16.8 Overview of indicators regarding health issues identified by the Global-Bio-Pact case study reports

No.	Indicators health issues	Qn/Ql	Measurement method
6.1	Number of workers reporting health concerns related to agrochemical use	Qn	Company/health clinic records and interviews
6.2	Level of compliance with a given standard for waste treatment and disposal	Ql	Company records
6.3	Number of accidents during work, as proportional to the total number of workers	Qn	National/regional: statistics Local level: company records
6.4	Number of deaths during work, as proportional to the total number of workers	Qn	National/regional: statistics Local level: company records
6.5	Number of retirements due to working accidents, as proportional to the total number of workers	Qn	National/regional: statistics Local level: company records
6.6	Benefits for disability and fatalities	Qn	Interviews and documentation
6.7	Health and safety policies	Ql	Company documentation and interviews
6.8	Noise above legal threshold	Qn	Company records, permit related documentation, and interviews
6.9	Risk of fire outbreak	Ql	Company records, permit related documentation, and interviews
6.10	Risk of gas emissions	Ql	Company records, permit related documentation, and interviews
6.11	Number of staff with medical insurance	Qn	National level: statistics Local: Company records and interviews

Ql qualitative, *Qn* quantitative

16.3.7 Gender Issues

Table 16.9 compiles the gender related indicators/verifiers.

The participation of women in a certain company can be determined relatively easily. However, as already observed, the indicator result is only informative not normative. Other issues like women's wages as percent of men's work are sometimes hard to quantify on company level, however, even in countries like Canada there is obviously a wage gap. Interviews done for the Indonesian case showed that in physical plantation work, the heavy work done by men, that women cannot perform physically, was paid better than the "light work" done by women. Also, participation of housewives, working for free in the family plantation was observed. In Tanzania, women cannot be owner of land, but have rights to plant and harvest jatropha on part of this land.

On national level, gender-specific indicators have been developed like Gender-related Development Index (GDI; similar to HDI) and Gender Empowerment Measure. However, it is difficult to quantify gender issues related to wage levels on company level due to, sometimes, incomparable tasks. Furthermore, it is observed that while it is difficult to quantify gender issues on local level, obvious gender

Table 16.9 Overview of gender related indicators identified by case study reports

No.	Gender related indicators	Qn Ql	Measurement method
7.1	Women's wages as % of men's (doing work judged objectively to be similar)	Qn	Local: Company records and interviews Regional/national: statistics
7.2	The extent to which equal opportunities are extended to women and men in the workplace	Ql	Company records and interviews
7.3	The extent to which women's reproductive rights are respected	Ql	Company records and interviews
7.4	Participation of women (in a type of job, company, or sector)	Qn	Local: Company records and interviews Regional/national: statistics
7.5	Women participation policies	Ql	Company records and interviews
7.6	% of women engineers in the company compared to % of women engineers graduated		
7.7	Labor employment gap between men and women	Qn	Statistics, literature
7.8	Presence of organizations for women's rights	Qn	Interviews, internet
7.9	Gender related Development Index (GDI)	Qn	National level: Like Human Development Index. GDI can also be expressed% of HDI
7.10	Gender Empowerment Measure (GEM)[a]	Qn	National/regional level: Result: ranking compared to other countries
7.11	Right of land ownership for women	Ql	National law and interviews
7.12	Benefits distribution between men and women in the family	Qn	Interviews

Ql qualitative, *Qn* quantitative

[a] Combines inequalities in (1) political participation and decision making, (2) economic participation and decision making, and (3) power over economic resources

issues can easily be described in a qualitative way (see the case of Tanzania for a good example (Sawe et al. 2011)). Other gender related issues, like discrimination and sexual harassment should be addressed on company level.

16.4 Conclusions and Recommendations

Both positive and negative socio-economic impacts are, for the most part, a function of company practices, in combination with the regulatory and institutional context. Furthermore, impacts on a local level are often not visible at an aggregated national level, especially if the sector is not fully developed yet, which is the case for the bioenergy sector. A very clear example of this is the economic indicators. The companies that have only started to produce biofuel recently are not reflected in the national GDP. At the same time, local negative impacts such as a number of people that have lost land rights can be offset by the total national employment that has been generated. Therefore, it is essential to look at impacts on different levels; national, regional, and local.

Background indicators provide a quick snapshot image to determine whether the theme, e.g., food security, is an issue at all in the project region. After this determination, more detailed indicators should be applied to give insight in the extent of the potential (local) impact.

Availability and reliability of data is a concern. More data collection is required on all levels (national, regional, and local). Most economic indicators are based on robust methodologies, but accurate data is lacking and therefore it is hard to use the indicators effectively. Government bodies or international organizations could collect and monitor the data which would provide for example the basic data for the background indicators.

Collecting large amounts of reliable data consumes an enormous amount of time, while collecting only general data is quick, but not very detailed. This trade-off between accuracy and practicability is not always the same. It can vary per country and per feedstock depending on data availability. The purpose of the indicators is an important determinant for the right level of detail, e.g., indicators that are required to monitor country progress over time can be more general than indicators that measure local impacts and that are included in a certification system. Also, the country and feedstock type, and thereby the level of development of a certain sector, plays a role.

More methodologies have to be developed to gain better insight in socio-economic impacts, especially on the long term. These methodologies should preferably be based on quantitative data. Many indicators are currently based on qualitative data, which is sufficient for themes such as working conditions, health issues, and land use conflicts. But other, more complex themes such as food security, land competition, or economic development of, e.g., a region, that link with many different factors, need more comprehensive methodologies such as I/O analyses or General Equilibrium models.

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Chapter 17
Summary: The Contribution of Bioenergy to Energy Access and Energy Security

Dominik Rutz and Rainer Janssen

Abstract Energy is a key factor for the general historic human development and today's society. With the exploitation of natural gas and crude oil in the mid-nineteenth century, human development experienced a techno-economic boom. The access to modern forms of energy, based mainly on fossil fuels, has led to technical, social, and economic growth and development on the globe. Still, today's modern society is mainly based on fossil fuels. In contrast, the main energy source of many developing countries depends on biomass, often used in a non-sustainable form, as wood is used from sensitive environments with no opportunity for regrowth. Depleting resources of fossil-based fuels and non-sustainable bioenergy requires new solutions and approaches in the production and use of energy in order to ensure energy access and security. This chapter provides a short overview on the contribution of bioenergy to energy access and security and relates the results to socio-economic aspects addressed in the other chapters of this book.

Keywords Energy access · Energy security · Fossil fuels · Energy mix

17.1 Introduction

With the exploitation of natural gas and crude oil in the mid-nineteenth century, human development experienced a techno-economic boom. The access to modern forms of energy, based mainly on fossil fuels, has led to technical, social, and economic growth and development on the globe. Still, today's modern society is mainly based on fossil fuels. In contrast, many developing countries heavily depend on biomass as energy, often used in a non-sustainable form, as wood is used from sensitive environments with no opportunity for regrowth. For instance, wood-based fuels (charcoal and firewood) provide more than 70–80 % of the total energy consumption in sub-Saharan Africa (Sawe 2012; Denruyter et al. 2010).

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Depleting resources of fossil-based fuels and non-sustainable bioenergy requires new solutions and approaches for the production and use of energy in order to ensure energy access and security. Besides other renewable energies, such as solar and wind energy, biomass will be a core energy source in the future energy mix. Bioenergy has received enormous attention in the past few years due to its contribution to address three of the world's great challenges—energy security, climate change, and poverty reduction (FAO/GBEP 2008).

On the other hand, bioenergy is constantly accused of having negative socio-economic impacts, besides negative environmental impacts. In doing so, arguments are often based on local examples and then generalized to the whole bioenergy sector. This needs to be avoided and local impacts have to be always addressed case-specific. As bioenergy is produced locally, many positive and negative impacts also occur locally. Furthermore, it is important to evaluate the impacts in a holistic way and always in comparison with other indicators, especially those that go beyond the local level.

Thereby, it has to be considered that energy security and access are among the main drivers for bioenergy development and thus influencing the overall socio-economic performance of bioenergy value chains.

17.2 Energy Security

Energy security is the continuous supply and availability of energy sources at an affordable price. It can be applied to several levels and timeframes:

- **Short-term energy security**: energy security on a daily basis to satisfy current energy demand
- **Long-term energy security**: energy security within the next decades and even beyond the fossil fuel age
- **National energy security**: energy security in a country; this depends on local resources and imports

17.2.1 Energy Security of Today's Energy Mix

As economic growth is based on the continuous supply and availability of energy sources, energy security is of utmost strategic importance for governments. Several conflicts and wars between countries occurred due to such strategic interests.

The need to increase energy security was the main objective underpinning the establishment of the International Energy Agency (IEA) with particular emphasis on crude oil security (OECD/IEA 2013a). Oil security remains a cornerstone of the IEA, with each member required to hold oil stocks equivalent to at least 90 days of net imports and to maintain emergency measures for responding collectively to disruptions in oil supply of a magnitude likely to cause economic harm to its members.

At the same time, the IEA recognizes the broader needs of ensuring energy security and is progressively taking a more comprehensive approach to the security of supplies, including natural gas supplies and power generation (ibid.).

In contrast to this short-term energy security, long-term energy security has to be considered as well. Fossil fuels are fuels formed by long-term decomposition of organic material that were produced typically millions of years ago. The availability of fossil fuels, including crude oil, natural gas, and coal, is depleting, as they are extracted by humans at a by far higher speed than they are reproduced. An important indicator for the availability of crude oil is "Peak Oil" which is the point in time when the maximum rate of crude oil extraction is reached, after which the rate of production is expected to enter terminal decline.

Due to the depleting fossil sources and the associated increasing energy prices, new approaches in energy supply and consumption are needed. The two main cornerstones are energy efficiency and renewable energies.

17.2.2 The Contribution of Bioenergy to Energy Security

Today, bioenergy contributes with about 10 % of the world's total primary energy supply (47.2 EJ of bioenergy out of a total of 479 EJ in 2005, i.e., 9.85 %) (OECD/IEA 2013a). Thereof, 97 % are solid biofuels which are mainly used in the residential sector (71 %) in developing and emerging countries (ibid.). Thus, bioenergy already today contributes to short-term energy security.

However, solid biomass can be classified into renewable wood from sustainable managed forests and into nonrenewable wood from land where trees/shrubs do not regrow (Rutz and Janssen 2012). Furthermore, the produced biomass has to have a positive energy balance to be renewable. Renewable biomass is an important contributor to long-term energy security.

The limiting factor of fossil fuels is its depleting resources. In contrast, the limiting factor for renewable biomass production is land availability. This limitation applies to biomass production for different uses such as for food, feed, fibre, and biomaterials. In a bio-based economy, the different uses of biomass, including energy, coexist and benefit from synergies as multiple products can be derived. An example for such synergy is the increased agricultural efficiency due to, e.g., diversified crop rotation and intercropping. Furthermore, synergies are created during harvesting and during the conversion process as all coproducts are efficiently used. As all production and conversion processes require large amounts of energy, bioenergy is an important factor that contributes not only to energy security, but also to food security, and the supply of bio-products.

Thereby, especially the agricultural sector depends on carbon-based fuels due to their heavy machinery. The only alternative to fossil-based heavy-duty machineries fuels, is the use of liquid or gaseous biofuels, as it is not foreseeable that these heavy-duty machineries can operate with other sources such as hydrogen or electricity in the short to medium term. Biofuels are available today and could be immediately used in the agricultural sector.

Besides agricultural machinery, also the process energy for the conversion of biomass to various products can be derived from biomass. Examples include the use of bagasse in the sugar and ethanol industry, the use of straw as process energy for different purposes, or the use of empty fruit bunches (EFB) in the palm oil industry. Still today, these resources are often not used, but wasted.

In conclusion, bioenergy cannot *ensure* energy security alone, but it can significantly contribute to important sectors such as agriculture, which is also relevant for the security of other supplies like food or bio-products.

17.3 Access to Energy

Modern energy services are crucial to human well-being and to a country's economic development. Therefore, access to modern energy is essential for the provision of clean water, sanitation, and healthcare and for the provision of reliable and efficient lighting, heating, cooking, mechanic power, transport, and telecommunications services. As the World Energy Outlook 2012 shows, 1.3 billion people are without access to electricity and 2.6 billion people rely on traditional use of biomass for cooking, which causes harmful indoor air pollution (OECD/IEA 2013b). These people are mainly in either developing Asia or sub-Saharan Africa, and in rural areas. According to United Nations Development Programme (UNDP)/World Health Organization (WHO) (2009), 2 million deaths annually are associated with indoor burning of solid fuels in unventilated kitchens and 1.5 billion people are still living in darkness, over 80 % of them in South Asia or sub-Saharan Africa.

The World Energy Outlook (WEO) defines modern energy access as "a household having reliable and affordable access to clean cooking facilities, a first connection to electricity and then an increasing level of electricity consumption over time to reach the regional average" (OECD/IEA 2013c). The lack of access to modern energy services is also called energy poverty (OECD/IEA 2013d). The lack of access to modern energy services is a serious hindrance to economic and social development, and must be overcome if the Millennium Development Goals (MDG) are to be achieved (ibid.).

In addition to energy access at the household level, energy access for businesses and the public sector, that are crucial to economic and social development, need to be included in this definition. Besides the local availability of energy (grid connection; local markets for modern fuels) consumers also need to have financial power to purchase energy at the given prices.

The simplest form of access to energy in developing countries is the use of firewood for cooking and heating. This, however, as mentioned in Chap. 17.2, is often based on nonrenewable wood. Therefore, alternatives are needed to substitute this traditional use of biomass. Alternatives include the use of LPG, kerosene, natural gas, or electricity. Usually, LPG or kerosene is used as they are cheaper than, e.g., electricity. However, all these fuels are prone to steep price increases in the short- to long-term. An alternative could be the use of modern bioenergy. This includes biogas, bioethanol, plant oil, and biodiesel. These fuels can be either directly burned for cooking or lighting purposes or converted to electricity. However, modern bioenergy markets are still largely artificial markets that need policy and financial support. They are usually still not competitive with traditional and fossil fuels, as often the fossil fuels are highly subsidized. In many cases, a shift in the support scheme from subsidies for fossil fuels to renewable fuels would be sufficient to establish new bioenergy markets. The main barriers for this are often the existing phlegmatic schemes.

The advantage of modern bioenergy is that it can be produced locally, in comparison to fossil fuels that will be always imported to the local markets. The main challenge is to stimulate the market and to educate people in order to develop local supply chains.

In the overall debate about sustainability of bioenergy it has to be acknowledged that energy security and access are among the main drivers for bioenergy development, besides its potential to mitigate climate change. This has to be considered when assessing and evaluating the multitude of other socio-economic and environmental impacts of bioenergy, that are presented in this book and investigated in the Global-Bio-Pact project. It is without doubt that in the short-term, but especially in the long-term, bioenergy will be a crucial energy source that cannot be neglected. A main contribution of bioenergy will be to ensure the functioning of the overall agricultural system through the provision of energy and thereby also to ensure crucial other socio-economic aspects like food security.

17.4 Conclusion

In summary, bioenergy has the large potential to improve short- and long-term energy security. It thereby has also positive impacts on other sectors, such as the food sector, as bioenergy is the only carbon-based alternative to carbon-based fossil fuels which are urgently needed in the heavy-duty machinery of the agricultural sector. Due to its contribution to the security of supply in the food and product sectors, the application of bioenergy generates multiple socio-economic benefits. However, the sustainability of the value chains, especially local environmental and socio-economic impacts have to be considered.

In order to ensure overall long-term energy security worldwide, the sustainable production of bioenergy, as one measure parallel to the application of energy efficiency and other renewable energies, has to be supported. The main advantage is that technologies for bioenergy production and use are readily available and could be immediately applied. In doing so, also the technologies and thereby the efficiency will be continuously improved. The challenge is to convince decision makers about bioenergy in the energy sector that is mainly dominated by the power of fossil fuel-based companies.

Thereby, bioenergy will also contribute to improve energy access, if produced in a sustainable way. It has to be recognized, however, that different scales of bioenergy systems and value chains need to be addressed differently, as the framework conditions and impacts differ (Rutz and Janssen 2012). Especially, smaller-scale systems have the opportunity to improve energy access for the poor in rural areas. This, however, needs to be supported and framed by education, awareness raising, suitable policies, and the stimulation of economic activities which allow income generation.

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