Powering Mali with sustainable biofuels? Livelihood opportunities and policy challenges of *Jatropha curcas*

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The candidate confirms that the work submitted is his own, except where work which has formed part of jointly authored publications has been included. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

The following chapters are based on work from jointly authored publications:

Chapter 4

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- Favretto, N. 2013. Energising development with *Jatropha curcas*? Policy and institutional frameworks in the promotion of sustainable biofuels in Mali. Policy Innovation Systems for Clean Energy Security (PISCES) Policy Briefing. UK: Practical Action Consulting and Department for International Development.

Chapter 5

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The candidate authored the chapters on his own with guidance on research design from the supervisors, whereas the candidate led the writing of the publications, with co-authors providing editorial input around the structure and writing style.

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Abstract

Biofuel investments have been fostered as an attempt to mediate the energy crisis and climate change, and as a way to assist rural development. Great hopes have been pinned on the oil-bearing, "drought resistant" non-edible tree *Jatropha curcas* (*Jatropha*) through both its small- and large-scale cultivation. However, the *Jatropha* sector is still young and empirical analyses on the potential impacts on rural livelihoods and improved access to energy are largely lacking. This hampers the development of effective policy to promote the use of biofuel for sustainable development.

This research presents new integrated mixed-method, multi-level assessments of the implications of the Malian Strategy for Biofuels Development for the promotion of *Jatropha* in Mali: a sub-Saharan African country that has led the region's biofuel policy initiatives. Semi-structured interviews were undertaken with government departments, international organisations, private sector representatives and NGOs. National level data, household questionnaires and participatory methods for livelihoods assessments were integrated using conceptual frameworks of discourse analysis, stakeholder analysis and policy implementation and impact analysis. A multi-scale approach to assess the role of *Jatropha* as a tool for reducing energy poverty and fostering rural development is adopted. In the decade of the United Nations' "Sustainable Energy for All" initiative, lessons from Mali on these vital energy and development issues could usefully inform the adaptation and transfer of successful approaches and practices to other sub-Saharan countries.

Livelihoods data show that households involved with NGO or private sector activities linked to *Jatropha* cultivation can gain financial capital due to income from the sale of *Jatropha* seeds and soap and reduce household expenditure. When grown on a small-scale as a living fence, *Jatropha* demarcates property and can reduce soil erosion. Projects focusing on *Jatropha* use for rural electrification offer potential to improve energy access. However, farmers' difficulties in establishing successful plantations are observed and *Jatropha* oil supplies remain insufficient for these benefits to materialise. National-level interviews and policy analysis show that mainstreaming internationally agreed principles into national policies are vital to attracting monetary, institutional and technical support from international organisations and donors. However, gaps between policy targets, actual yields and land cover are identified. The limited availability of *Jatropha* oil supplies hampers the substitution of national consumption. While

small-scale cultivation does not threaten food security, ambitious land cover targets set within national policies can risk land use shifts away from food towards biofuel production.

The findings presented in this thesis advance academic understanding of the opportunities and challenges of biofuels for sustainable development, contributing to key debates on food versus fuel, large-scale land acquisitions, rural development and fossil fuel substitution potential. A theoretical contribution is made by extending the use of the Sustainable Livelihoods Framework by incorporating policy and stakeholder analysis into a more integrated analysis of the impacts of biofuels on rural and energy development. The policy analysis advances the understanding of the role of national policy instruments in the uptake of biofuel activities.

To address the identified policy gaps and move towards the development of a *Jatropha* biofuel industry that meets pro-poor development objectives, the following policy measures and ways forward are proposed, to:

(i) Adopt a cohesive mix of country-specific policies that integrate biofuel promotion with rural development concerns, private sector needs and international donor priorities;
(ii) Promote coherent institutional frameworks as well as strong partnerships and effective dialogue between state departments, the private sector and NGOs;
(iii) Enhance monitoring of biofuel programmes and projects; and
(iv) Establish and enforce adequate legal and regulatory frameworks governing private biofuel investments, access to land and water resources in order to avoid threats to food security and land tenure disputes.

By better linking policies to local-level practices, these measures offer the potential to achieve more sustainable outcomes.

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Acronyms and abbreviations

AEDD	Environment and Sustainable Development Agency
AFD	French Development Agency
AfDB	African Development Bank
AMADER	Agency for the Development of Domestic Energy and Rural Electrification
ANADEB	National Biofuel Development Agency
API Mali	Investment Promotion Agency of Mali
CDM	Clean Development Mechanism
CMDT	Malian Company for Textile Development
CNESOLER	National Centre for Solar and Renewable Energies
DNA	National Directorate of Agriculture
DNE	National Directorate of Energy
ENI	National School of Engineers
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Produce
GERES	Groupe Energies Renouvelables
GoM	Government of Mali
G-PRSP	Poverty Reduction and Growth Strategy Paper (2nd generation)
IEA	International Energy Agency
IER	Institute of Rural Economy
IPR/IFRA	Rural Polytechnic Institute
JMI	Jatropha Mali Initiative
KP	Kyoto Protocol
LOA	Agricultural Orientation Law
MA	Ministry of Agriculture
MBSA	Mali Biocarburant SA
MEA	Ministry of the Environment and Sanitation
MESSR	Ministry of Secondary and Higher Education and Scientific Research
MFC	Mali-Folkecenter Nyetaa
MMEE	Ministry of Mines, Energy and Water
NAP	UNCCD National Action Programme
NAPA	National Adaptation Programme of Action to Climate Change

NGO	Non-Governmental Organisation
NSBD	National Strategy for Biofuels Development
NSREN	National Strategy for the Development of Renewable Energy
OECD	Organisation for Economic Co-operation and Development
PEN	National Energy Policy
PN/PTFM	Multifunctional Platforms National Programme
PNCC/SNCC	National Climate Change Policy and Strategy
PNPE	National Environmental Protection Policy
SDDR	Rural Development Master Plan
SLF	Sustainable Livelihoods Framework
SREP	Scaling Up Renewable Energy Program for Low Income Countries
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank

Chapter 1

Introduction

"*Energy is the golden thread that connects economic growth, increased social equity, and an environment that allows the world to thrive. Development is not possible without energy, and sustainable development is not possible without sustainable energy*"

(Sustainable Energy for All, 2013)

Outline

This thesis presents new integrated mixed-method, multi-level assessments of the implications of the Malian Strategy for Biofuels Development for the promotion of the oil-bearing, non-edible tree *Jatropha curcas L*. (hereinafter termed *Jatropha*) as a sustainable development tool in Mali. It provides useful lessons on vital energy and development issues that could inform the adaptation and transfer of successful approaches and practices to other sub-Saharan countries that are committed to the development of a sustainable biofuel industry. This introductory chapter provides an overview of the research context and explores the role of biofuels in addressing international priorities in the fields of both energy and development, with a focus on the cultivation of *Jatropha* in Mali. The key academic and applied contributions of this research are highlighted and the aim and objectives identified. The chapter concludes with an outline of the thesis structure.

1.1 Global energy challenges and the role of biofuels

Exponential growth of global energy demand is occurring as a consequence of major demographic and socio-economic trends. In the developing world, rapid population growth and economic expansion (notably in Africa, China and India) will double primary energy use in the next two decades (Kaygusuz, 2012). Such unprecedented growth raises concerns over "energy security" across the globe, particularly in the context of increasing global oil prices (Hamilton, 2009), scarcity of known petroleum reserves (Sorrell *et al.*, 2010) and political

instability of regions where these reserves are located (Luft and Korin, 2009). A multitude of definitions of energy security have been proposed in literature (Andrews, 2005; Jansen and Seebregts, 2010; William *et al.*, 2008; Turton and Barreto, 2006). These have been integrated and summarised by Winzer (2012: 36) as "*the continuity of energy supplies relative to demand*" with low risks of disruption due to political or environmental shocks.

Eighty percent of the total world supply of primary energy depends on fossil fuels (IEA, 2012), which are foreseen to remain the dominant source of future energy worldwide, accounting for 77% of the demand increase over the period 2007-2030 (IEA, 2009). Combustion of fossil fuels remains the largest contributing factor to the release of greenhouse gases (GHG) into the atmosphere, producing several environmental impacts collectively referred to as “climate change”. These include an increase in the average surface temperature of the Earth over time, changes in precipitation patterns, storm severity and sea level rise (IPCC, 2007a). The largest increase in the future carbon emissions is foreseen to occur in the developing world, where emerging economies fuel economic development with fossil energy (IEA, 2012) and will account for 52% of global energy-related CO_2 emissions by 2030 (Kaygusuz, 2012).

In order to meet these global challenges and reach energy and development goals, there has been growing pursuit of alternative energy sources (Oyedepo, 2012; Boyle, 2012). While the positive environmental benefits from renewable energy use are widely demonstrated, Sathaye *et al.* (2011) note that the exact contribution to socio-economic development remains ambiguous and more research is needed to bridge existing knowledge gaps. A study by the Global Network on Energy for Sustainable Development (Karekezi *et al.*, 2007) found that household and productive energy needs – *i.e.* cooking, heating and water pumping – in areas with no access to electricity, can be effectively served by a variety of renewable energy technologies, including solar energy, biofuels, biogas and wind power.

In such a context, the opportunities and benefits of biofuels as a viable option for enhancing access to energy, substituting oil, reducing CO_2 emissions and promoting sustainable development have attracted growing attention of policy makers (Kuchler and Linnér, 2012; Franke *et al.*, 2012; UNDESA, 2007), industry (Lengkeek, 2009), Non-Governmental Organisations (NGOs) (Palliere and Fauveaud, 2009) and the research community (Janssen and Rutz, 2012; Janssen and Rutz, 2011; Peters and Thielmann, 2008; Reddy *et al.*, 2008; Yan and Lin, 2009; Arndt *et al.*, 2010; German *et al.*, 2011; Sorda *et al.*, 2010). Biofuels are also

perceived as a tool that can stimulate agricultural research and provide farmers with innovative sources of income in the promotion of a "pathway out of poverty" for developing countries (Schut *et al.*, 2010: 1).

Biofuels are liquid, solid or gaseous energy sources produced from organic matter. Depending on which feedstock is used, they are classified into two main categories. "First generation" biofuels can be produced in relatively simple manufacturing processes and are most commonly derived from: (i) edible agricultural products such as sugar or starchy crops (bioethanol) or vegetable oil crops (biodiesel), and (ii) anaerobic digestion (biogas) (Tat Tan *et al.*, 2008; Ruth, 2008; IEA, 2011a; FAO, 2008a). "Second generation" biofuels are mainly derived from (i) lignocellulosic biomass such as timber and waste products from forestry, agriculture, industry or households, (ii) specific non-edible energy crops such as switchgrass, miscanthus and willow, and (iii) biomass-to-liquids (BtL)-diesel and bio-synthetic gas (bio-SG) (IEA, 2011a). While the sophisticated technologies required for production appear to be mature and manufacturing processes are relatively well-understood (IEA, 2010a), high production costs remain the major constraint in the expansion of second generation biofuels (Fairley, 2011). These technologies are estimated to become competitive at the earliest by 2020 (IEA, 2011a). This research focuses on biodiesel produced from *Jatropha*, which according to Ravindranath *et al.* (2010) and Peters and Thielmann (2008) is the only non-edible crop belonging to the "first generation" category.

Annual production of first generation biofuels worldwide rose from 16 million litres in 2000 to 100 million litres in 2010 (Fairley, 2011). Currently ethanol is predominantly produced from sugarcane in Brazil, maize in the U.S., and wheat in Europe. Biodiesel is mainly derived from palm oil in Asia, rapeseed in Europe and soybeans in Brazil (Goldemberg, 2008). Table 1.1 presents the main sources of biomass feedstock for first and second generation biofuel production.

Table 1.1: Main biomass feedstocks used for first and second generation biofuel production

<table>
<tr>
<td>Sugar crops

• Sugar cane (Saccharum officinarum L.)
• Sugar beet (Beta vulgaris)
• Sweet sorghum (Sorghum spp.)

Starchy crops

• Maize (Zea mays)
• Wheat (Triticum aestivum)
• Cassava (Manihot esculenta)</td>
<td>(1st generation)

Fermentation and distillation</td>
<td rowspan="2">ETHANOL</td>
</tr>
<tr>
<td>Cellulosic materials

• Corn straw and bagasse
• Timber
• Waste products
• Switchgrass (Panicum virgatum)
• Miscanthus (Miscanthus sinensis)
• Willow (Salix caprea)</td>
<td>(2nd generation)

Saccharification, fermentation and distillation</td>
</tr>
<tr>
<td>Oil crops

• Rapeseed (Brassica napus)
• Palm (Elaeis guineensis)
• Soybean (Glycine max)
• Sunflower (Helianthus annuus)
• Peanut (Arachis hypogaea)
• Jatropha curcas L.</td>
<td>(1st generation)

Extraction and esterification</td>
<td>BIODIESEL</td>
</tr>
</table>

Source: elaborated from Tat Tan *et al.*, 2008; Ruth, 2008; IEA, 2011a; FAO, 2008a.

Despite the claimed benefits of biofuels, academics and environmentalists have started to draw attention to the negative aspects of first generation biofuels (Sengers *et al.*, 2010; Brenton *et al.,* 2010). Their capability to contribute to long-term fossil fuel substitution has been questioned and the need to move towards production of more environmentally-friendly second generation biofuels has been stressed (Charles *et al.*, 2007; Deurwaarder, 2005). Key concerns have been raised regarding four key debates:

i) "Food versus fuel", where fuel production diverts biomass previously used as a source of food (Nonhebel, 2012);
ii) Emerging threats from large-scale land acquisitions (Cotula *et al.*, 2009; Fairhead *et al.*, 2012), where land is leased or purchased by external investors for biofuel production disregarding customary rights and displacing local communities;
iii) The limited potential for biofuels to deliver rural development benefits and substitute fossil energy (ActionAid, 2012; Nuffield Council on Bioethics, 2011; Hall *et al.*, 2009; Da Silva Césa and Batalha, 2010);
iv) Indirect land use change, where increased biofuel cultivation displaces pre-existing agricultural production into new areas causing significant increases in greenhouse gas emissions (Searchinger *et al.*, 2008; Berndes *et al.*, 2011; Afionis and Stringer, 2012).

Figure 1.1 summarises the driving forces (triangle) and challenges (rectangular shapes) associated with biofuels development. These are described in detail in Chapter 2. Energy, environmental and socio-economic development are identified as three key reasons for the promotion of biofuels, while the issues concerning the four major debates outlined above are presented in more detail through 16 rectangles which address environmental, socio-economic and technical aspects.

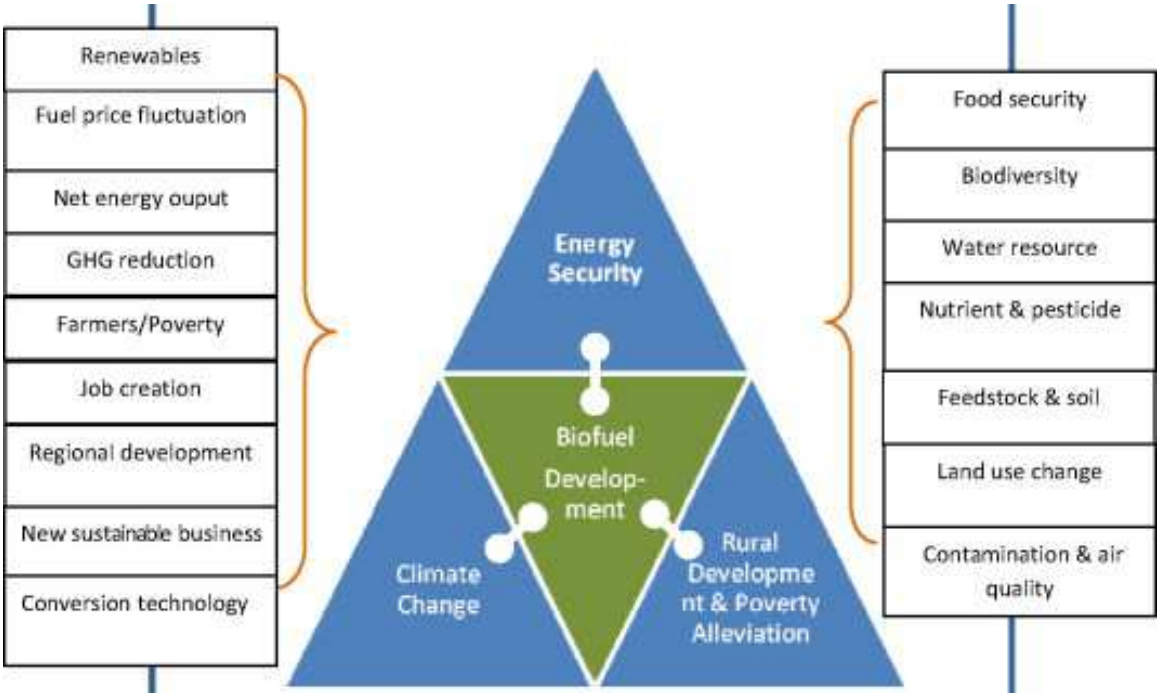

Figure 1.1: Driving forces and challenges of biofuels development

Source: Yan and Lin (2009)

In the effort to address these debates, great hopes have been pinned on the oil-bearing, "drought resistant" non-edible tree *Jatropha* to deliver benefits through both small and large scale cultivation (Achten *et al.*, 2010; Dyer *et al.*, 2012; Gilbert, 2011; Jongschaap *et al.*, 2007) (see Chapter 2). The use of *Jatropha* is introduced in the next section, with particular focus on its use in Mali, the geographical location of this research.

1.2 *Jatropha* in Mali

Jatropha is a large shrub or small tree belonging to the *Euphorbiaceae* family that can grow up to 6-8 metres tall. Its fruits are split into 3 segments, which commonly contain a black seed each (Morton, 1977; Holl *et al.*, 2007) (Figure 1.2).

a.

b.

c.

Figure 1.2: a. three year old *Jatropha* tree in Garalo, Mali (2010); b. and c. *Jatropha* fruits and seeds in Koulikoro, Mali (2011)

Jatropha's lifespan is approximately 50 years and oilseeds can be pressed and used to produce biodiesel after approximately two-three years, while full production is reached by the fifth year of growth. The tree historically originates from Central America and the northern parts of South America but it presently grows in tropical areas worldwide (sub-Saharan Africa, Southeast Asia, India) (FACT, 2010; Jongschaap *et al.*, 2007). As of 2008, 242 *Jatropha* projects were identified across the world, totalling approximately 900,000 ha (GEXSI, 2008). The number and size of these projects is thought to be increasing sharply. In 2008, estimates predicted that roughly 1.5 to 2 million ha of *Jatropha* would be planted each year for the following five-seven years, resulting in a total of approximately 13 million ha by 2015 and global investments of up to USD 1 billion per year (*ibid*).

Mali, where roughly 99% of the population lacks modern energy services (COMPETE, 2009a), is one of the few sub-Saharan countries with policies that have proactively fostered *Jatropha* cultivation. In 2008, a National Strategy for Biofuels Development (NSBD) was approved, setting quantitative targets for *Jatropha*-based biofuel production. Motivated by this policy driver, a range of initiatives has been supported since the 1990s by a variety of actors, including development agencies, government, private sector and NGOs. However, as shown in the literature review (Section 2.3), claims and potential impacts of *Jatropha* are understudied and available research is often controversial. The *Jatropha* sector is still young and empirical analyses of the potential impacts on rural livelihoods, income generation, induced land use changes, food security and improved access to energy (both at local and national levels) are largely lacking. As such, it is unclear from a policy perspective how to best enhance the country's biofuel potential. Mali thus provides a useful national context in which to explore the challenges and opportunities associated with *Jatropha* and address key empirical data gaps[1].

1.3 Academic and applied contributions of this research

Research presented in this thesis bridges the gaps outlined in the previous section and advances academic understanding of the opportunities and challenges of biofuels for sustainable development, contributing to the major debates on: food versus fuel, land access threats, rural development and fossil fuel substitution potential. It provides detailed mixed-

[1] This research was undertaken prior to the coup which changed the Malian political landscape and structures in 2012. The current political instability faced by the country might have an impact on the institutional and regulatory frameworks presented in Chapter 4 and discussed in Chapter 6.

methods, multi-level case study empirical evidence that is needed to improve understanding of the impacts of *Jatropha* promotion and use at multiple levels in Mali.

Quantitative research methodologies tend to dominate over qualitative methodologies in the assessment of the socio-economic implications of first generation biofuel production on the rural poor in developing countries. As noted by Hodbod and Tomei (2013), many of these debates remain rather abstract and studies that empirically examine local level social impacts of biofuels projects are lacking. This research targets these gaps by providing case study insights that display the leading role that participatory methods can play in integrating poverty and rural energy security concerns into the more holistic analyses required for sustainable development. Nowhere are the challenges greater and the local need more explicit, than in understudied rural regions of dryland Africa. Contributions to the literature on sustainable livelihoods are made by demonstrating the utility of the Sustainable Livelihood Framework (SLF) to investigate the implications of *Jatropha* cultivation for rural livelihoods, with particular focus on the several forms of capital that households employ for livelihood generation. An academic theoretical contribution is made by extending the use of the SLF by incorporating policy and stakeholder analysis to overcome some of the limitations identified in its use to date (see Section 2.4). This allows a more in-depth understanding to be gained of the complex multi-level issues surrounding *Jatropha* promotion and use than has been provided in previous case study assessments of *Jatropha* uptake and impacts in sub-Saharan Africa.

The policy analysis component of this study advances the understanding of the role of policy, particularly highlighting the links between policy goals and outcomes, with special focus on how Malian political institutions and stakeholders involved with biofuels affect the policy process. The drivers and barriers to the achievement of policy goals are outlined through the integration of multi-level data (from national to village level) (see Section 3.3). Policy recommendations are made to reduce policy gaps and enhance livelihood benefits towards the achievement of positive outcomes. The key lessons identified in the research will be useful to other sub-Saharan African countries that are committed to the development of a sustainable biofuel industry.

1.3.1 Research outputs

In addition to the PhD thesis, as detailed in Table 1.2, academic outputs include the publication of the research findings through three Working Papers and thus far, one peer-reviewed

international journal article. Findings have also been presented at a range of international conferences and seminars. At the policy level, this research feeds into on-going discussions and work on *Jatropha* use as a biofuel in Mali (led by the National Biofuel Development Agency (ANADEB), various ministries, UNDP and others institutional actors (see Chapter 4)) with a view to identifying interventions targeted at improving policy coherence and reducing implementation gaps. A policy brief on biofuels in Africa was produced in the first year of the research, while another policy brief focused on the Malian regulatory and institutional frameworks was published in year three. In 2013 the latter has been framed into a Conference Paper commissioned by the Government of Burkina Faso.

Table 1.2: Academic and policy outputs of this research

Chap.	Publications	Policy briefs	Presentations
4	• **FAVRETTO, N.**, L.C. STRINGER and A.J. DOUGILL. 2012. *Policy and institutional frameworks for the promotion of sustainable biofuels in Mali* [online]. Centre for Climate Change Economics & Policy Working Paper No. 103. London and Leeds. Available from: http://www.cccep.ac.uk/Publications/Working-papers/Papers/100-109/WP103-policy-sustainable-biofuels-mali. pdf	• **FAVRETTO, N.** 2013. *Energising development with Jatropha curcas? Policy and institutional frameworks in the promotion of sustainable biofuels in Mali* [online]. Policy Innovation Systems for Clean Energy Security (PISCES) Policy Briefing. UK: Practical Action Consulting and Department for International Development. Available from: http://practicalaction.org/media/preview/31796 • **FAVRETTO, N.** and J.C. DYER. 2010. *Sustainable biofuels in Africa: cultivation of Jatropha curcas in Mali and Malawi* [online]. Africa College Policy Briefing. Leeds: University of Leeds. Available from: http://www.africacollege.leeds.ac.uk/downloads/BriefingNotes/Favretto_Dyer_ACP_BriefingNote_Nov2010.pdf	• Consultation, feasibility study for biofuels investments in Mali, **Brazilian Development Bank**, Sao Paulo, Brazil, 03/2013 • Seminar on energy and sustainable development, **Yale University**, CT, 04/2012 • Talk on biofuel policies in Mali, **United Nations Development Programme**, NY, 04/2012 • Workshop on Sustainable Development, **Columbia University**, NY, 04/2012

5	• **FAVRETTO, N**., L.C. STRINGER and A.J. DOUGILL. [in press]. Unpacking livelihood challenges and opportunities in energy crop cultivation: perspectives on *Jatropha curcas* projects in Mali. *The Geographical Journal*. In Press. doi: 10.1111/geoj.12053. • **FAVRETTO, N.,** L.C. STRINGER and A.J. DOUGILL. 2011. *Cultivating clean energy in Mali: policy analysis and livelihood impacts of Jatropha curcas*. [online]. Centre for Climate Change Economics & Policy Working Paper No. 84, London and Leeds. Sustainability Research Institute Paper No. 28, Leeds. Available from http://www.cccep.ac.uk/Publications/Working-papers/Papers/80-89/WP84_clean-energy-mali-jatropha-curcas.pdf		• 2nd UNCCD Scientific Conference, **UN Convention to Combat Desertification**, Bonn, 04/2013 • Seminar on biofuels and rural livelihoods impacts in Mali, **University of Leeds**, UK, 11/2012 • Knowledge Gaps in Climate Change Research, **University of East Anglia**, UK, 04/2012 • Energy and People: Futures, Complexity and Challenges, **Oxford University**, UK, 09/2011 • Towards Low Carbon, Climate Resilient Societies, **London School of Economics**, UK, 09/2010
6		• **FAVRETTO, N.** 2013. *Promoting Jatropha curcas for biofuel production in Mali: policy and institutional frameworks*. Conference Paper.	• 4th International Conference "Bioenergy in Africa", **Ministry of Mines, Quarry and Energy of Burkina Faso**, Burkina Faso, 11/2013

1.4 Research aim and objectives

This research aims to assess the Malian Strategy for Biofuels Development and its impacts on energy production and livelihood diversification in rural Mali through the cultivation of *Jatropha*. The research aim is met through three objectives, which are outlined in Table 1.3, together with the research questions used to achieve them.

Table 1.3: Outline of the research objectives and questions used in this research

Objective 1. Identify and analyse the stakeholders and policies concerned with biofuels in Mali taking into account policy motivations for prioritising *Jatropha*
Research questions   i) What are the policy goals concerned with biofuels in Mali and why is *Jatropha* prioritised in the NSBD?   ii) Who are the main stakeholders supporting biofuels (particularly *Jatropha*) policy in Mali and what are their respective roles and responsibilities?
Objective 2. Undertake a livelihoods analysis with focus on *Jatropha* at household level in rural Mali, exploring its role in livelihood diversification and its potential to contribute towards rural development
Research questions   iii) What are the opportunities offered by small-scale *Jatropha* agriculture to improve livelihoods and rural energy security?   iv) Does small-scale *Jatropha* farming compete with land, labour and food production at the household level?   v) To what extent do people achieve their livelihood goals, and what barriers do they face?
Objective 3. Evaluate the drivers and barriers to the achievement of policy goals in relation to local rural development and energy security, proposing policy recommendations and ways forward that better link the realities of policy and local practice
Research questions   vi) To what extent is the NSBD achieving its intended outcomes and what are the key barriers to the achievement of policy goals?   vii) What considerations are needed to achieve policy goals and promote *Jatropha* as a sustainable development tool for Mali?

1.5 Outline of the thesis structure

This thesis comprises seven chapters. After this introduction, Chapter 2 reviews and synthesises the pertinent literature within which *Jatropha* promotion is situated, including the international debates on energy for sustainable development, biofuels, livelihood diversification, agricultural development, policy analysis and political ecology. The theoretical foundations on which the research is based are presented and gaps in the existing research literature identified. Chapter 3 outlines the research design, mixed-method multi-level analysis and participatory methods used in the achievement of the research objectives. The research process and the methodology employed are discussed. Justification for selection of Mali as a case study is provided, together with an outline of the field site selection and sample design. Considerations on positionality and research ethics are included. Chapters 4 and 5 are results and analysis chapters, addressing respectively research objectives 1 and 2. The stakeholder and policy analysis presented in Chapter 4 (objective 1) addresses knowledge gaps on the role of national policy instruments in the uptake of biofuel activities. The main stakeholders supporting biofuels in the country and the goals set in national policy with relation to *Jatropha* promotion are identified. Policy gaps are observed and ways forward proposed. Guided by the SLF, Chapter 5 outlines the livelihood analysis carried out at household level in rural Mali with the aim of addressing research objective 2. It assesses the factors affecting the socio-economic and environmental vulnerabilities of smallholder farmers, as well as identifying and evaluating the capital assets available in the pursuit of different livelihood strategies. The role played by *Jatropha* cultivation in the determination of different livelihood outcomes is then evaluated by integrating the information gathered through participatory methods. Chapter 6 integrates the knowledge produced at multiple levels to address research objective 3. It discusses the findings from Chapters 4 and 5 and situates them within the broader literature identified in Chapter 2. The drivers and barriers towards the achievement of the energy policy goals in Mali are identified through the lenses of political ecology and outcome analysis. This allows policy recommendations to be made to government and practitioners towards the development of a *Jatropha* biofuel industry that meets pro-poor development objectives. Chapter 7 is the concluding chapter. After presenting the policy recommendations, it briefly summarises the key findings of this research and highlights its primary contributions to wider academic debates.

Chapter 2

Literature review and theoretical grounding

"Theory without practice cannot survive and dies as quickly as it lives.
He who loves practice without theory is like the sailor who boards ship without a rudder and compass and never knows where he may cast"

(Leonardo Da Vinci, from Kline (1972: 230))

Outline

To better understand the theoretical context underpinning this research, this chapter reviews and synthesises the pertinent academic, policy and development project literature and international debates on energy for sustainable development, biofuels, livelihood diversification, agricultural development, policy analysis and political ecology. The role of *Jatropha* cultivation within such a context is outlined. The Sustainable Livelihoods Framework (SLF) is presented as an appropriate conceptual foundation on which to base the research, in light of the evaluation of its previous utilisation in policy-directed research in the developing world, including its outcomes, limits and critiques. Gaps in the existing research literature and policy needs with respect to the proposed research are identified as a guide for the specifics of the research design and methods developed for use in the present study.

2.1 Linking energy to sustainable development: the "energy trilemma"

In light of the unprecedented challenges faced by the global energy system, growing intensity of discussions on the interplay between sustainable development, universal energy access and climate change mitigation has made the "energy trilemma" an international development priority (World Energy Council, 2012; Gunningham, 2013; SEI, 2009; Scott, 2012). The relevant literature surrounding this trilemma is summarised here to better situate the academic discussions that will follow on *Jatropha* promotion as a sustainable biofuel source within these broader energy debates.

2.1.1 Universal energy access: what is energy poverty?

The International Energy Agency (IEA) (2011) World Energy Outlook has drawn attention to the 1.4 billion people across the globe without access to electricity and the 2.7 billion people without clean cooking facilities (accounting for 40% of the global population). These are two crucial indicators of household level energy poverty. Multiple definitions of energy poverty have been provided by multilateral organisations such as the United Nations Industrial Development Organization (UNIDO), United Nations Development Programme (UNDP), IEA and the Asian Development Bank (IEA, 2010b; Gaye, 2007; Masud *et al.*, 2007). These mainly include two dimensions: lack of access to electricity and high reliance on traditional biomass such as wood, agricultural residues, dry shrubs, and animal dung for cooking (Sovacool, 2012).

Energy poverty causes serious threats to human health, mostly affecting women and children (World Health Organization, 2006). Every year, the indoor pollution caused by the use of traditional biomass stoves for cooking and heating translates into the premature death of 1.3 million people worldwide (Kaygusuz, 2012). Reliance on biomass for cooking and heating also poses severe threats to the environment, as fuelwood collection can result in deforestation, desertification and land degradation (Sovacool, 2012). A wealth of literature has been produced on the importance of widening access to modern energy in order to reduce poverty and promote socio-economic development (*e.g.* Leach, 1992; Mulugetta *et al.*, 2005; Pachauri and Spreng, 2011; Zulu and Richardson, 2013; Jones 2010; Sokona *et al.*, 2012; Legros *et al.*, 2009; Bailis, 2011; GNESD, 2011). Monetary efforts at an unprecedented scale are needed to meet this challenge: it is estimated that the annual investment required to tackle energy poverty will range between US$48 and US$136 billion by 2030 (IEA, 2011b; Bazilian *et al.*, 2010). Nevertheless, Sathaye *et al.* (2011) stress that while benefits of modern renewable energy appear to be more evident with regards to the environmental dimension of sustainable development (*e.g.* emissions reduction and climate change mitigation), the exact contribution of this type of energy to socio-economic development (e.g. livelihood diversification and revenue generation) remains ambiguous. The authors (*ibid*) call for more research to bridge existing knowledge gaps, particularly on the links between the economic efficiency and social acceptability (*i.e.* livelihood impacts) of renewable energy. The present research addresses this call by providing empirical data on the impacts of *Jatropha* promotion as a source of sustainable energy both at the household and national levels.

The largest concentration of energy poverty is found in sub-Saharan Africa, where biomass contributes to roughly 80% of total domestic supply of primary energy, and electric power accounts for less than 3% of total consumption of energy (AfDB, 2008). Modern energy services are available to less than 10% of the rural population in sub-Saharan Africa, while electric power supplies are accessed by roughly 1% (*ibid*). Agriculture and transport energy needs are often met by deploying human and animal labour. These data exemplify the energy-poor context of Mali (see Chapter 3), where improvements in energy production at both national level and in rural areas could generate substantial livelihood gains. This reconfirms the relevance of Mali as a useful country context, where the challenges and opportunities associated with alternative energy sources such as *Jatropha* can be explored.

2.1.2 Climate change mitigation

The fight against climate change has turned into one of the most accepted global environmental policy priorities, in which the decarbonisation of the world economy is pursued to improve the life quality of our population (IPCC, 2007a). Links between sustainable energy and climate change in the African context are explored by Davidson (2002). The Intergovernmental Panel on Climate Change (IPCC) outlines the role that renewable energy can play in climate change mitigation in a report (IPCC, 2011) which explores the socio-environmental impacts arising from the use of renewable energy technologies.

The UN Framework Convention on Climate Change (UNFCCC) - signed at the UN Conference on Environment and Development in 1992 and entered into force in 1994 (UN, 1992) - considers energy production and consumption in the context of reducing the GHG emissions derived from fossil fuel combustion. Others have placed their attention on the links between energy security and climate change. Bazilian *et al.* (2011) show that improved energy security can positively affect climate change in a developing country context, whereas Karekezi *et al.* (2007) indicate that climate change mitigation is important to improve energy security.

Policy can play a major role in tackling these issues. For instance, the International Institute for Applied Systems Analysis (IIASA) shows that universal energy access policies combined with climate policy can fight energy poverty and reduce the health impacts related to both outdoor and indoor air pollution (van Vliet *et al.*, 2012). Focusing on Africa, Smeets *et al.* (2007) stress the importance of putting in place the right policies so that the continent can achieve its potential for bio-energy production, which could bring strong environmental gains. As outlined

in Chapter 1, biofuels are widely promoted by governments to tackle environmental problems. However, various authors call for more research to enable the adoption of more coherent institutional and regulatory frameworks to support biofuel development (Jumbe *et al.*, 2009; Amigun *et al.*, 2011). This research provides an in-depth understanding of the climate and energy policy instruments that are used by the Malian government to promote sustainable biofuels, and explores the roles played by different stakeholders involved in the *Jatropha* supply chain.

2.1.3 Sustainable development

Sustainable development is variously defined, but most commonly described as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (World Commission on Environment Development, 1987: 15). This concept involves three main components of sustainability: environmental, economic and social (Oyedepo, 2012; Meyar-Naimi and Vaez-Zadeh, 2012). Towards the fight against global poverty, environmental degradation, food insecurity, gender inequality, illiteracy and disease in the developing world, in 2000 the United Nations Millennium Summit agreed a set goals referred to as the Millennium Development Goals (MDGs) (UN, 2000). While energy is not explicitly cited in the components of sustainability or in the MDGs, the Johannesburg 2002 World Summit on Sustainable Development (WSSD) recognised that attaining energy sustainability is key to achieving sustainable development (World Summit for Sustainable Development, 2002). The following definition of sustainable energy is used: "*energy providing affordable, accessible and reliable energy services that meet the economic, social and environmental needs within the overall developmental context of the society for which the services are intended, while recognizing equitable distribution in meeting those needs*" (Oyedepo, 2012: 2584). Article 8 of the Plan of Implementation of the WSSD (2002) directly links energy services to poverty reduction. It recommends that governments should "*work together at all levels to improve access to reliable and affordable energy services for sustainable development sufficient to facilitate the achievement of the MDGs*" (*ibid*: 3).

Energy services can contribute to a virtuous cycle of economic, social and environmental development in developing countries in a variety of ways. Electricity and fuels are essential for enabling enterprise development and generating jobs (Bailis and Cowan, 2009). Mechanical power used for transportation and agriculture (such as water pumps, tractors and grinding machines) increases productivity, income generation and food security (DfID, 2002; UNDP,

2005; Kaygusuz, 2012; IEA, 2010b). Clean energy fuels for cooking and modern cook-stoves reduce the respiratory illnesses of the women and children exposed to the effects of indoor air pollution and also improve environmental conservation through reduced rates of fuelwood consumption (resulting in less pressure on forest resources, reduced deforestation and land degradation) and outdoor pollution (Sovacool, 2012; Balmer, 2007). Electric light extends the day allowing after dusk study and the extension of working hours. Refrigeration allows food to be kept fresh and the storage of medicines. Electrification of health centres can also improve the quality of health facilities and access for rural people (Larson and Kartha, 2000).

With the 2015 deadline for achieving the MDGs, the interplay between energy, climate change and poverty has received growing attention (UN, 2012a). The year 2012 was declared the "International Year of Sustainable Energy" under the UN's "Sustainable Energy for All" initiative, which aims to achieve key development goals by 2030 reflecting the energy trilemma. These include "(i) ensuring universal access to modern energy services, (ii) doubling the global rate of improvement in energy efficiency and (iii) doubling the share of renewable energy in the global mix" (UN, 2012b: 6). The increasing relevance of this agenda is highlighted by the consistent financial resources mobilised by this initiative and the designation of an "International Decade of Sustainable Energy for All" (UN, 2012a). Energy is also likely to play a central role in the Sustainable Development Goals (SDGs) that will be discussed at the sixty-eighth session of the United Nations General Assembly in late 2013 and which are expected to follow on from the MDGs from 2015 (Neal, 2012). The process to develop a set of SDGs was launched in 2012 at the Rio+20 United Nations Conference on Sustainable Development through the outcome document "The future we want" (UN, 2012c). This process is guided by the post-2015 development agenda, which is designed upon eleven key global thematic consultations, including one on energy.

This research contributes to these energy and development debates by assessing the initial impacts of and future prospects for *Jatropha* crop promotion and use as a source of sustainable energy in the developing world. The detailed livelihood assessments carried out at household level provide much needed evidence of the role that this crop can play in the promotion of a virtuous cycle of socio-economic and social development.

2.2 Major debates surrounding biofuels sustainability

To assess the potential of *Jatropha* to provide an effective source of energy and livelihood diversification, it is essential to situate the research in the context of the most widespread criticisms surrounding the sustainability of first generation biofuels. This section provides a detailed understanding of these criticisms, highlighting how the research findings will contribute to each debate.

Critiques of first generation biofuels range from describing biofuel agriculture as the major cause of food insecurity in developing countries (Nonhebel, 2012), to competing claims on land and labour (Cotula *et al.*, 2009), social malpractices (Sawyer, 2008), the limited impact on GHG emissions reduction (Searchinger *et al.*, 2008), deforestation (Gao *et al.*, 2011) and loss of biodiversity (Fitzherbert *et al.*, 2008). These are explored in the sections below, which are grouped according to the major socio-economic and environmental discussions identified in Figure 2.1.

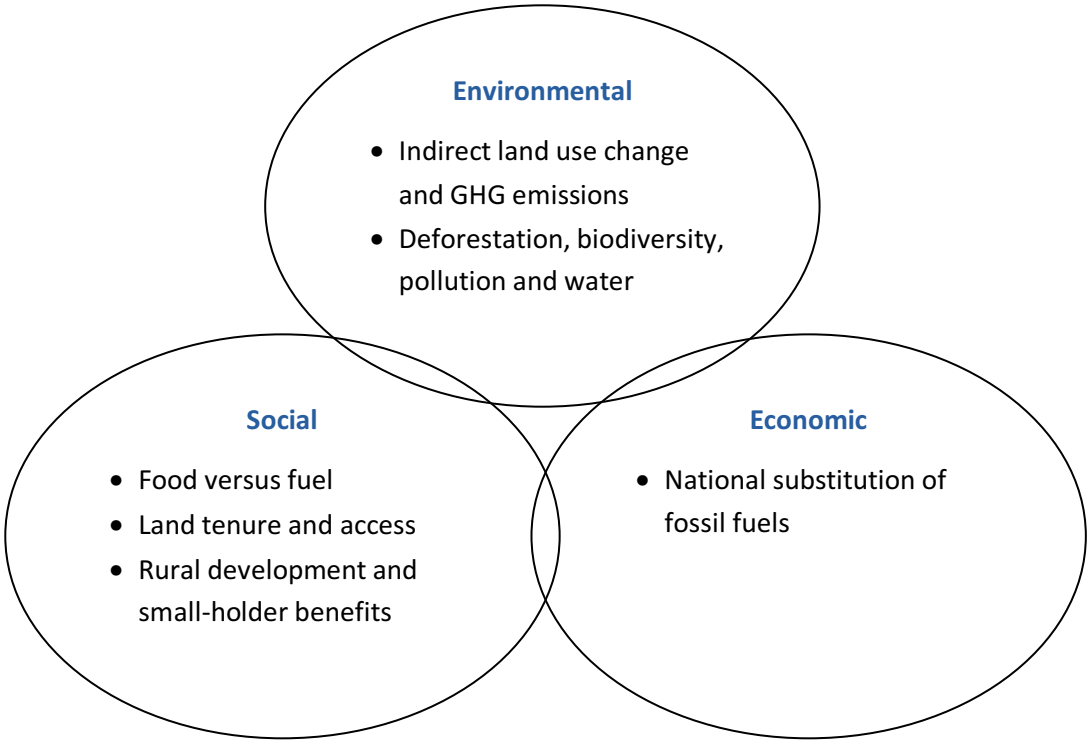

Figure 2.1: Social, environmental and economic debates surrounding biofuel sustainability

2.2.1 The social and economic dimensions of biofuels sustainability

2.2.1.1 Food versus fuel

Concerns about biofuels in the academic and media discourse are especially visible in the debate on food security as the vast majority of first generation biofuel feedstocks constitute edible materials. While the issue of "*turning food for the poor into fuel for the rich*" (Kovarik, 1998: 2) has been raised since the early 1980s by the opponents of alcohol fuel (Barnard, 1983), the food versus fuel debate gained global relevance in the aftermath of the 2007–2008 food price crisis, which was followed by a second food price spike in 2011 (WB, 2011). Between 2002 and 2008 the International Monetary Fund index of traded food prices increased 130% (Mitchell D., 2008), with the biggest increase registered since late 2006 (Mueller *et al.*, 2011). This trend is confirmed by the FAO Food Price Index, which rose sharply between 2006 and 2008 – respectively 8% in 2006, 24% in 2007 and 53% in the first three months of 2008 (FAO, 2008b). After a rapid price decline occurred in mid-2008, the index reached its highest peak in mid-2011 (Figure 2.2). The effects of these price spikes are particularly severe in Africa, where households spend between 50 and 70% of their budget on food (Diao *et al.,* 2008).

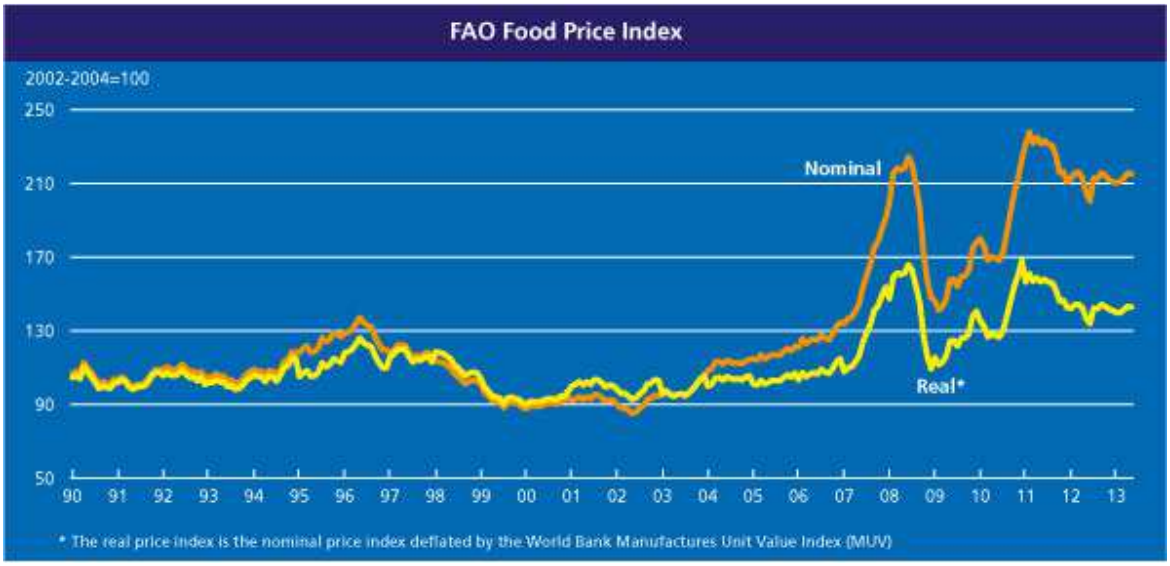

Figure 2.2: FAO Monthly Food Price Index (2002-2004=100)

Source: http://wwwfao.org/worldfoodsituation/wfs-home/foodpricesindex/en/

There is a widespread view that the root cause of these price spikes was the rapid biofuel expansion which replaced food with fuel production (Nonhebel, 2012; Diao *et al.*, 2008;

Collins, 2008; Bates *et al.*, 2008; Abbott et. al, 2008; Naylor *et al.*, 2007; Runge and Senauer, 2007). Mitchell D. (2008) estimates that the rapid demand for first generation biofuel feedstock accounted for 65% of the 2007-2008 food price rise.

In contrast to these claims, more balanced views suggest the food versus fuel controversy has been exaggerated as an oversimplification of a complex issue, where the food price spike has been driven only in part by biofuels. According to Qiu *et al.* (2012), increased biofuel production may generate food prices shifts only in the short-run, while prices are not affected in the long-run. Other authors contest that biofuel production impacts on food shortages and price increases must be considered in the context of a range of interrelated trends in global agricultural markets, including the rapid growth of economy and population, droughts experienced by major cereal-producers, increasing oil prices and a combination of policies which favoured financial speculation in commodity markets (Zhang *et al.*, 2010; Dewbre *et al.*, 2008; Headey *et al.*, 2008; Muhammad *et al.*, 2009; Senauer, 2008; Ajanovic, 2011; Ghosh 2010). Figure 2.3 summarises the main drivers of food price inflation and volatility.

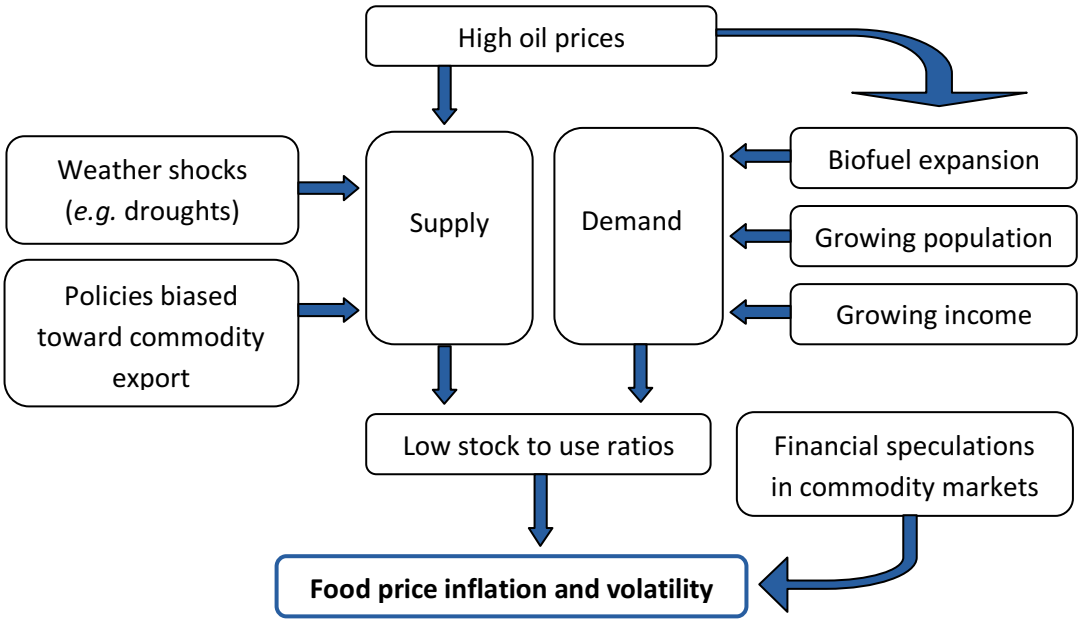

Figure 2.3: Drivers of food price inflation and volatility

Source: Adapted from Committee on Climate Change (2011: 39)

Reluctance about biofuel expansion remains in both academia and the NGO community considering the challenge of meeting arable land needs, particularly in the context of

increasing demands for food (ActionAid, 2010; Biley, 2007; Cotula *et al.*, 2008). Howarth *et al.* (2009) estimate that between 118 and 508 million ha of new agricultural land would be needed to meet 10% of global transport fuel needs by 2030 through biofuels. In the most extreme scenario, this would account for up to one third of the actual global area of arable land, standing at roughly 1,400 million ha (*ibid*).

Solutions to decrease competition between biofuels and food production have been proposed, including the use of marginal and degraded land for energy crop cultivation (Howarth *et al.*, 2009; Lynd and Woods, 2011) and the establishment of Integrated Food Energy Systems (IFES) (Bogdanski *et al.*, 2010; Sachs and Silk, 1991). In an IFES, food is simultaneously produced with energy on the same land through intercropping or agroforestry systems (Bogdanski *et al.*, 2010). Within these solutions, the opportunities offered by *Jatropha* as a viable alternative energy crop look promising. Nevertheless, evidence on the possibility to grow this crop effectively on land that is not suitable for food production in an IFES system is largely lacking. This research offers important contributions to the food versus fuel debate by providing empirical evidence of the land use implications of small-scale *Jatropha* agriculture for food production. Through the use of participatory methods (including farming calendars) in-depth data is gathered on the cultivated land area, intercropping practices, labour use and land trade-offs in Mali.

2.2.1.2 Land tenure security

As of 2013 the largest share of global ethanol production (over a total quantity of 113,854 million litres) originates in the US (55,770 million litres), Brazil (28,685 million litres) and the European Union (EU) (7,049 million litres) (OECD-FAO, 2013). The main biodiesel producers (over a total quantity of 28,508 million litres) are the EU (11, 288 million litres), US (6,058 million litres) and Brazil (2,587 million litres) (*ibid*). However, great potential for the diversion of land to energy crops is recognised in the African continent due to the lower cost of land and labour and a more amenable climate (Lynd and Woods, 2011; Smeets *et al.*, 2008). In this regard, an important concern for local communities is the use and allocation of land. Critics argue that biofuel cultivation might negatively impact local villagers' livelihoods, involving a loss of rights over customary lands and the way these could be used (Sulle and Nelson, 2009). Land acquisitions threats emerge when the land used for biofuel production is leased or purchased by large-scale external investors (Cotula *et al.*, 2009; Fairhead *et al.*, 2012; Matondi *et al.*, 2011; Von Braun and Meinzen-Dick, 2009). The World Bank (Deininger *et al.,* 2011)

examined 464 large-scale acquisitions worldwide, accounting for 56.6 million ha, and found that 21% of all land acquired by foreign investors was used as a source of feedstock for the biofuels industry.

Fairhead *et al.*, (2012: 238) observe that land appropriation, intended as the "*transfer of ownership, use rights and control over resources that were once publicly or privately owned*", can happen in a variety of ways, which include the use of violence, legislation or market mechanisms. As summarised by Borras *et al.* (2011: 209), market mechanisms range from "*private–private purchases and public–private leases for biofuel production to acquisition of large parcels of land for conservation arrangement, with variegated initial outcomes*". With a view to the African context, a major problem observed in these operations is the non-recognition of customary land rights, where existing land users are "legally" displaced by governments in cooperation with local firms and foreign investors (Alden Wily, 2011; Makki and Geisler, 2011). Bassey (2003) notes that the use of land for socio-economic development depends on land tenure systems and institutions. The author stresses the importance for governments to recognise traditional tenure rights in order to avoid abuses and improve the conservation of natural resources. Similarly, Barbier and Burgess (2001) observe that land tenure insecurity may create incentives that encourage the unsustainable conversion of forestland to crop production. Fairhead *et al.* (2012: 238) argue that the aggressive appropriation of land for food or fuel, defined as "*green grabbing*", is often justified by narratives that call upon "*green credentials*". De Schutter (2011) questions the capacity of the countries that host large-scale land deals to ensure that these effectively foster rural development and reduce poverty. The author calls for a need to move beyond regulations with a view to providing concrete alternatives to these kinds of investments and improving access to land and water for the local farming communities. Case studies from India (involving *Jatropha* cultivation) (Ariza-Montobbio and Lele, 2010) and Africa (Vermeulen and Cotula, 2010) provide evidence of how large-scale land acquisitions may threaten the rights of local communities, which are often displaced with little or no recompense or without being provided the right to free informed consent. Developing countries are not prepared to face these problems, as they often have a weak legal framework, local people may not be aware of their rights, and land valuations are carried out using inadequate criteria (Sulle and Nelson, 2009; Nhantumbo and Salomão, 2010). Along these lines, Woodhouse (2012) stresses that weak regulatory and legal frameworks may fail to safeguard the interests of local land users against international capital investments. This is confirmed by the World Bank (Deininger *et al.,*

2011), which recognise that "land grabs" have predominantly taken place in the most corrupted or indebted countries with weak regulations, where buyers could easily displace rural communities from the lands on which they held customary rights.

These considerations are vital in the development of a sustainable biofuel industry, particularly in sub-Saharan African countries with overlapping land tenure systems. In Mali for example, land rights are regulated by the Agricultural Orientation Law (GoM, 2006a), which recognises two different levels of authority: official (town hall) and traditional (village chief). Land rights in rural settlements are claimed by gaining the authorisation of both the village chief and mayor. This is the typical situation for much of sub-Saharan Africa, where, as highlighted by Toulmin (2009), there is a risk of overlapping claims for the rights to land, depending on customary use, season and negotiation. Toulmin (*ibid*: 12) provides the example of Mali, where "*cultivation rights to a millet field in Mali may be held by one household, with women from the wider family having rights to glean after harvest, and neighbours then allowed to let their animals graze on the remaining stubble*".

It is vital to ensure that biofuel-driven large-scale land acquisitions in Africa do not threaten the traditional rights of local communities. The multi-level assessments presented in this study contribute to these debates by investigating the actual and prospective impacts of *Jatropha* promotion for land use in Mali at both the national and local levels.

2.2.1.3 Rural development, small-holder benefits and national substitution of fossil fuels

Various authors have discussed the potential of biofuels to modernise agriculture, generate rural employment and promote development (Janssen and Rutz, 2012; Lynd and Woods, 2011; Ejigu, 2008; Sagar and Kartha, 2007; Mol, 2007; Molony, 2011; Clancy, 2008; Arndt *et al.*, 2010; Yan and Lin, 2009). Nevertheless, a variety of concerns are raised. Ravindranath (2010) notes that impacts of biofuels on employment generation are not uniform. If the production techniques employed for biofuel production under current land use are more labour-intensive than those under previous land uses then rural employment is generated. Conversely, increased mechanisation would displace traditional agriculture and lead to loss of employment. A report from ActionAid (2012) points out that biofuel policy targets set by developed countries will contribute to worsening hunger and nutrition and will erode the global poverty reduction efforts made by financial donors. Case study research from Cambodia

(Hought *et al.*, 2012) finds that the participation of smallholder farmers in the cassava-based biofuel market intensified their economic vulnerability as well as threatened food security and land access. Da Silva César and Batalha (2010) observe that production of biodiesel from castor beans in Brazil is impractical. Companies investing in these activities were found to lack the capacity to implement contracts with family farmers, translating into poor and inefficient technical assistance, low production rates and high debts of farmers. The inclusion of smallholder farmers in biodiesel social projects is thus highlighted as a major challenge (*ibid*). In the case of ethanol from sugarcane, Brazil has been accused of not respecting workers' rights, with unhealthy working conditions being reported (Martinelli and Filoso, 2008; Sawyer, 2008; Smeets *et al.*, 2008). Ribeiro (2013) further points out that ethanol development can increase levels of social vulnerability because in Brazil, labour and social laws are not firmly enforced. The Brazilian ethanol model is characterised by industrial-scale, export-driven production which generates highly unskilled and temporary employment at the plantation level. The workers being employed for manual harvesting of sugar cane are underpaid and, as a result, they are overworked (as guided by the Brazilian Labour Code (CLT, 1943)) in order to earn a higher wage. This system has been found to increase social inequality (*ibid*). Although beyond the scope of the present research, these aspects will need to be considered in relation to *Jatropha* cultivation in an African context too.

Other authors highlight the positive impacts that can be generated for local communities through energy crop cultivation. These include an overall empowerment of local people through local business (Hall and Matos, 2010) as well as local investments in education, sport and health promoted by ethanol projects (Neves, 2010). Milder *et al.* (2008) note that such benefits are enhanced when smallholder producers are organised into locally-run cooperatives. Lynd and Woods (2011) point out that the impacts of biofuels on poverty in underdeveloped rural areas of Africa depend on a variety of factors, which include the crop grown, land used, technology employed and how the supply chain is integrated into socio-economic systems. It is asserted that positive impacts can be achieved if adequate planning and monitoring are implemented. Still, the effective substitution of relatively large shares of fossil energy with biofuels in a developing country context remains a major challenge due to the variety of organisational and financial constraints faced throughout the supply chain, from national to local levels (Hall *et al.*, 2009; Da Silva Césa and Batalha, 2010).

This study contributes to these debates by assessing the social and economic impacts of biofuels. It assesses how *Jatropha* has been integrated into the Malian energy and agricultural systems at multiple levels. New opportunities offered by this crop to foster income generating activities in rural areas are identified and the feasibility to substitute a large share of national fossil fuels consumption is assessed. The integrated use of mixed methods involving in-depth household level assessments in rural Mali and national level interviews generate new empirical evidence that is useful to identify policy measures that maximise the positive outcomes for rural development and livelihood improvement.

2.2.2 The environmental dimension of biofuels sustainability

2.2.2.1 Indirect land use change and GHG emissions

The effectiveness of using biofuels for GHG emissions reductions and environmental preservation is highly contested. While several studies agree that substitution of fossil fuels with first generation biofuels results in significant GHG emission reductions when the effects of possible land use changes (both direct and indirect) are not considered (Mirza *et al.*, 2011; Goldemberg and Coelho, 2004; Goldemberg *et al.*, 2008), these land use change impacts may significantly affect these estimates (Berndes *et al.*, 2011; Ravindranath *et al.*, 2009; Fargione *et al.*, 2008; Gibbs *et al.*, 2008; Fritsche, 2011; Searchinger *et al.*, 2008). Direct land use change (LUC) occurs when an existing land use is modified by biofuel feedstock production (Mirza *et al.*, 2011), while indirect land use change (ILUC) occurs when increased biofuel cultivation displaces pre-existing agricultural production into new areas (Searchinger *et al.*, 2008).

Life-cycle analysis indicates that these land conversions may cause significant increases in greenhouse gas emissions (Searchinger *et al.*, 2008; Fritsche, 2011; Howarth *et al.*, 2009). As Figure 2.4 on LUC shows, quantification of these variables is surrounded by uncertainties and estimates vary consistently among authors.

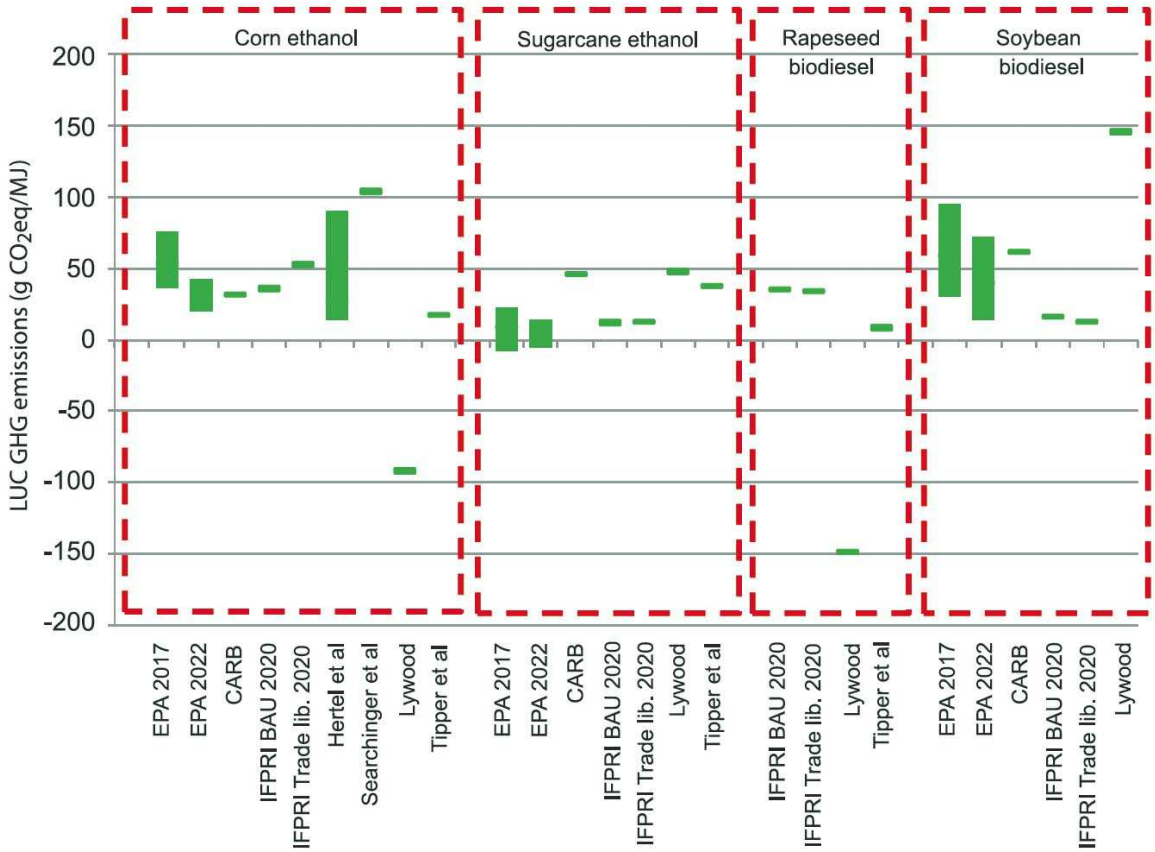

Figure 2.4: Ranges of model-based quantifications of direct land use change emissions associated with the expansion of selected biofuel crops combinations.

Source: Berndes *et al.* (2011: 30)

Havlík *et al.* (2011) observe that second generation biofuels perform better than first generation ones. However, results highly depend on the type of feedstock used.

2.2.2.2 Deforestation, biodiversity, pollution and water

The environmentally-friendly rhetoric surrounding biofuels has often been disputed and critiques have emerged with regard to the impacts that biofuel driven land-use conversion may have in terms of deforestation, biodiversity loss, soil degradation and water use / quality (Charles *et al.*, 2007; Ravindranath *et al.*, 2009; Schubert *et al.*, 2010; Gao *et al.*, 2011). Fitzherbert *et al.* (2008) and Sala *et al.* (2009) note that biofuel-driven deforestation negatively

affects biodiversity and decreases the environmental goods and services provided by forests to local populations.

When large-scale commercial cultivation uses nitrogenous fertilisers, pesticides and herbicides, pollution of soil and downstream water bodies is observed (Ravindranath *et al.*, 2009; Righelato and Spracklen, 2007; Patzek *et al.*, 2005). Another environmental issue that must be considered is that most first generation biofuel crops are more water-intensive to produce compared to conventional fossil fuels (Hoff, 2011). As noted by Peña (2008) and confirmed by the case of corn-derived ethanol in the US (Nuffield Council on Bioethics, 2011), large-scale commercial energy crops plantations may lead to water competition between biofuel and food production. These observations raise further concerns over the implications of biofuel-driven large scale land acquisitions for land and water use (see Section 2.2.1.2). For example, Woodhouse (2012) stresses that the impact on water resources is often underestimated in land deals, and that foreign investments in sub-Saharan Africa may threaten existing water use. Commercial-scale production of *Jatropha* could potentially affect negatively the use of natural resources, including water, if not adequately managed. This research provides new perspectives on the implications of *Jatropha* cultivation at both small and large scales in Mali, with a view to the previous land uses and future implications for land and water use in the achievement of national policy goals.

2.3 *Jatropha*

This section looks at the agronomic qualities of *Jatropha* and its traditional and modern uses. It explores *Jatropha*'s potential contributions towards livelihoods diversification and rural development.

2.3.1 Traditional uses and agronomy

Since the beginning of the 21st century the oil-bearing tree *Jatropha* has been promoted as "green gold" (Renner, 2007) to provide a source of sustainable biofuel in the tropics and subtropics (Achten *et al.*, 2010). Despite some cases of human consumption of *Jatropha* roots, branches, leaves and seeds being reported in Guinea and Mexico (Orwa *et al.* 2009; Hunsberger, 2012), the tree is considered inedible as it contains toxins such as phorbol esters and curcains (Jongschaap *et al.*, 2007). The presence of these toxins reduces some of the concerns surrounding the food versus fuel debate outlined in Section 2.2.1. *Jatropha* has been

known for many years throughout the world as a multi-purpose tree with a myriad of uses. These are summarised in Figure 2.5 and outlined in the sections below.

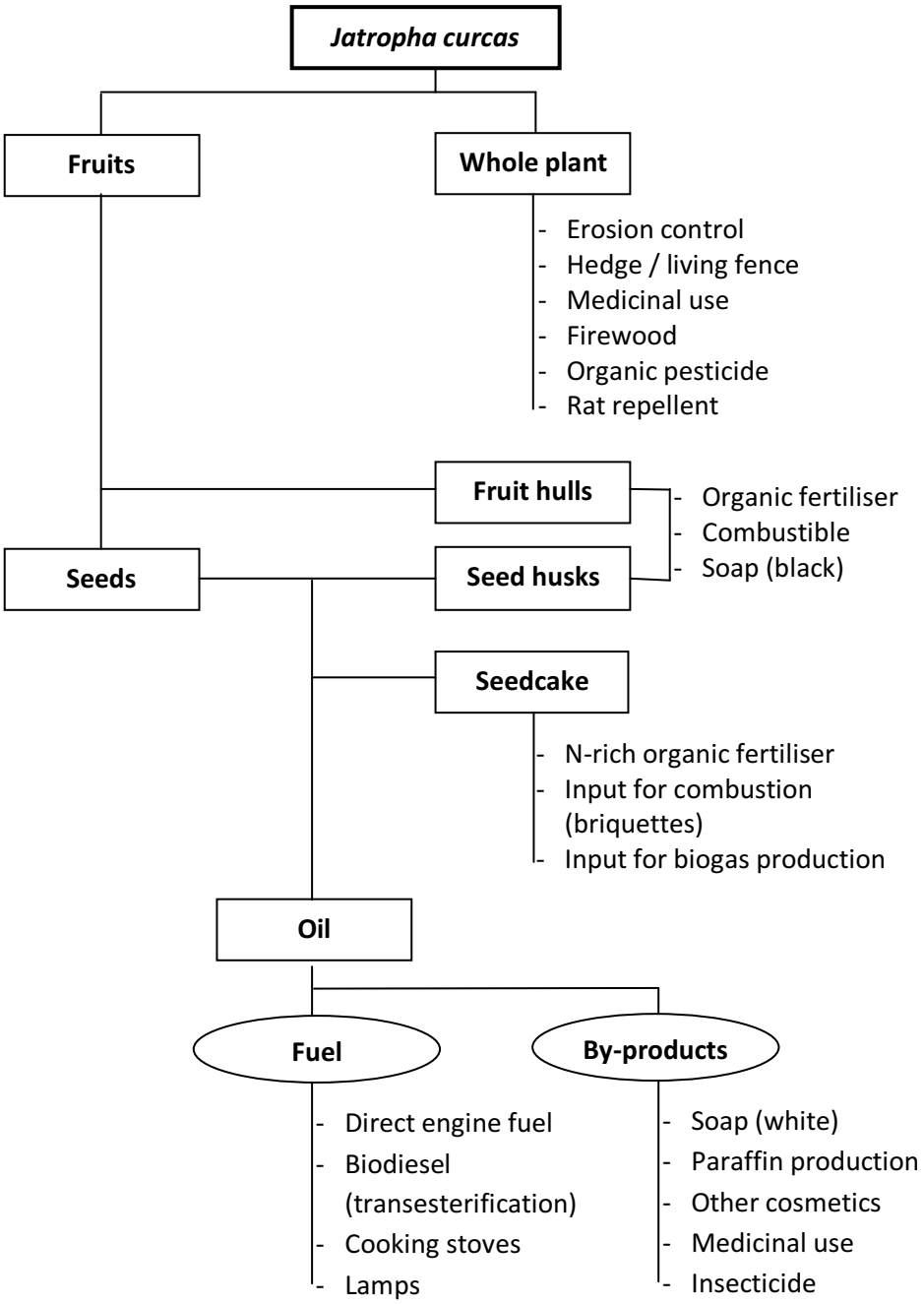

Figure 2.5: Range of uses and applications of *Jatropha*

Jatropha is widely used in Latin America, Africa and Asia as a traditional health remedy. The whole plant can treat wounds, burns, allergies (Kaushik and Kumar, 2004) and diarrhoea (Patil, 2005). The seed oil is used as purgative (Kirtikar and Basu, 1980) and the seeds are used to treat abdominal pain and dysentery (Kirtikar and Basu, 1980). Other traditional medicinal applications are found in the treatment of malaria, fevers, headaches and sore throat (Openshaw, 2000; Sabandar *et al.*, 2013; Orwa *et al.* 2009).

The tree has been widely used as a living hedge to protect food crops from grazing animals, demarcate property and combat soil erosion (Brittaine and Lutaladio, 2010; GTZ, 2009; Achten *et al.*, 2010). *Jatropha* fences effectively protect cultivated areas from wind and water erosion (Henning 2004 and 2002). The lateral root systems decrease soil erodibility by improving soil cohesion (Reubens *et al.*, 2011). However, evidence is lacking as to whether *Jatropha* is any more effective than other plants with regards to the prevention of soil erosion. Minor uses of the plant seeds and leaves are found in the preparation of insecticides (Openshaw, 2000), rat poison, inks and dyes (Orwa *et al.* 2009). In the beginning of the 19th century, *Jatropha* seeds were exported by Portuguese traders from Africa to France and Portugal, where they were used for street lighting and soap production (Heller, 1996).

The recent enthusiasm for *Jatropha* as a biofuel crop is grounded in the variety of optimistic claims made about its agronomic qualities. These are summarised here and further detailed in the following paragraphs. It has been argued that *Jatropha:*

- Grows high oil content seeds (Jongschaap *et al.*, 2007);
- Tolerates drought and has low water use (Gush *et al.*, 2007; Rao *et al.*, 2012; Jain and Sharma 2010); and
- Requires low nutrients and can grow in areas with poor soil (Jongschaap *et al.*, 2009).

In the production of *Jatropha* for energy, the high oil content of the seeds and the high yields are two key factors (Whitaker and Heath, 2010). *Jatropha* has been identified as a low-input, high-output crop by various authors and reports suggest that the tree produces abundant seeds using limited irrigation and fertiliser (Gush *et al.*, 2007; Jain and Sharma 2010). Nevertheless, estimates found in literature on the production potential are highly variable, with seeds yields ranging between 0.4 to 4.0 tonnes of seeds per ha and oil content ranging from 17% to 45% (Jongschaap *et al.*, 2007; Srivastava *et al.*, 2011; Tambunan *et al.*, 2012).

Francis *et al.* (2005) note that seed yields per tree can vary widely even in the same plantation, ranging from 0.2 to 2 kg.

Data is particularly lacking for *Jatropha* grown under dry and low-nutrient conditions. However, these are conditions under which the tree can grow according to numerous authors (Achten *et al.*, 2010; Holl *et al.*, 2007; Rao *et al.*, 2012; Jain and Sharma 2010). Holl *et al.* (2007) report that *Jatropha* survives with a minimum mean annual precipitation of 250 mm, while it grows well with values ranging between 500 and 1200 mm. Case study research from Cape Verde carried out by the Institute of Pacific Islands Forestry (2004) indicates that the tree can even survive for several years without rainfall. According to the study, *Jatropha* grows well on sandy and saline soils and it also survives on stony soils with low nutrient content. Similarly, Holl *et al.* (2007) and Jain and Sharma (2010) assert that the plant does not require fertiliser input and can produce satisfactory yields on marginal, degraded and unproductive lands, including along canals, roads, railway tracks, arid or semi-arid areas and alkaline soils. As such, *Jatropha* is identified as a species suitable to reclaim degraded lands, stop soil erosion and combat desertification (GTZ, 1995).

Conversely, these combined claims on drought tolerance and high production potentials are deemed as unrealistic by other authors (Jongschaap *et al.*, 2009; Hoekstra and Gerbens-Leenes, 2009). The FACT Foundation (FACT, 2010) observes that an annual precipitation between 1,000 and 1,500 mm is required for optimum seed production. A recent report examined the field activities carried out by the Foundation in Mali, Mozambique and Honduras (De Jongh and Nielsen, 2011). It concludes that when grown under marginal conditions, *Jatropha* yields are lower than expected and the plant develops adequately only when nutrients and water are available. This mirrors findings from Rao *et al.* (2012), who recognise that while *Jatropha* can tolerate drought, notably higher growth and yields are achieved when continuous irrigation and fertiliser input are provided. Ariza-Montobbio and Lele (2010) observe that irrigated plots (in terms of average number of seeds per plant) yield twice as high in comparison to the rainfed ones. In line with observations from Francis *et al.* (2005), these considerations indicate that reliable scientific evidence on the agronomic qualities of *Jatropha* is currently lacking. The household-level livelihood analysis performed by this study informs these academic debates by assessing local perceptions on the actual yields achieved under dry and low-nutrient conditions in rural Mali. From a policy perspective, this study informs the Malian policy makers towards the development of more coherent energy targets. This is

achieved by integrating the national-level policy analysis with the data on yields gathered at the household level.

2.3.2 A pro-poor biofuel crop for Africa

In light of the abovementioned agronomic claims, since the early 1990s *Jatropha* has been gaining an increasing status as a "wonder" energy crop that allows restoration of degraded lands and the substitution of high quantities of oil without competing with food production (Jain and Sharma 2010; Jumbe *et al.*, 2009). A variety of pilot and commercial activities have been implemented across the world, thanks to substantive financial support offered by international donors, with the aim to promote the use of plant oil as a fuel. Poverty reduction goals, with a strong focus on gender equality and women's empowerment, are pursued based on the underlying idea that the establishment of a *Jatropha* biofuel supply chain stimulates economic activities in rural areas (Achten *et al.* 2010; Dyer *et al.*, 2012) and improves the environment through land reclamation, erosion control and GHG mitigation (Achten *et al.*, 2012; Ogunwole *et al.*, 2008).

From a technical perspective, straight vegetable oil (SVO) is obtained by crushing the seeds. This can be used directly in some types of diesel engines such as grinding mills or electricity generators (Eckart and Henshaw, 2012). When further processed through transesterification, the oil is turned into biodiesel that can be used for transport (Jain and Sharma, 2010). The transesterification of vegetable oil also produces glycerol, a by-product commonly used for soap production to generate additional revenues (Weyerhaeuser *et al.*, 2007). Another by-product is the residue from seed pressing, called seedcake. This can be used as a fertiliser as it is rich in nitrogen (Srinophakun *et al.*, 2012), burned as cooking fuel after being compressed into briquettes, or fermented to produce biogas (Jongschaap *et al.* 2007; Hunsberger, 2012).

The greatest production potential is found in Africa thanks to the favourable climatic and soil conditions combined with the availability of agricultural land (Lynd and Woods, 2011; Sorda *et al.*, 2010). According to a study from Gexsi (2008) the major African producers of *Jatropha* are in Madagascar, Zambia and Tanzania, while future major production is foreseen to occur in Ghana and Madagascar. Large farms are also found in Togo, Niger, Nigeria and Mozambique (Jumbe *et al.*, 2009; Amigun *et al.*, 2011; Energy Commission of Nigeria, 2013).

Mali is not reported in these broad studies because they only focus on large-scale plantations, which are lacking in the country. Nevertheless, Mali has been a pioneer in the promotion of *Jatropha* through an integrated approach to fuel production and rural development in Africa. First use of the plant oil to run engines is found in the country during World War II (Orwa *et al.* 2009), while in 1993, the German Technical Assistance (GIZ, formerly GTZ) tested the potential uses of *Jatropha* through an integrated approach to rural development. The oil was used to fuel local grinding mills and make soap, with a production system based on the cultivation of the plant as a living hedge to protect farmers' fields against grazing animals (Wiesenhütter, 2003). Since then, the number of implemented pilot activities in the country has been growing exponentially (see Chapter 4). Mali was chosen as a study country for this research in light of its relevant experience in *Jatropha* testing and promotion.

2.3.3 *Jatropha*, livelihood diversification and rural development

The impacts of *Jatropha* cultivation on poverty, agriculture, land use and food security are explored at multiple levels by a number of authors (Brittaine and Lutaladio 2010; Gasparatos *et al.*, 2012; Romijn, 2011; Pandeya, 2012; Borman *et al.*, 2012, Everson *et al.*, 2012). Initial research has been carried out at local levels across African (German *et al.*, 2011; Dyer *et al.*, 2012; Schoneveld *et al.*, 2011; Schut, 2011; Grimsby *et al.*, 2012), Indian (Findlater and Kandlikar, 2011) and Latin American (Skutsch *et al.*, 2011) farming systems, but claims on the potential impacts of *Jatropha* cultivation on poverty and rural development were found to be contrasting (Hodbod and Tomei, 2013). This research extends and bridges these debates by assessing the contribution of *Jatropha* to livelihood diversification in rural Mali. The underlying concepts required for such analysis are here provided.

Smallholder cultivation of *Jatropha* has been widely presented as a "pro-poor" strategy for enhancing rural livelihoods (Brittaine and Lutaladio, 2010: 1). Figure 2.5 in Section 2.3.1 showed the variety of uses through which the plant can contribute to diversification and rural development. Achten *et al.* (2010) and Nelson and Lambrou (2011) note that by adding an additional crop to the current set of farmers' activities, small-scale production allows the diversification of income sources. An additional source of income is generated through the sale of the plant's seeds and by-products (Achten *et al.*; 2010; Brittaine and Lutaladio, 2010; Dyer *et al*., 2012), including soap and paraffin (Weyerhaeuser *et al.*, 2007; Kumar and Sharma, 2008), fertiliser (Srinophakun *et al.*, 2012; Achten *et al.*, 2007), insecticides (Gubitz *et al.*,1999), inks and dyes (Orwa *et al.* 2009) and medicines (Sabandar *et al.*, 2013). When used as a living

fence, *Jatropha* protects arable land against soil and water erosion, so it provides a diversification strategy that can improve natural capital and food production (Reubens *et al.*, 2011; Henning 2004).

The plant's use for oil and biogas production limits the dependency of rural communities on fossil fuels and improves access to energy (Hunsberger, 2012; Achten *et al.*, 2010). According to the GNESD (2011), Mali is today among the most experienced West African countries in *Jatropha*-fuelled electricity generation. This claim is supported by Gilbert (2011), who reports that as of 2011, *Jatropha* provided a Malian village with public lighting and electricity to 350 homes and businesses. Case study research from Malawi indicates that capital expenditure is reduced when *Jatropha* oil is used to make soap and paraffin (Dyer *et al*., 2012). Openshaw (2000) identifies soap making as the most profitable use, while Tomomatsu and Swallow (2007) suggest that relatively small but steady amounts of revenue are generated when *Jatropha* is used as a living fence to demarcate boundaries around houses and farms. Locally produced *Jatropha* oil can run Multifunctional platforms (MFPs)[2] (Eckart and Henshaw, 2012) providing several advantages: it is cheaper than diesel and more accessible for isolated communities (Walters and Morris, 2009). According to Rodriguez-Sanchez (2010) the oil has the potential to increase the economic benefit of a MFP. Brittaine and Lutaladio (2010) note that the use of *Jatropha* oil in diesel powered machines particularly benefits women as it reduces their amount of domestic work spent on fetching water and grinding cereals (Figures 2.6 and 2.7). When used in stoves, the oil can help to reduce indoor pollution and respiratory diseases (Achten *et al.*, 2010).

[2] A Multifunctional Platform (MFP) consists of a stationary diesel engine which can power a variety of tools, including huskers, cereal mills, welding and carpentry equipment, alternators (to provide lighting), battery chargers and water pumps. Thanks to the mechanisation of tedious tasks such as dehulling crops, MFPs have shown great potential in Africa in the reduction of women's workloads (Nygaard, 2009).

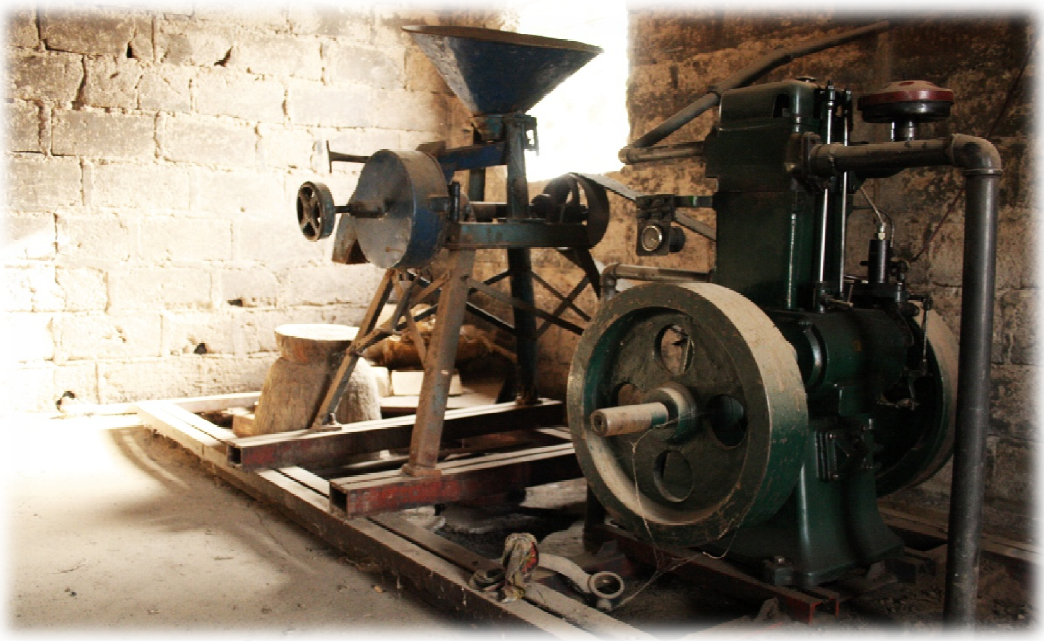

Figure 2.6: Multifunctional Platform, Garalo, 2011

Figure 2.7: Women grinding cereals on a Multifunctional Platform, Dongoroná, 2011

The promotion of *Jatropha*-derived biofuel therefore offers a potential solution to address the multiple challenges of the energy poverty trilemma outlined in Section 2.1. Energy poor African countries could particularly benefit from a crop that allows a shift from traditional to modern use of biomass in order to produce energy; a step that is key to the development of economic activities.

Several concerns have nevertheless been raised. Case study research from Tamil Nadu in India (Ariza-Montobbio and Lele, 2010) finds that *Jatropha* cultivation is not pro-poor and impoverishes the farmers. This is due to the negative economic returns produced by low yields, as well as the fact that it may generate social conflicts and threaten food security when water resources are scarce. The study concludes that development impacts from *Jatropha* in India mainly benefit large-holder and wealthier farmers. Grimsby *et al.* (2012) observe that Tanzanian farmers are reluctant to venture into harvesting *Jatropha* as the potential income is considered too low. In such a context, generous subsidies are necessary to enhance the socio-economic sustainability of *Jatropha*-based rural electrification activities. This mirrors findings from Skutsch *et al.* (2011) in Mexico, who report low profitability of *Jatropha* as a cash crop and high dependence of the farmers on government subsidies. Along these lines, Clancy (2008) states that unless the farmers are engaged with small-scale decentralised oil extraction the benefits to local communities will be minimal. Land dispossessions of smallholder farmers by commercial companies have been reported in Ghana (Schoneveld *et al.*, 2011; WRM, 2008) and India (Lahiri, 2009). In contrast, evidence from Mexico (Skutsch *et al.*, 2011) indicates that outgrower production did not negatively impact land access. Findlater and Kandlikar (2011) conclude that while *Jatropha* has a potential as a biodiesel crop, the establishment of commercial plantations should be approached with caution in light of the low productivity and land-use change problems that may arise. German *et al.* (2011) support this view and emphasise that the risk of failure of such an unproven feedstock in Zambia is likely to be borne to a large extent by the most vulnerable smallholder farmers. These authors also question whether smallholder feedstock production schemes could address problems associated with large-scale land acquisitions.

2.3.4 Summary of the different positions on *Jatropha* in literature

Table 2.1 provides a summary of the key positions on *Jatropha* identified from the analysed literature.

Table 2.1: Key positions on *Jatropha* from literature

Source	Illustrative quotations
	Positive
Dyer *et al.* (2012)	"*Small-scale initiatives do have the potential to contribute positively to rural livelihoods... actions should be focused at the local level in order to realise developmental, sustainability and climate change benefits across a range of scales*" (p. 110)
Gilbert (2011)	"*In addition to providing light, heat and fuel for transportation, biofuels [from Jatropha] have given Garalo's businesses and trades people the tools and confidence to modernize and expand... The [Jatropha] project is a testament to how biofuel production can greatly improve the lives of poor people in developing countries*" (p. S18)
Jain and Sharma (2010)	"*Jatropha can be grown in arid zones (20 cm rainfall)... It is a quick yielding species even in adverse land situations, viz., degraded and barren lands... dry and drought prone area, marginal lands and alkaline soils... The plant is highly pest and disease resistant*" (p. 765)
	Cautious
Skutsch *et al.* (2011)	"*Outcomes would need to be reexamined as [the Jatropha programme] develops... In these early-adopter cases in Mexico, Jatropha does not appear to be a win–win–win wonder plant that is going to provide a profitable alternative to fossil fuels, while at the same time creating large savings in carbon emissions and providing a major new source of income for small farmers*" (p. 11)
De Jongh and Nielsen (2011)	"*Only under some circumstances Jatropha is an attractive option... The yield is lower and it takes longer to reach than assumed. However, the sturdiness of the plant and its ability to survive under extreme conditions have largely been confirmed... Where Jatropha oil is used directly in engines it has turned out to be more difficult and more costly than anticipated... More research is needed in every aspect of the Jatropha production chain... Jatropha has the potential to play an important role in alleviating poverty*" (p. 50)

Brittaine and Lutaladio (2010)	"*The expectation that Jatropha can substitute significantly for oil imports will remain unrealistic unless there is an improvement in the genetic potential of oil yields and in the production... the main pro-poor potential of Jatropha is within a strategy for the reclamation of degraded farmland along with local processing and utilization of oil in a way that can improve and diversify rural livelihoods... by providing physical barriers, Jatropha can control grazing and demarcate property boundaries while at the same time improving water retention and soil conditions*" (p. 88)
Jongschaap *et al.* (2007)	"*Jatropha has great potential and value to be exploited in its natural environment of semiarid and arid conditions in the tropics... However claims of low nutrient requirements, low water use, low labour inputs, the non existence of competition with food production, and tolerance to pests and diseases are definitely not true in combination with high oil yield production*" (p. 27)
Weyerhaeuser *et al.* (2007)	"*For Jatropha... research is a means to lower program costs and create a more viable industry in the longer term. In the near term, Jatropha development should follow the route... 'First understand, first take initial steps, first see results'*" (p. 19)
Openshaw (2000)	"*Oil for soap making is the most profitable use... The emphasis should be adjusted and moved away from [Jatropha] use as a diesel substitute or as a household cooking and illumination fuel. The focus should be switched to examining all the attributes of the plant... and to develop and expand the most profitable uses of its many products*" (p. 14)
	Negative
Lahiri, 2009	"*The promotion of Jatropha is compromising the rights of India's rural communities to access common resources, to grow their own food and feed their families ... More research is still needed to understand the potential for Jatropha but evidence suggests that it is unlikely to be viable commercially if grown in monoculture plantations*" (p. 22)
Ariza-Montobbio and Lele, 2010	*"The crop impoverishes farmers, particularly the poorer and socially backward farmers. Jatropha cultivation therefore not only fails to alleviate poverty, but its aggressive and misguided promotion will generate conflict between the state and the farmers, between different socio-economic classes and even within households. The water demands of the crop can potentially exacerbate the conflicts and competition over water access"* (p. 1)

The literature analysis outlined in Table 2.1 reveals that current knowledge on *Jatropha* is highly controversial and the claims made on its agronomic qualities are often not grounded in rigorous scientific evidence. There is a strong need to investigate and understand more, not only about the plant itself, but also its production system, as well as its alternative utilisations to enhance income generation and livelihood diversification. Adequate understanding of these factors is vital in order to develop optimal policies to fight energy poverty and promote sustainable development across dryland developing countries.

While *Jatropha* seems to offer the potential to enhance energy access and diversify livelihoods, many articles reviewed tend to favour the adoption of small-scale outgrower approaches rather than large-scale commercial activities (Achten *et al.* 2010; Dyer *et al.*, 2012). In line with observations from Hunsberger (2012), cautious or negative views on large scale activities are grounded in the following factors:

- Limited knowledge of the agronomic aspects, which hampers the capacity to generate energy and the commercial viability of large operations;
- Social and environmental risks; and
- Lack of capacity to concretely benefit smallholder farmers.

Cultivating *Jatropha* only for the purpose of producing energy is not foreseen as an option that can bring observable benefits to the farmers. Numerous authors stress the importance of involving multiple uses of *Jatropha* in its promotion (see Figure 2.5) (Openshaw, 2000; Jongschaap *et al.*, 2007; Grass, 2009). This could notably improve livelihood gains and guarantee that the plant's added value is more evenly distributed along the value chain. The majority of authors call for more research on the crop, particularly on its socio-economic impacts on smallholder farmers, before establishing large scale activities (Tomomatsu and Swallow, 2007; Weyerhaeuser *et al.*, 2007; Lahiri, 2009; Brittaine and Lutaladio, 2010; Clancy, 2008; Achten *et al.*, 2010, Jongschaap *et al.*, 2007). This research addresses these calls and provides the much needed empirical evidence of the impacts of *Jatropha* on the livelihood diversification of smallholder farmers in Mali, where household-level analysis is currently lacking.

2.4 The Sustainable Livelihoods Framework

As explored in Section 2.1.3, since the 1990s the concept of "sustainable development" has been gaining momentum within political discourse and development theory. Scoones (2009) notes that in the same period increased attention has been put on the themes of poverty reduction, sustainability and people-centred approaches. The origin of livelihoods literature is generally traced to Chambers and Conway (1992). These authors sought to theoretically shift from the typically top-down and market-oriented approaches on which development thinking has been traditionally based (Chambers, 1984, 1987, 1997) to newer approaches that emphasize the perspectives of people, with a focus on environmental and social sustainability. As defined by Chambers and Conway (1992: 6), "*A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term*".

This definition incorporates fundamental concepts from Sen (1981; 1984, 1985, 1987) on capabilities, Swift (1989) on assets, and the World Commission on Environment Development (1987) on sustainability. It is inspired by the Human Development Approach (UNDP, 1990) which arose under the influence of Sen and scholars from so-called "*household economics*", which focuses on household labour, income generation and expenditure (Guyer and Peters, 1987). The approach prioritises the enhancement of capability in terms of "*enlarging people's choices...and freedoms*" (UNDP, 1990: 10), for example by widening their capital base. Along these lines, Chambers and Conway (1992: 4) intend capability as "*being able to perform certain basic functionings, to what a person is capable of doing and being*". This notion contemplates the importance of the freedom of individuals or households to choose pathways that increase their quality of life (Sen, 1984; Chambers and Conway, 1992).

As the livelihoods literature has evolved, it has resulted in the emergence of a variety of sustainable livelihoods definitions (Hussein, 2002; de Haan and Zoomers, 2005) and adoption of a number of sustainable livelihoods approaches by international organisations (*e.g.* FAO, UNDP, World Bank, World Food Programme), bilateral development agencies (*e.g.* UK Department for International Development), NGOs (*e.g.* Oxfam and CARE) and research institutes (*e.g.* Institute of Development Studies, Overseas Development Institute,

International Institute for Sustainable Development, and International Institute for Environment and Development) (Bennett, 2010).

Chambers and Conway's sustainable livelihood definition has been expanded by Scoones (1998) and Carney (1998), who added a natural resource dimension. According to Carney (1998: 4), "*A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base*". Based on this conceptualisation, DfID developed the Sustainable Livelihoods Framework (SLF) as an analytical tool to assess sustainable livelihoods (Figure 2.8).

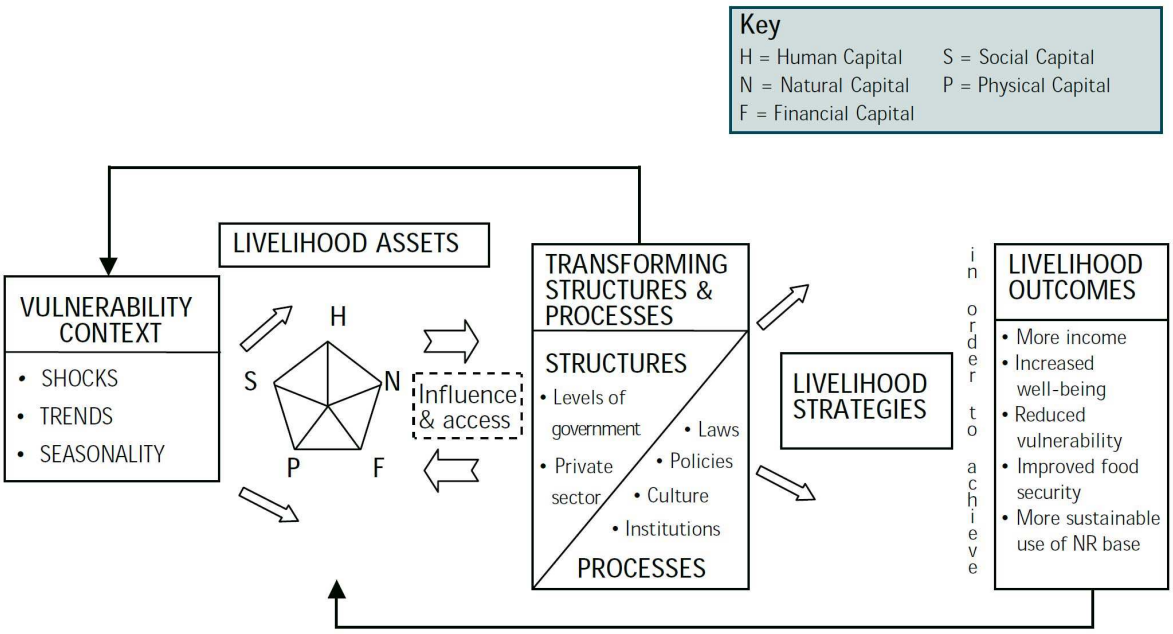

Figure 2.8: Sustainable Livelihoods Framework

Source: DFID, 1999

The SLF recognises that people rely on a range of capital assets (*i.e.* human, natural, financial, physical and social) to achieve their livelihood objectives and reduce their vulnerabilities to trends, shocks and seasonality over which households have minimum control (DFID, 1999). The capital assets are presented as a pentagon in Figure 2.9, while the vulnerability context is detailed in Table 2.2.

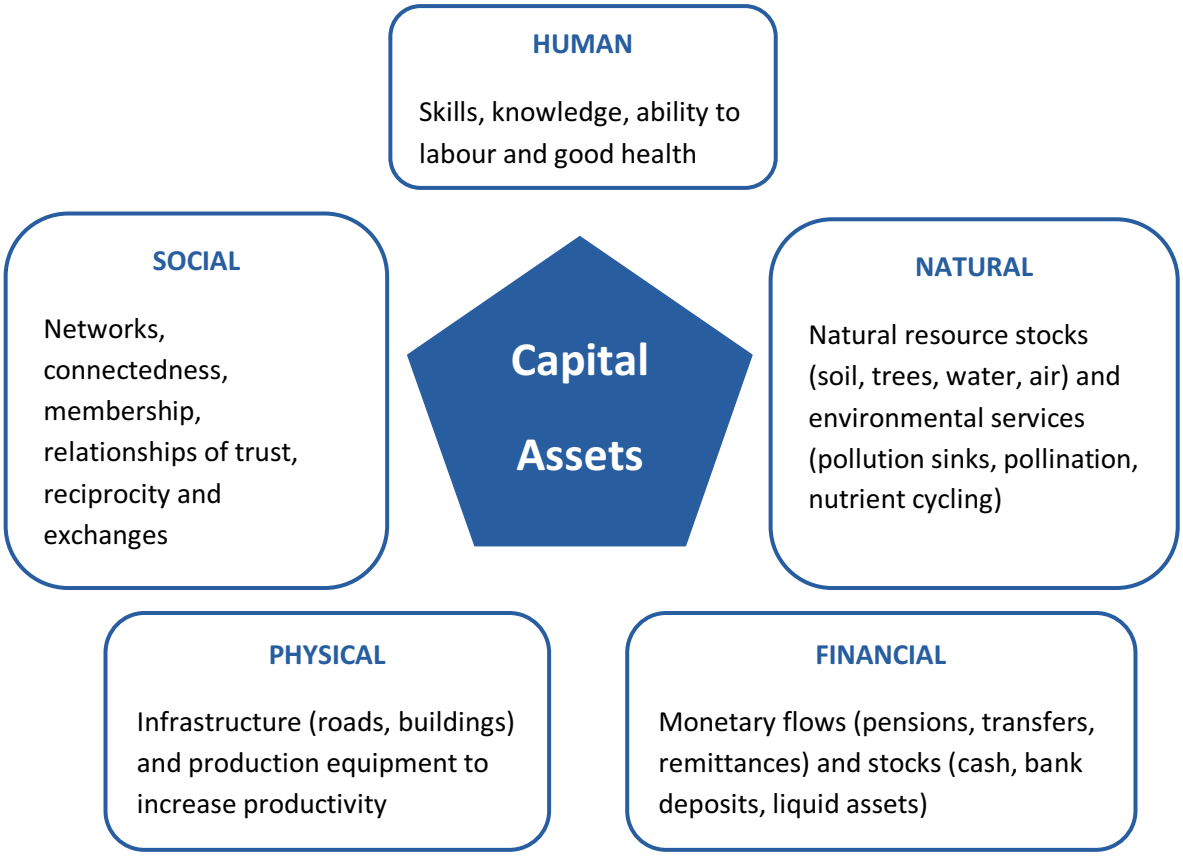

Figure 2.9: The five Capital Assets of the SLF

Source: Figure adapted from DFID (1999)

Table 2.2: The vulnerability context of the SLF

Trends	Shocks	Seasonality
• Population • Governance • Economic trends • Technological trends	• Human health shocks • Crop failure • Livestock health shocks • Economic shocks • Conflict • Environmental shocks	• Labour availability • Weather • Market prices

Source: adapted from DFID (1999)

The SLF recognises the importance of analysing the policy and institutional context within which the capital assets exist. These transforming structures and processes (which include laws, policies, governmental institutions, private sector and civil society) mediate access to assets and determine the extent to which people can meet their livelihood objectives. Livelihood outcomes can be either tangible (*e.g.* increased income and/or food security) or intangible (*e.g.* increased well-being or more sustainable use of natural resources).

DFID (1999) outline six core principles of the framework:

(i) It is people-centred as it engages directly with the people meant to benefit of an intervention or policy;
(ii) It is holistic and recognises that multiple-sectors have to be considered;
(iii) It assumes that livelihoods are dynamic rather than being static;
(iv) It builds on the analysis of strengths;
(v) It emphasises complex micro-macro links; and
(vi) It is sustainable.

A number of reviews suggest that the SLF provides a valuable analytical tool to understand the underlying causes of poverty and identify the opportunities and challenges related to livelihood improvement (Farrington *et al.*, 1999; Ashley and Carney, 1999; Scoones, 2009). Particular merits of the framework include its flexibility in allowing the use of multiple research methods (Carney *et al.*, 1999), the promotion of participatory approaches (Butler and Mazur, 2007), its ability to be used as an inter-disciplinary tool between natural and social scientists (Scoones, 2009) and its capacity to bridging micro-with macro-aspects of rural poverty reduction policies (Ellis, 2000b). The SLF has been used for project and programme design across India (Turton, 2000), for project and programme review and impact assessment in Africa (Ashley and Hussein, 2000) and even to frame energy development projects in Wales (Hinshelwood, 2003).

A major critique raised against the SLF is that it fails to explain adequately the multi-level institutional and policy aspects affecting the achievement of livelihood outcomes (Hobley, 2001; Ashley and Carney, 1999). It has been noted that the framework's vocabulary and processes are complex and often there is a need to provide additional tools and skills to complement the SLF in support of policy making (Bennett, 2010). Knutsson (2006) stresses that

the different uses of the approach may exclusively relate to production of knowledge and calls for the development of more integrated methodologies and methods. Morse *et al.* (2009) observe that while the outcome of a livelihoods approach may result in highly detailed analysis, in certain cases it may be unclear how this can be translated into policy interventions that will benefit people. Concerns have also been expressed on the framework's failures to deal with politics and rights (Hussein, 2002; Carney, 2003; Baumann, 2000) and the lack of engagement with environmental change and long-term economic processes (Scoones, 2009). It is stressed that considerable amount of time and money is required to adopt the framework in research (Farrington *et al.*, 1999), while difficulties are also found in quantifying and analysing the information gathered on the various capital assets (Ashley and Carney, 1999; Hussein, 2002).

Despite these limitations, research in dryland Africa (Dyer *et al.* 2012; Brock, 1999) and India (Vaidyanathan, 2009) shows that the SLF can be a powerful analytical tool in providing an objective assessment of the local-level impacts of biofuel projects, by integrating multiple views of different actor groups into livelihoods analysis. The framework provides understanding of the interrelationship between agriculture and the other factors that may influence livelihoods (Stringer, 2009). It may therefore be applied in research on energy crop cultivation, especially in countries where increasing areas of land are being diverted to use for biofuel crop cultivation. This research attempts to address some of the criticisms of the SLF though the use of a multi-level, multi-method analysis that better engages with those institutional and policy dimensions that are normally downgraded in the framework's application. It is the first research that systematically applies the SLF in rural Mali to provide a case study assessment of the potential for, and initial impacts of, *Jatropha* projects aimed at improving livelihoods.

2.5 Livelihood diversification in the context of biofuels promotion and agricultural development

The analysis of livelihood strategies, intended as the choices of activities that households undertake to achieve their livelihood goals, is central to the SLF (DFID, 1999). Scoones (1998) identifies three major strategies, which include: agricultural intensification/extensification, livelihood diversification and migration. Livelihood diversification is explored in the following sections as it is relevant to understanding the links between biofuel cultivation, livelihood strategies and rural development in the context of the SLF.

2.5.1 Livelihood diversification

Livelihood diversification is defined by Ellis (1998: 1) as the "*process by which rural families construct a diverse portfolio of activities and social support capabilities in order to survive and improve their standards of living*". The author makes a distinction between diversification pursued out of necessity and by choice. This results in six determinants, which include "*seasonality, risk, labour markets, credit markets, asset strategies, and coping strategies*" (Ellis, 2000a: 289). Similarly, Barrett *et al.* (2001: 1) explain that households are prompted to diversify their assets, incomes, and activities by a multitude of reasons. These include "push factors" such as risk reduction, labour availability and cost, crisis and liquidity shortages, and "pull factors" such as strategies to increase integration among activities, or specialisation due to comparative advantage of technologies, skills and endowments.

Diversification is described as a survival strategy for rural households, which allows them to decrease their vulnerability to the negative effects of shocks and seasonality (Ellis, 2000a), reducing pressure on natural resources, supporting asset building and reducing poverty (Elliot et al, 2001; Ellis & Allison, 2004). This research situates the cultivation of *Jatropha* in rural Mali within these debates by assessing the key drivers of farmers' adoption of *Jatropha* within their livelihood portfolio, as well as the actual and potential contributions that the plant offers to livelihood diversification.

2.5.2 Biofuel cultivation, agricultural development and poverty reduction

Biofuel production is often identified as a way to modernise agriculture and deliver positive impacts to local communities, for example by increasing access to new markets (Ejigu, 2008), and generating income through the introduction of new cash crops which expand rural enterprises (Brittaine and Lutaladio, 2010). The positive implications of agricultural modernisation and development for poverty reduction are numerous and small-scale *Jatropha* cultivation may play an important role in this process. DfID (2005) note that an increase in agricultural productivity, especially in the context of labour-intensive, small-scale agriculture, can generate growth in other areas and lead poor countries to prosperity. It also highlights the need to design country-specific policies that adequately support agriculture. Byerlee *et al.* (2009) show that rural poverty is most effectively reduced in those countries that experience the highest agricultural growth per worker. Juma (2011) asserts that improving Africa's

agricultural performance will improve food security and sustain the overall economic development of the continent.

Agricultural extension can play an important role in fostering agricultural and economic development (Birkhaeuser *et al.*, 1991). Davis (2008) examines the role of different models in sub-Saharan Africa and concludes that extension has significant positive effects on knowledge, adoption and productivity. An example is given by the Farmer Field Schools (FFS), which have been widely applied as extension by governments, but also by international organisations (*e.g.* FAO) and practitioners since the 1990s in roughly thirty sub-Sahara African countries (Braun *et al.*, 2006) with the aim to increase food security and promote soil and water conservation. FFS are used in Mali by the private sector and NGOs to support *Jatropha* farmers (MBSA, 2010). Similarly to the SLF, FFS promote farmers' participation and are grounded in principles of people-centred approaches to foster the improvement of the different forms of capital. In a FFS small groups of farmers meet on a weekly basis with a facilitator, from planting to harvest times, to discuss common problems and identify their own solutions. FFS activities may involve exchange visits among members of different field schools, allowing the identification of optimal practices. Ownership and responsibility are promoted throughout the decision making process (Davis, 2008). The FFS approach can be useful in the promotion of new energy crops such as *Jatropha*, where the farmers have limited knowledge on the farming techniques and much support is needed. This study considers the different forms of support provided by project developers to *Jatropha* farmers across rural Mali and identifies opportunities and challenges in project implementation.

Despite that the links between agriculture and development are well explained, empirical analysis of the impacts of biofuel cultivation on income generation, livelihood diversification and poverty reduction at village level is lacking or remains controversial and contested. This is particularly evident in the case of *Jatropha* farming, (see Section 2.3.3). Mitchell A. (2008) highlights the need to situate biofuel research within broader agricultural livelihood strategies so that resource allocation is considered. According to COMPETE (2009b), research on value-added products is needed to improve livelihood gains from biofuel cultivation. Jumbe *et al.* (2009) call for country-specific analyses of biofuel activities. This research addresses these calls by providing much needed case study evidence on the implications of *Jatropha* cultivation for rural livelihoods, with focus on the several forms of capital that households employ for

livelihood generation. Guided by the use of the SLF, agricultural strategies are assessed through farming calendars and in-depth household interviews.

2.6 Policy analysis for sustainable livelihoods

This section offers an overview of the literature that guided this research in the analysis of the policy process. The wide range of government policies in the fields of energy, environment, agriculture and rural development plays a vital role in ensuring that the biofuel sector advances sustainable development. Nevertheless, a lack of policies targeted at supporting biofuel development has been observed by various authors. This gap is particularly relevant to the African continent, which according to Smeets *et al*. (2007) will have the largest potential for bio-energy production worldwide by 2050, as long as appropriate agricultural technologies and policies are in place. Jumbe *et al.* (2009) observe that the amount of sub-Saharan African countries that include biofuel policies in national development programmes remains limited. Amigun *et al.* (2011) stress that where the biofuel policy exists, it often lacks adequate implementation strategies and institutional frameworks. This view is supported by Jumbe *et al.* (2009: 4985) who stress the urgency for African countries to take "*bold steps*" towards the adoption of a policy framework that regulates the development of the biofuel sector.

Grounded in the SLF, this research advances the understanding of how biofuel-related policy (with a special focus on *Jatropha*) is designed and implemented to reduce energy poverty and sustain rural livelihoods in Mali. While it is demonstrated that the framework offers the potential to connect local realities (micro level) to the macro-level (Carney, 1998; Shankland, 2000), as described in Section 2.4, criticisms are raised regarding the SLF's lack of capacity to offer relevant policy recommendations that are grounded in local-level insights. Excessively detailed findings that reflect local complexities are difficult for policy makers to digest (Brock, 1999). However, Booth *et al.* (1998) stress the importance for policies to consider the heterogeneity of local conditions through the use of case studies, even if these cannot be representative of a large share of population from a statistical point of view.

This research addresses these limitations by adopting a mixed-method, multi-level approach which combines the use of participatory methods aimed at livelihood analysis with conventional policy analysis literature and stakeholder analysis (Shankland, 2000). It targets calls from Cotula *et al.* (2008) to provide an improved understanding of biofuels based on a debate that is more balanced and evidence-based. Table 2.3 outlines the key questions

addressed by this research in the analysis of *Jatropha*-related polices for sustainable livelihoods.

Table 2.3: Key questions in the analysis of polices for sustainable livelihoods

Livelihood priorities • Who are the Malian *Jatropha* farmers? • What are their livelihood priorities? • What policy sectors are relevant to these priorities?
The policy context • What policies and national strategies can be found in the relevant policy sectors? • Who are the stakeholders in charge of policy elaboration?
Policy measures • What measures have been put in place to implement policy? • Who are the stakeholders involved with policy implementation?
Policy in the local context • What institutions affect local responses to policy? • What opportunities exist for rural people to influence policy?

Source: Adapted from Shankland (2000: 22)

2.6.1 Defining key concepts of policy analysis

The promotion of biofuels is dominated by a combination of political, practical and socio-cultural forces. Objective 3 of this research aims to evaluate the drivers and barriers to the achievement of policy goals (with a focus on *Jatropha* development) and better link policy to the realities of local practice. It is therefore essential to clarify the concepts underlying this analysis, such as "development discourse", "policy narrative", "policy gap", "policy outcome"

and "discourse analysis". These concepts are addressed by a variety of theoretical approaches, which include political ecology, political science, sociology and anthropology.

A development discourse is a way of thinking grounded in a system of values or configuration of ideas that excludes other possible ways of thinking (Sutton, 1999). Hajer (1995: 44) defines discourse as the "*ensemble of ideas, concepts, and categorisations that are produced, reproduced, and transformed in a particular set of practices*". Various discourses can be found in the policy process, prescribing actions that should be taken "*in the name of development*" (Apthorpe, 1986: 377). Referring to policy making, Grillo (1997: 12) states that "*discourses identify appropriate and legitimate ways of practising development as well as speaking and thinking about it*".

A policy narrative is a "*story*" which attempts to simplify complex issues and development processes (Roe, 1994: 3). It aims to reduce the ambiguity of the overall problem and provide policy makers with a solution which will be likely to generate action (*ibid*). Sutton (1999) notes that narratives can be part of a broader discourse when they describe specific stories which are in line with the set of values of a discourse.

Outcomes are understood as the achieved effect that policy has in terms of producing the desired change initially sought (Theodoulou and Kofinis, 2004). Policy gaps are defined by Jordan (1999: 70) as differences "*between the stated aims of policies and their practical impact on the ground*". A gap occurs when a policy statement is not turned "*into action*" (Jordan, 1999: 70) that meets the original policy goals on the ground. These gaps can be identified using conceptual frameworks (grounded in the disciplines outlined above) of discourse analysis (Apthorpe, 1996; Hajer, 2006) and policy outcome analysis (Theodoulou and Kofinis, 2004). Discourse analysis attempts to "*understand, break down and deconstruct discourses*" in order to understand the perspective that they bring to the development process (Sutton, 1999: 14). According to Hajer (2006: 69), the actions of different stakeholders including institutions, private sector, academia and media are combined in discourse-coalitions which share a set of simplified narratives – "*story-lines*" – to give meaning to wide and complex debates. These story-lines are subsequently "*institutionalised*" or translated into policy documents (*ibid*: 70).

Discourse analysis has been widely used in political ecology to analyse concepts of environmental change and crisis. Post-structuralist political ecologists stress that development

discourses are often based on shared blueprints of the world, defined as "*myths, ideologies, conventional wisdoms or fads*" (Roe, 1991: 287), rather than relying on more site-specific learning (Adger *et al.* 2001). The use of blueprint discourses depicting "*crisis*" images has been adopted by a broad public which includes the scientific community and media (Leach and Mearns 1996: 2; Thomas and Middleton 1994). Bernstein and Woodhouse (2001: 283) criticise the use of environmental "*crisis*" narratives to explain patterns of environmental change in the African context and suggest "*telling environmental change like it is*". Adams (2001) analyses the concept of green development within the sustainable development discourse and stresses that traditional conservation measures are based on a narrow view of the links between environment and development. In a study of deforestation in West Africa, Fairhead and Leach (1998) stress that the problems formulated in development policy are often in contrast with local-level perspectives, noting how "*demonstrably false ideas about environmental change have come to acquire validity in policy circles*". In an earlier publication (1997), the two authors describe how a misinterpretation of the reasons driving forest change in Guinea led to the adoption of inappropriate solutions. Similarly, Forsyth (2003: 24) observes that "*environmental orthodoxies*" are often not correspondent with local realities. On the topic of natural resource management, Woodhouse (2002: 2) critically examines the "*small farmer*" model underpinning most rural development policies aimed at poverty reduction in sub-Saharan Africa. The author argues that such a model "*does not correspond to many of the processes of change observed in rural areas*" and concludes that "*poverty is better understood through an analysis of the dynamics of agrarian change, in which a historical perspective and an appreciation of population mobility are key elements*" (*ibid*: 19). Various political ecology frameworks have been used by Ariza-Montobbio and Lele (2010) to analyse the impacts of *Jatropha* cultivation in India. These authors analysed and deconstructed the discourse surrounding the crop and concluded that the approach for smallholders was incongruent and that the plant is not "pro-poor" and "pro-wasteland" as depicted.

This research uses discourse analysis to analyse the *Jatropha* narrative in Mali and the drivers of its institutionalisation in the policy discourse. It sets out to show how the use of conventional policy analysis frameworks can be combined with local level livelihood studies to overcome major limits of the SLF towards the identification of a sustainable path for biofuel development.

2.7 Summary

Ensuring access to energy is vital in advancing socio-economic and environmental development. Biofuels such as *Jatropha* represent one route towards renewable energy, agricultural development and livelihood diversification, particularly in developing countries such as Mali. Biofuels nevertheless remain controversial and major questions surround their capacity to deliver sustainable outcomes and enhance livelihoods. This chapter has outlined the research gaps in the literature (focused on the themes of energy for development, biofuels sustainability, *Jatropha* cultivation and use, livelihood diversification and agricultural development) and how this study contributes towards them. The SLF is presented as an appropriate analytical framework to provide a case study assessment of the potential for, and initial impacts of, *Jatropha* projects aimed at improving livelihoods in sub-Saharan Africa. This research expands the SLF by adopting a mixed-method, multi-level approach which combines the use of participatory methods aimed at livelihood analysis with conventional policy analysis literature and stakeholder analysis. The relevant literature on discourse analysis and policy implementation and impact analysis has been explored. The following chapter moves on to outline the research design, framework and methodology used in the research process.

Chapter 3

Research design, framework and methodology

"*Knowing what you want to find out leads inexorably to the question of how you will get that information*"

(Miles and Huberman, 1984: 42)

Outline

This chapter outlines the research design that guided the mixed-method, multi-level data collection and analysis used in the achievement of the research objectives outlined in Chapter 1. Justification for selection of Mali as a case study is provided, together with an outline of the field site selection and sample design. The research design is linked to the range of methods adopted. Guided by the SLF and incorporating elements of ethnographic and Grounded Theory styles of approaches to data collection, the combination of conventional social science and participatory methods employed is described. The advantages and weaknesses of each approach are highlighted. Research ethics are also discussed, together with positionality considerations associated with undertaking such development research in a foreign language and setting.

3.1 Case study and field site selection

This section outlines why Mali was selected as a case study focus for the research and justifies the field site selection. Information on country background, socio-economic development, energy context, climatic and environmental setting is provided.

3.1.1 Country background

Mali is a land-locked West African country located between 17° 00' North latitude and 4° 00' West longitude. It covers an area of 1.24 million km^2 and is bordered by Mauritania, Algeria,

Niger, Burkina Faso, Côte d'Ivoire, Guinea and Senegal (Figure 3.1). It consists of the capital district of Bamako and eight regions (Sikasso, Kayes, Mopti, Timbuktu, Segou, Koulikoro, Kidal and Gao) which are subdivided into 49 "*cercles*" (circles), the second level administrative units. The circles and the district are subdivided into 703 communes, of which 36 are urban (GoM, 1999). Mali consistently sits amongst the lowest countries on the Human Development Index (HDI), ranking 175th out of 197 countries in 2011 (UNDP, 2011a), and is considered a Least Developed Country. Growing population is a major concern that places pressures on food and energy production. In 2010 Mali was ranked 13th in terms of population growth rates in a list of 196 countries, reaching an average annual rate of +3.1% in the period 2005-2010 (UNDESA, 2011). Agriculture accounts for 80% of the labour force (CIA, 2013). Almost 70% of Malians live in rural areas (AfDB *et al.*, 2012) and roughly 90% of the population is concentrated on 30% of the territory in the southern regions of Kayes, Koulikoro, Sikasso, Segou and Mopti (Wong *et al.*, 2005).

Figure 3.1: Location of Mali

Source: Department of Peacekeeping Operations, Map No. 4231. United Nations. 2004.

In March 2012 (after the field research for this study was completed), Mali experienced a *coup d'état* following which a group of Tuareg separatist rebels (supported by the Al-Qaeda Organisation in the Islamic Maghreb) took the control of the northern half of the country. On April 2012, independence of northern Mali as "Azawad" was proclaimed (AfDB *et al.*, 2012). In early 2013 the north was recaptured under the guidance of French troops supported by a regional African force. After a peace accord between the Tuareg nationalist rebels and the government was signed in June 2013, a new president was elected in August 2013. The current political instability faced by the country might have an impact on the institutional and regulatory frameworks studied in this research (see Chapter 4). However, as described in Section 3.2.4, Mali provides a useful country context in which to explore the challenges and opportunities associated with *Jatropha* and the lessons learnt through this research remain widely applicable to the sub-Saharan African countries that are committed to the development of sustainable biofuels.

3.1.2 The energy context

Major challenges faced by the energy sector hamper the socio-economic development of Mali and can be summarised as follows:

(i) *High dependence on imported oil*. Petroleum is not produced in the country and refineries are totally absent. Energy dependency increases Malian vulnerability to the high volatility of oil prices and external shocks in the petroleum supply countries (WB and GoM, 2011). The large scale production of *Jatropha* oil is seen by several African governments as a solution to partially substitute national fossil fuel consumption and enhance energy independence;

(ii) *Energy mix dominated by traditional biomass sources*. Wood, charcoal and vegetation residue account for 73% of Mali's energy mix, followed by petroleum products (22%) and electricity (5%) (GoM, 2009). Renewable energies account for 1% of total energy production. The volume of biomass for energy used in the country encourages the overexploitation of forestry resources (Maiga *et al.*, 2008) and is 60% above the African average (GoM, 2009). It is evident that growing energy needs cannot be met by fuelwood, particularly in light of the major environmental problems faced by the country (see Section 3.2.3). *Jatropha* offers an alternative energy source to replace traditional biomass and reduce negative environmental trends.

(iii) *Electrification rates are still very low*. Access to electricity is estimated at 58% in urban areas and 11% in rural areas (GoM, 2009). According to COMPETE (2009a), 99% of the rural population lacks modern energy services. Energy poverty constrains the achievement of various socio-economic dimensions of development (see Chapter 1). The introduction of alternative energy sources such as *Jatropha* could generate potential synergies between improved energy access, the development of economic activities and job creation.

The Malian 2007-2011 Poverty Reduction and Growth Strategy Paper (GoM, 2006b) considered energy as a key support sector for the development of the country. The features described here make Mali an ideal case study country in which to investigate the contribution of biofuels to the fight against energy poverty. Such findings are widely relevant to other sub-Saharan African countries that face similar problems.

3.1.3 Major climatic and environmental challenges

Mali faces increasing pressure on natural resources caused by a variety of factors, including (i) a growing population, (ii) a declining amount, and increased intensity, of rainfall, and (iii) delays in the rainy season (GoM 2012; GoM 2007; IPCC, 2007b). Prolonged dry spells favour land degradation processes, increase the risk of desertification and severely disrupt the cropping schedule (Lutz *et al.*, 1998). According to COMPETE (2008), only 3.76% of the country's total area is arable farmland. Pressures such as deforestation and desertification combined with the growing scarcity and degradation of natural resources favours the emergence of problems such as reduced soil fertility and high susceptibility to soil erosion (COMPETE 2008; GoM 2012, 1998; IPCC 2007a). The Malian National Adaptation Programme of Action on Climate Change (NAPA) (GoM, 2007) highlights that these environmental challenges mainly affect the agriculture and energy sectors. As discussed in Chapter 2, *Jatropha* might play an important role in coping with these threats in two ways, by: (i) reducing fuelwood dependence when used as an alternative energy source, and (ii) reducing land degradation and desertification when used as a living fence.

3.1.4 Why Mali?

In light of the major environmental and socio-economic challenges related to international biofuels expansion identified in Chapter 2, Mali is considered an appropriate case study country for this research because:

(i) It has a high profile in biofuel literature debates and has received growing attention from the international community (Gilbert, 2011; Palliere and Fauveaud, 2009; Practical Action Consulting, 2009);

(ii) It is one of the pioneers among dryland sub-Saharan countries in the promotion of *Jatropha* cultivation and its use as fuel. Indeed, *Jatropha* development is prioritised by several national policies (see Chapter 4). Mali was one of the first West African countries to experiment with the use of *Jatropha* oil as a biofuel during the early-1990s. Through UNDP and government support it hosted the first Multifunctional Platform (MFP), a source of mechanical and electrical energy provided by a diesel engine that can be run on pure *Jatropha* oil, in sub-Saharan Africa. As of 2011, roughly 1,000 MFPs are installed in the country (UNDP, 2012);

(iii) The potential of *Jatropha* energy for livelihood diversification in West-Africa, and specifically Mali, is of particular interest more widely across the globe. This is due to the extent of pilot activities and rural electrification schemes that have been supported across the country over the last decade by various institutional actors (*i.e.* Malian Agency for Household Energy and Rural Electrification (AMADER) and UNDP) as well as Decentralised Service Companies (SSD) (*i.e.* Yeelen Kura), NGOs (*i.e.* Mali-Folkecenter Nyetaa (MFC) and Groupe Energies Renouvelables (GERES)) and the private sector (*i.e.* The *Jatropha* Mali Initiative (JMI) and Malibiocarburant SA). Lessons from Mali could inform the adaptation and transfer of successful approaches and practices to other countries and contexts.

3.1.5 Field site selection

Field site selection was guided by the presence of major pilot *Jatropha* activities in the country. Given the variability among these activities in terms of objectives and structure, it is desirable to conduct research in different areas to gain a broader picture of the livelihood strategies being employed. Using a case study approach (Yin, 2009) and informed by the research activities undertaken during a scoping visit (see Section 3.4.1), three farming communities in

southern Mali were selected. These are located in the provinces of Kita (13° 04' N, 9° 29' W), Kayes region; Garalo (11° 0' N, 7° 25' W) and Koury (13° 1' N, 5° 31' W), Sikasso region (Figure 3.2). Each community is covered by a different pilot activity, namely: MFC, JMI and GERES.

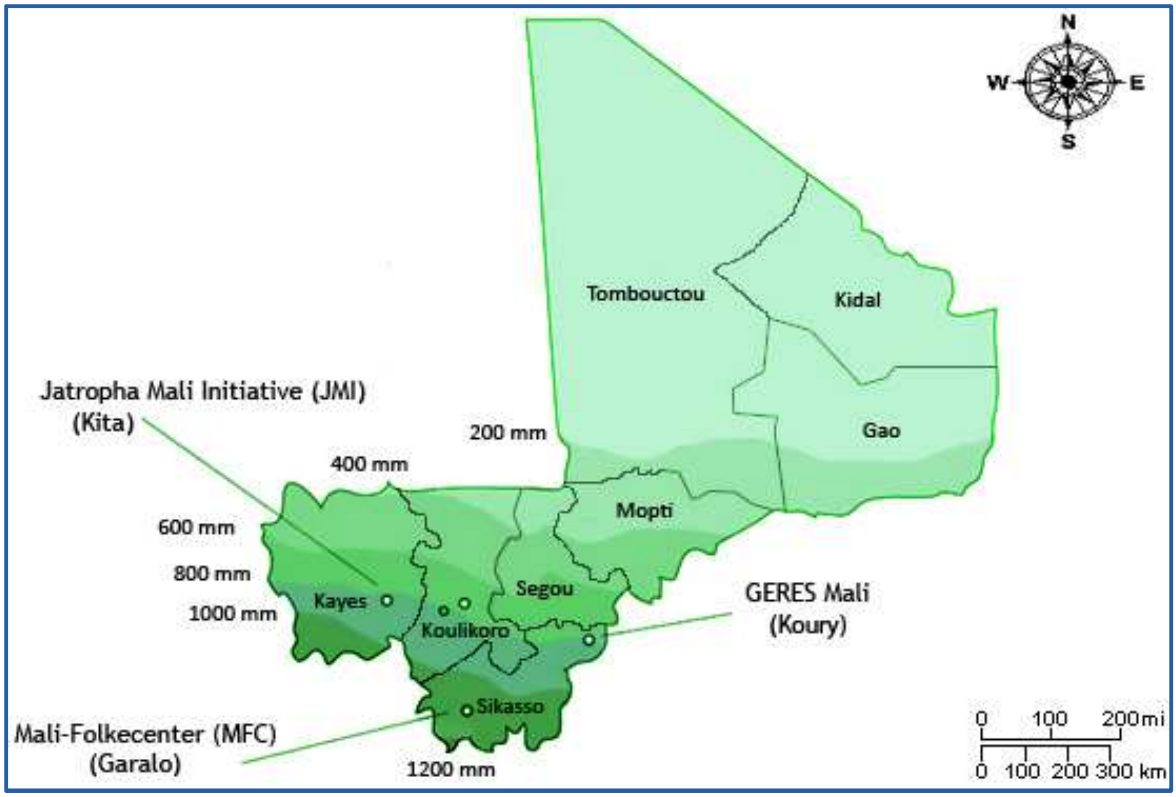

Figure 3.2: Location of the selected study areas and annual rainfall patterns (1971-2000)

Source: rainfall data integrated from GoM (2007)

These farming communities were selected for the following reasons:

(i) They are located in the regions where agro-ecological conditions are most suitable for *Jatropha* cultivation (Holl *et al.* 2007; FACT, 2010). In these areas, annual rainfall patterns range from 800 mm to 1,000 mm (GoM, 2007) (Figure 3.2);

(ii) Population densities and poverty are high: roughly 90% of the population is concentrated on 30% of the territory in the south and the incidence of poverty exceeds 60% (Wong *et al.*, 2005);

(iii) The country's three main pilot activities aimed at establishing local supply chains of pure *Jatropha* oil are taking place here. These include one of the most widely discussed examples of *Jatropha* rural electrification projects in the international arena (Gilbert, 2011; Practical Action Consulting, 2009). In the area surrounding

these projects, households and communities are currently relying to varying degrees on *Jatropha* farming and an increasing number of communities are expected to be involved in *Jatropha* cultivation in the future;

(iv) The different pilot activities are covered by different types of stakeholder: private sector enterprise (JMI) and development NGO (MFC and GERES). This allows diversity in sampling to be explored in order to unravel different causal conditions connected to different outcomes (Ragin, 1994).

3.1.6 Village selection

Fourteen study villages within the three farming communities were selected in consultation with the directors and general staff of the three different pilot *Jatropha* activities (*i.e.* JMI, MFC and GERES), based on the following criteria:

- Status of *Jatropha* operations: smallholders started planting in 2008. Despite this, activities are still in their initial stage. Three-years of maturity allows the assessment of the initial livelihood outcomes and estimation of future developments;
- Level of project involvement and extent of cultivation: villages where the (i) largest number of *Jatropha* farmers and (ii) most extensive cultivated areas are located.

Lists of *Jatropha* farmers, information on their performance and local maps shared by these organisations (see Figure 3.3) informed the identification of suitable case study villages. The final consideration in village selection was to achieve a total of thirty in-depth interviews with key informants. Considering the fieldwork timeframe, this was considered a feasible amount of interviews that would allow the production of significant data to meet research objectives 2 and 3. Final selection of 14 villages was mainly due to the fact that suitable case study households were found to be scattered. Indeed, while the lists of farmers provided by the organisations might declare large numbers of *Jatropha growers* in certain areas (sometimes up to 30), it was commonly found that only a minority of these farmers were successfully growing *Jatropha* as of 2011.

Issues of "research fatigue" (where respondents are tired of responding to same type of questionnaires, find the questions irrelevant or perceive that "nothing changes") have been widely explored in literature (Clark, 2008; Finau *et al.*, 2011). In light of these considerations, it was decided to avoid some of the most easy-to-access areas where the majority of national as

well as international research activities have been intensively carried out since 2008 by the project organisations and academia. It is understandable that the farmers in these areas might be tired of dedicating additional time to interviews that address further questions on *Jatropha* developments without getting concrete and immediate benefits. In some cases, this led to selection of isolated villages. As a result, the overall data provided by the selected *Jatropha* cultivators allowed a deep understanding to be gained, not only of the different impacts and perspectives among project organisations, but also among different villages working with the same organisation.

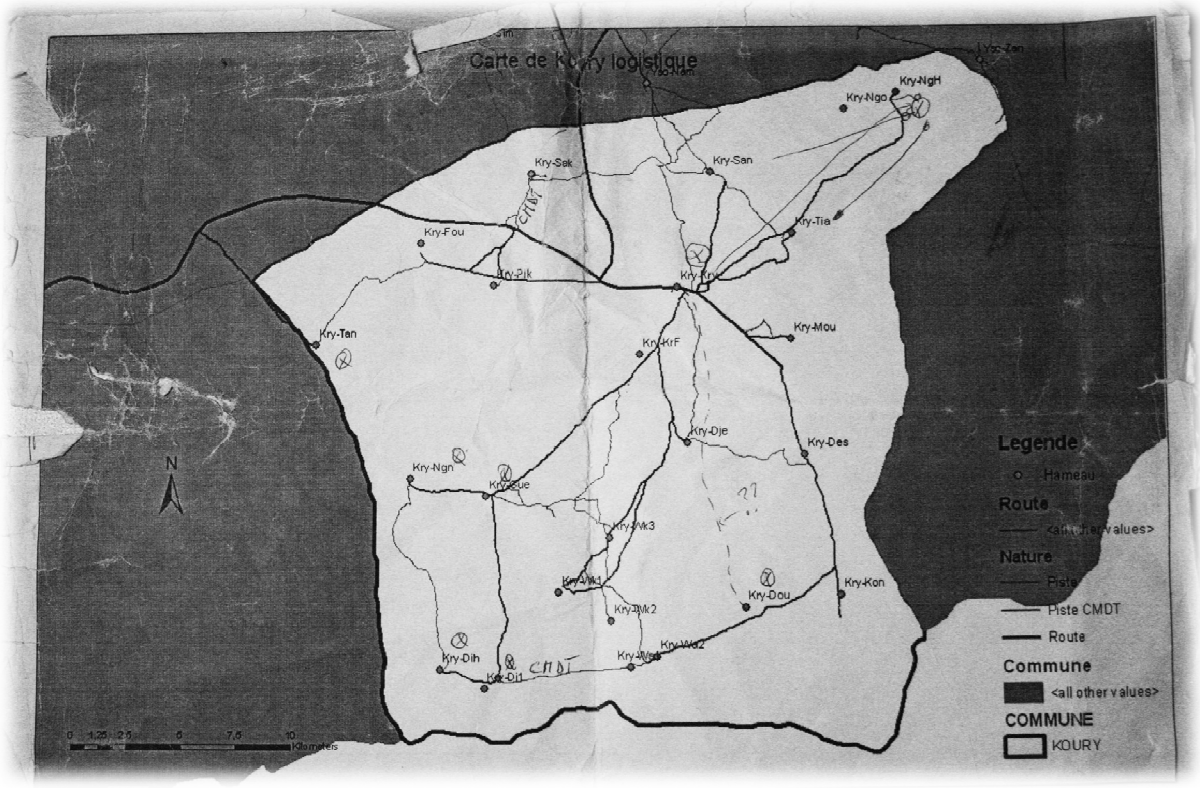

Figure 3.3: Example of map provided by a case study organisation to support study site selection

Source: JMI, Kita, 2011.

3.2 Research design

This section presents the different stages of the integrated research design developed in this research. It outlines the research approaches and multiple methods used to collect the empirical data at different levels of analysis, guided by the SLF and incorporating elements of ethnographic and Grounded Theory styles of approaches.

3.2.1 Overview of research design

The research process was divided into five stages (Figure 3.4). The first two stages were carried out during the first year. Stage one involved: (i) a review of the relevant literature on biofuels and rural development with particular focus on *Jatropha*, (ii) selection of the case study country, and (iii) elaboration of preliminary research questions in preparation for field season one. The second stage involved an exploratory scoping study in Mali, the aims and outcomes of which are outlined in Section 3.4.1. During stage three, findings and observations from the scoping study were analysed and used to: (i) outline feasible research questions and objectives, (ii) select study areas, and (iii) prepare for the main field season. The main field season was carried out during stage four, and involved expert interviews and a detailed livelihoods assessment in rural regions of Mali, with particular focus on *Jatropha* and its role in livelihood diversification. Stage five involved transcription, household case study data analysis, stakeholder and policy analysis, triangulation, writing up of the PhD thesis and the dissemination of research findings.

The methods and data collection techniques used at each stage of the research, together with their merits and drawbacks, are described in detail in Section 3.4.

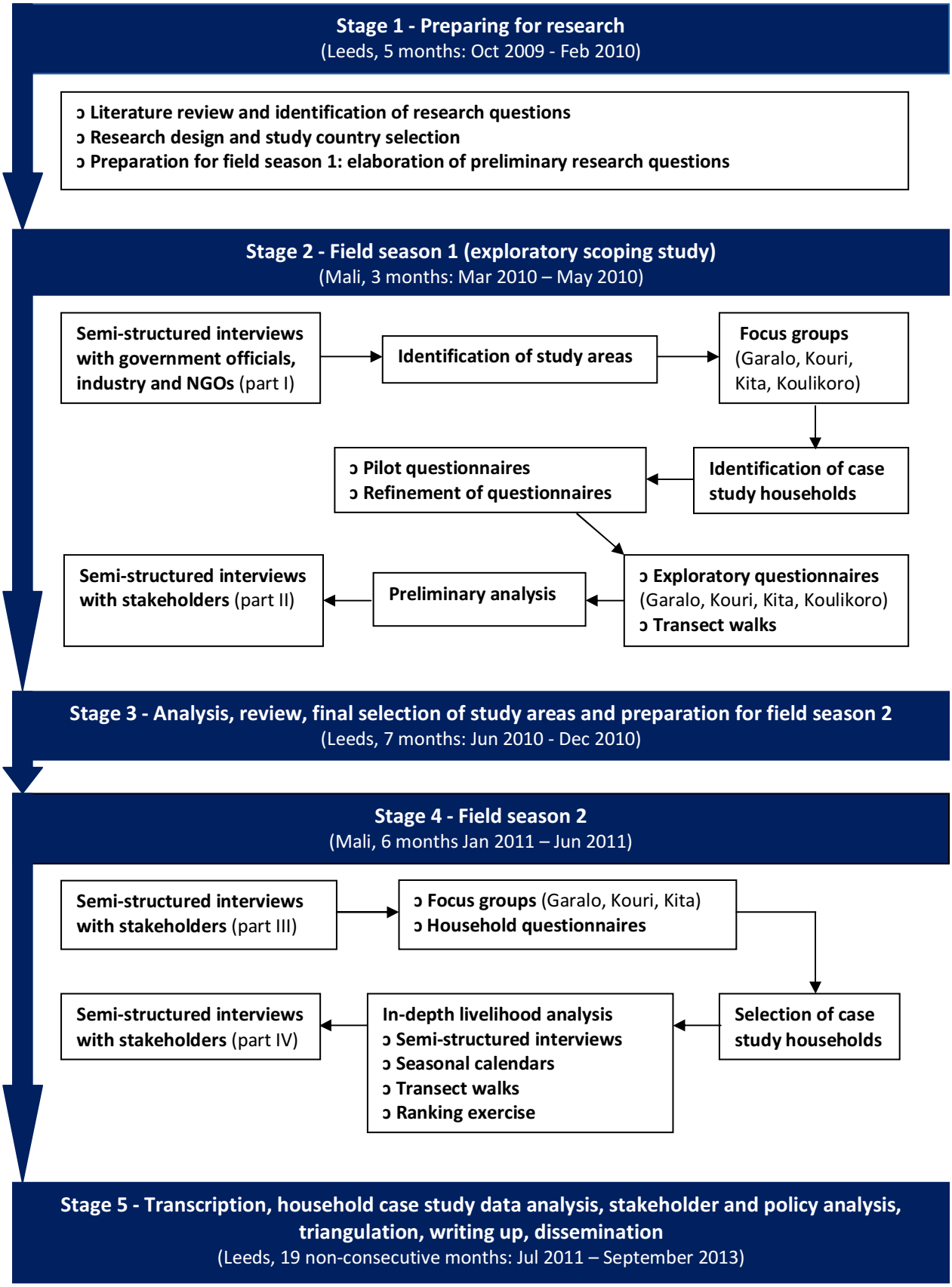

Figure 3.4: Research design stages

3.2.2 Research approaches and methodology

Elements of various approaches are incorporated in the research design to allow achievement of the research objectives, including stakeholder analysis, policy and discourse analysis, Sustainable Livelihood Approaches, ethnography and Grounded Theory. Such varied approaches are important as this study spans political dimensions of sustainable development and people-centred livelihood assessments in relation to *Jatropha* cultivation, inherently demanding the use of mixed methods and approaches (McKendrick, 2010).

This research followed an iterative approach of data acquisition (Dey, 1999) which took place over a three-year and 8 month period (October 2009 – June 2013) and involved two field seasons. In the achievement of objective one ("*Identify and analyse the stakeholders and policies concerned with biofuels in Mali taking into account policy motivations for prioritising Jatropha*"), stakeholders' responsibilities and relationships were investigated using stakeholder analysis (Turcksin *et al.*, 2011). "Stakeholders" are the individuals or groups who are affected by (either positively or negatively) or can affect the decisions taken in the country's energy policy context in the development of a *Jatropha* supply chain (Reed *et al.*, 2009). Initial stakeholder identification at different levels of action (*i.e.* national, industry / NGO and village) and identification of relevant policies in the sectors where *Jatropha* development has cross-cutting relevance (*i.e.* energy, agriculture, rural development and environment) was carried out through desk-based documentary analysis during stage one of the research, and semi-structured interviews during field season one (see Section 3.4.1 for details on the exploratory scoping visit). An ongoing process of identifying stakeholders with a potential interest in *Jatropha* in Mali and relevant policies continued throughout the research. Using a snowball sampling technique, stakeholder and policy lists were expanded as long as more interviews were conducted and names of other contacts were provided.

Policy documents were analysed drawing on explanatory dimensions from the conceptual frameworks of discourse analysis (Hajer, 1995, 2006; Hajer et al, 2005, Apthorpe, 1986; Gasper and Apthorpe, 1996) and policy implementation and impact analysis (Theodoulou and Kofinis, 2004; Knill *et al.*, 2007; Shankland, 2000; Weale, 1992) (See Section 2.7.1). The discourse was coded and deconstructed and the information summarised into matrices entered into Microsoft Word 2007 to identify key themes and categories linked to the socio-economic and environmental problems tackled by these documents (Apthorpe, 1996). Discourse analysis allowed research question two of objective one ("*What are the policy goals concerned with*

biofuels in Mali and why is Jatropha prioritised in the NSBD?") to be addressed, by assessing the: (i) international environmental, energy and development commitments of Mali, (ii) political, economic and cultural factors that influence the formulation of Malian biofuels policy, (iii) reasons for prioritising *Jatropha* in the national strategy; and (v) main policy goals, at national and local scale, that policymakers aim to achieve through the promotion of *Jatropha*.

In the achievement of objective two ("*Undertake a livelihoods analysis with focus on Jatropha at household level in rural Mali, exploring its role in livelihood diversification and its potential to contribute towards rural development*"), an exploratory study was undertaken in field season one following a case study methodology in which a small number of case study organisations and households were selected as the focus of empirical data collection (Yin, 2009). This was followed by a second field season which involved a detailed livelihoods assessment. Case study data was gathered by using multiple sources of evidence through household questionnaires and a variety of participatory methods identified from the SLA literature (see Chapter 2, Section 2.5). These include focus groups, ranking exercises, semi-structured interviews, informal conversational interviewing, seasonal calendars, transect walks and visual recording through photos (Creswell, 2007). This allowed the generation of rich information on the livelihood goals and strategies pursued by the farming communities involved with *Jatropha* cultivation, as well as assessment of the emphasis that *Jatropha* growers place on different livelihood outcomes and the main constraints faced in the achievement of national policy goals at the local level.

Incorporation of ethnographic and Grounded Theory styles of approaches to data collection, which according to Matthews (2010: 135) "*follow a case study design*", permitted the integration of lived experience and socio-cultural patterns. In order to assess household level perspectives of *Jatropha* uptake and key livelihood challenges, the researcher engaged with the respondents in their everyday lives with the aim of empathising with them and building a trusting relationship that would allow a genuine understanding of the participant's perspective (Kitchin and Tate, 2000). At a basic level, the research methods come before the theory (*ibid*). The interview and transect walk notes were partly analysed as they were collected to identify emerging issues for field discussions and as themes for semi-structured interviews. Analysis was carried out by coding and comparing data through the writing of analytic notes called memos (Charmaz, 2006). Such an approach to data collection relies on the inductive ability of

the researcher and influences the way further data is collected in light of emerging issues (Matthews, 2010).

After completion of field season two, the data generated by all research methods were analysed by: (i) reviewing the research questions, (ii) categorising the information through tables and matrixes to highlight similarities and contrasts, (iii) carrying out numerical calculations and creating graphs, and (iv) integrating and synthesising the findings (Slocum, 2005). Policy outcome analysis guided the integration of the multi-level results from interviews and livelihood assessments, allowing identification of implementation gaps (objective three, "*Evaluate the drivers and barriers to the achievement of policy goals in relation to rural development and energy security, proposing policy recommendations and ways forward that better link the realities of policy and local practice*").

The use of mixed-methods gave the researcher the opportunity to offset the biases or weaknesses of a single method (Creswell, 2009), and allowed cross-checking and triangulation of data in the field (Kumar, S. 2002). It also provided a more comprehensive evidence base by generating complementary data that could be brought together in order to enrich, expand, clarify, or illustrate the studied issue (McKendrick, 2010). Also, as observed by Glaser *et al.* (1967), the use of constant comparative methods at each stage of analysis is one of the defining components of the Grounded Theory style approach that was adopted in this study.

The studied topic unfolds across multiple levels of analysis and, ultimately, unpacking the varied and interlinked aspects of rural livelihoods within the Malian energy policy context required multi-level thinking (Termeer *et al.*, 2010). This research aims to understand local realities of *Jatropha* development not only in terms of individual characteristics, but also in terms of the connection to the level at which policies are formulated in order to change these realities (Lawrence, 2005). The use of mixed-methods, guided by the adoption of a Sustainable Livelihoods Approach, enhanced understanding of the research topic at multiple scales of analysis, linking the “micro” to the “macro” (Easterling *et al.*, 2004).

3.3 Primary data collection

A detailed explanation of the purpose, sample selection techniques, advantages and disadvantages of each method used during the research is provided in this section. Primary data collected at all levels of analysis in each field season is summarised in Table 3.1.

Table 3.1: Primary data collected and levels of analysis in each field season

Data	Participants and scales of data collection		Total quantity
	Field season 1 March 2010 – May 2010	**Field season 2** January 2011 – June 2011	
Semi-structured interviews	**National level** • UNDP Senior representatives and staff (*i.e.* Environment Programme Adviser and National energy consultant) • ANADEB Senior representatives • IER Former Director of the *Jatropha* national research Programme and Research Officer • DNA Agricultural engineer • CNESOLER Responsible for the *Jatropha* electrification project • AMADER Officer in charge of rural electrification • AfD Research Officer **Industry and NGO level** • Malibiocarburant SA Senior representatives • 2 women employed in the Malibiocarburant SA soap production unit • JMI Senior representative • ACCESS power company Senior representative • MFC Senior representative and agronomists • GERES NGO Senior representative	**National level** • ANADEB Senior representatives and staff • IPR Researcher in charge of agricultural research • DNA Focal Point for the project "Development of a *Jatropha* supply chain in Mali" • IER Scientific Coordinator of Forestry Resources • API Mali Official **Industry and NGO level** • Malibiocarburant SA Senior representative • JMI Senior representatives and staff (*i.e.* agronomist) • MFC Senior representatives and staff (*i.e.* agronomist) • GERES NGO staff (*i.e.* agronomists) • ACCESS power company Senior representative	n=76 interviews in total: • National level (macro): 18 • Industry and NGO level (meso): 20 • Village level (micro): 38

	• Teriya Bugu *Jatropha* project manager • OXFAM Director of the Cotton Programme **Village level** • Senior representative of the Union of the *Jatropha* farmers of Koulikoro • 5 women involved in household soap production from *Jatropha* feedstock • 4 Multifunctional Platform women associations	**Village level** • Senior representative of the *Jatropha* farmers' cooperative of Garalo • 14 interviews with village chiefs (one in each visited village) in the communes of Garalo, Kouri and Kita • 7 in-depth interviews with women involved in household soap production from *Jatropha* feedstock in the communes of Garalo, Kouri and Kita • 10 interviews with non-adopters of *Jatropha* in the communes of Garalo, Kouri and Kita	
Exploratory questionnaires	40 households located in 17 villages distributed in the communes[3] of Garalo (n=10), Kouri (n=10), Kita (n=10) and Koulikoro (n=10)	80 households located in 14 villages distributed in the communes of Garalo (n=30), Kouri (n=25) and Kita (n=25). The first 10 questionnaires were carried out in full and the remaining 70 in a shortened version. Seven households (short questionnaires participants) overlapped with participants from field season 1.	Household level (micro): 120 (n=50 full, n=70 shortened)
Focus groups	17 (one in each visited village) in the communes of Garalo, Kouri, Kita and Koulikoro	14 (one in each visited village) in the communes of Garalo, Kouri and Kita	Village level (micro): 31
In-depth livelihood analysis[4]		30 households located in 14 villages in the communes of Garalo, Kouri and Kita	Household level (micro): 30 (n=10/commune)

[3] The hierarchy of "communes" is explained in Section 3.1.1.

[4] In-depth livelihood analysis includes semi-structured interviews, seasonal calendars, transect walks and ranking exercises.

3.3.1 Scoping fieldwork

Scoping fieldwork was carried out between March and May 2010 with the following objectives:

- Identifying the actors involved and investigating the major issues in the supply and demand sides of the Malian *Jatropha* sector;
- Gaining a preliminary understanding of farmers' perceptions as regards their involvement with *Jatropha* farming and the livelihood impacts that ensued;
- Establishing collaborative links with the relevant actors (*i.e.* research institutions, private sector, NGOs, policy makers, international organisations) in order to schedule work for the main field season;
- Identifying research gaps in the existing literature and producing a research proposal that is linked to the actual stakeholder research needs.

Twenty-three semi-structured interviews were undertaken with policymakers, members of the international community, industry and NGOs using a snowball sampling method in order to (i) identify the relevant stakeholders (Sections 3.2.2 and 3.3.2 detail the selection of relevant policies and informants); (ii) map the main ongoing *Jatropha* activities and (iii) investigate the policy and institutional constraints related to *Jatropha* development in Mali. This preliminary work informed the preparation of a list of the main existing *Jatropha* activities in the country. The list was used for a) selecting the study areas to be visited in the next stage of the study and b) establishing initial contacts with the project developers. Such collaborative links provided the researcher with access to the Regional Workshop for the presentation and implementation of the National Strategy for Biofuels Development held in Sikasso (April 2010), organised by ANADEB (National Agency for Biofuels Development). Attendance at this event furthered the researcher's understanding of the role and vision of different stakeholders from the government, regional administration, international organisations, private sector and NGOs.

In the second stage of the scoping study, forty exploratory household questionnaires distributed in the communes of Garalo (n=10), Kouri (n=10), Kita (n=10) and Koulikoro (n=10) were carried out (sampling criteria outlined in Section 3.3.4) to gain a preliminary understanding of the farmers' perceptions as regards their involvement with *Jatropha* farming and its livelihoods impacts. These communes are located in the areas identified as the most representative of the *Jatropha* activities within the country. Information on demographics,

rural energy access, livelihood strategies and *Jatropha* farming were gathered through the questionnaires and triangulated with transect walks, open interviews and personal observations with the same respondents at the questionnaires. Triangulation allowed multiple perspectives to be provided, increasing the validity and strength of the study (Thurmond, 2001). When a lack of clarity was present or contradictions in participants' responses were found in data gained through the use of different methods, additional questions were posed to clarify and validate the findings.

Following Grounded Theory and ethnography styles of approach, data were partly analysed as they were collected by coding and comparing the information through tables and matrixes created in Microsoft Word in order to identify key trends and emerging issues using descriptive statistics (Charmaz, 2006). Such preliminary analysis informed and guided the researcher in the preparation of a second round of semi-structured expert interviews. These were carried out at the end of the scoping field season in order to discuss preliminary observations and issues emerging from the initial work. The scoping study identified a number of key socio-economic and organisational issues concerning *Jatropha* development in Mali that informed (i) the final selection of study areas, (ii) refinement of the overall research aim and objectives and (iii) preparation for field season 2.

3.3.2 Semi-structured interviews with key informants

As a central part of all participatory methods, semi-structured interviews are defined by Hay (2010) as guided interviews organised around ordered but flexible questioning. Throughout the study, a total of 76 interviews were carried out with key stakeholders at their various levels of action (see Table 3.1):

- National level – macro scale (n=18): these include government officials, representatives of international organisations and experts from national research institutes. In the achievement of research objectives one and three, these data allowed a detailed understanding of the factors that influence the formulation of Mali's biofuels policy, the prioritisation of *Jatropha* in the national strategy, and the main policy goals;
- Industry and NGO level – meso scale (n=20): including management (in the headquarters) and general staff (in the field) of the main *Jatropha* organisations identified in the country. This provided a detailed understanding of stakeholders' activities, aims, objectives and

achievements, as well as their operational constraints in line with research objectives one and three;

- Village level (n=38) – micro scale: including presidents of the *Jatropha* farmers' cooperatives, village chiefs, women involved in household soap production from *Jatropha* feedstock and non-cultivators of *Jatropha.* In the achievement of research objective two, this complemented the knowledge gained in field season 2 through in-depth livelihood assessments carried out to gain broader perspectives in terms of policy achievements and villagers' concerns.

Open-ended questions were posed following a general checklist in order to allow further questions to arise during the interview (Sallu *et al.*, 2008; Hay, 2010). Potential informants were approached using a snowball method. This means that one contact was used to help recruit another contact who in turn could put the researcher in contact with someone else with relevance to the research problem (Flowerdew *et al.*, 2005). The most effective way to arrange interviews was through direct telephone calls at the national and industry levels. The fact that the next informant was contacted on his/her personal mobile number showed the close collaborative link that the researcher had with the previous informant who provided the number, creating a sense of trust and making it less likely they would refuse a meeting. Both audio recording and note-taking techniques were used during the interviews. Recordings were transcribed and notes were summarised in meeting reports in the same day or week to facilitate preliminary analysis (Flowerdew *et al.*, 2005) and elaborate further questions for subsequent interviews. These interviews were then further coded, analysed and deconstructed in order to seek the meaning from the data in the achievement of the research objectives (Hay, 2010).

Attendance to the 4th International Conference on Biofuels and Bioenergy in Africa in Burkina Faso (November 21st-23rd 2013) allowed the researcher to meet with some key informants interviewed during field seasons 1 and 2 (i.e. senior staff of ANADEB, GERES, JMI and MFC). This was taken as an opportunity to carry out an additional round of short interviews so to update this thesis in light of the main on-the-ground changes that occurred since 2011.

3.3.3 Focus groups

Focus group discussions were used with purposively selected sets of participants (*i.e.* cultivators of *Jatropha*). Focus groups were convened to discuss issues and concerns on

Jatropha-related activities at village level based on a list of key themes described below (Kumar, 1987). The groups, which ranged from 5 to 20 participants, were organised with the permission of the village chief. Participant selection was guided by the lists of farmer names provided by the organisations. Participants were invited through the local farmers' representative (the key contact person for the researcher in the village). The focus groups were held in a public space in order to guarantee transparency and allow inclusion of all the people potentially interested in participating (even if not included in the lists). Efforts were made to include a balanced amount of male and female attendees by asking the farmers' representative to invite any female *Jatropha* grower that might be interested in joining the focus group. However, this proved difficult as the people in charge of the *Jatropha* activities within the farming households (*i.e.* the farmers registered in the organisations' lists) are predominantly males. One focus group was carried out in each village visited during the two field seasons (n=31 focus groups in total, n=17 in field season one and n=14 in field season two) before the in-depth studies were completed. The possibility to raise questions was provided throughout the discussions, which were organised as follows:

- Presentation of the researcher and the interpreter: who I am, what organisation I work for, what the purpose of my research is, description of previous work carried out in other Malian rural communities and reasons for selecting their village, what the expected outcomes of my study are and the possible future benefits to the local community, and the specific purpose of the focus group;
- Questions on who introduced *Jatropha* cultivation in the village, when, what past training was provided and actual support received by the project developers, quality and frequency of communications with them;
- Questions on uptake reasons, achievements and constraints. The possibility to outline the main problems in relation to both agricultural and organisational issues linked to *Jatropha* was provided.

Focus group discussions brought about group interaction, which may be lacking in a one-to-one interview (Darlington and Scott, 2002), and allowed understanding to be gained of how people thought or felt about the promotion of *Jatropha* agriculture to sustain their living. However, awareness was maintained about the fact that certain individuals within the group may have felt reticent to express their opinions in the presence of dominant personalities (Ritchie and Lewis, 2003) and a constant effort to include all the participants in the conversation was made. Figures 3.5 and 3.6 show typical focus groups.

Figure 3.5: Focus group discussion, Sorona, 2011

Figure 3.6: Focus group discussion, Sorona, 2011

Focus groups proved useful in highlighting major concerns surrounding *Jatropha* agriculture and in identifying the households that were most suitable for in-depth livelihood assessments (Krueger, 2000) (see Section 3.4.6). This demonstrates the value of iterative research in that it enables such issues to be flagged up and incorporated into the next stage of data collection.

3.3.4 Household questionnaires

This research conducted exploratory household questionnaires with household heads (n=120 in total: n=40 in field season one and n=80 in field season two (10 in full and 70 in a shortened version)) (Annex 1) in order to gather three types of primary data (Flowerdew, 2005) used to classify:

- People, their environment and circumstances: including information such as age, income, household size, farm characteristics, land tenure and livestock;
- Behaviour of people: what are their livelihood strategies? How do they participate in the *Jatropha* system?; and
- Attitudes, opinions and beliefs: why did they get involved with *Jatropha*? What is their perception (in terms of economic, social and environmental impacts) about it? What do they expect in the future?

Sampling was purposive non-random and case study households were selected for participation in the questionnaires following consultation with the organisations and focus group discussions. Criteria for selection included: (i) uptake in 2008, (ii) "good" current status of plantations (the majority of the trees are still alive and have already produced some seeds, therefore the farmer is expected to have gained some experience with *Jatropha* farming since uptake). The focus groups carried out prior to the questionnaires not only allowed the farmers that fulfil the above criteria to be identified, but also enabled the researcher to assess which farmers were most willing to participate further in the research. Considering that the questionnaire is more time-consuming than a focus group, it was important to select participants that would fully commit to such an exercise. The sample selection strategy also aimed to cover households located in the highest possible number of villages located across each project area (*i.e.* within the communes of Garalo, Kouri and Kita). This allowed a wider variety of livelihood impacts occurring within the same project to be assessed. In addition to these methodological justifications, the need to work across multiple villages was emphasized by the limited availability of suitable participants that fulfilled the sampling criteria outlined

above. While the lists provided by the project developers included high numbers of *Jatropha* farmers (up to 30) in each village, participants that fulfilled the sampling criteria were found to be fewer than 30 and scattered across villages. Variable numbers of participants were therefore selected across villages (depending on availability, between one and 10 per village) until the total planned number of questionnaires (n=40 in field season one and n=80 in field season two) was achieved.

In the preparatory phase of research (Stage one, Figure 3.4), questions in 10 pilot questionnaires were developed with the aim to cover all the major livelihood issues (identified in the literature review) that surround small-scale *Jatropha* farming. The design of the overall questionnaire structure was guided by examples provided in the sustainable livelihood literature outlined in Section 2.4. During the exploratory scoping study in field season one, the pilot questionnaires were carried out (in full) with the following goals (Hay, 2009), to:

- Identify redundancy or omissions in the questionnaire;
- Identify errors in survey research (*e.g.* distortions introduced from response errors): some questions were not understood in the way intended and produced ambiguous responses. For example, the question "*What is the size of your Jatropha crop?*" produced distorted answers as the respondents referred to the initial area planted at the beginning of the project, even if in most cases they had lost most of the cover in the subsequent years due to pests attacks (*i.e.* termites). This question was therefore reframed as: "*What is the actual cultivated surface of Jatropha (where the trees are still alive)?*";
- Test the questionnaire length and output;

Thirty additional questionnaires were carried out in field season one after the 10 pilot surveys. Overall, the total 40 full questionnaires aimed to:

- Gain a preliminary understanding of farmers' livelihood activities and links to *Jatropha*; and
- Develop the analytical design of research in preparation for field season two.

Questionnaires were initially constructed in English, than translated into French by a professional translator hired from the University of Bamako in order to allow data collection to be undertaken with assistance from a local interpreter in French/Bambara. These two rounds

of translations obviously raised concerns about the danger of losing clarity and rigour. This problem was reduced by having detailed discussions with the interpreter before starting the work to provide him with the best understanding of the overall aim of the research and specifically of each question. In addition, the questionnaires were revised on a daily basis. When it was found that a specific question did not produce informative answers, this was discussed with the interpreter. The purpose was to assess if the lack of clarity came from the question itself, or rather the fact that the interpreter did not fully understand its meaning or did not translate it adequately. This allowed constant improvement of the questionnaire wording while also maintaining comparability of responses by keeping the same data needs and question foci in mind.

During research stage three, qualitative data from the 40 initial questionnaires carried out in field season one were analysed by transcribing the answers into summary tables organised by variables (*i.e.* demographics, *Jatropha* farming, energy and fuelwood). Quantitative analysis was carried out through the use of spreadsheets. Percentages of responses under each category identified within the variables above were calculated, allowing basic quantitative information to be derived. Within the variable "*Jatropha* farming", the following themes were analysed: uptake reasons, plantation size and techniques, harvest and sale, harvest period, irrigation and fertilisers, market price and intercropping. As a result of this analysis, questionnaires used in field season two were further refined by shortening some sections that were considered beyond the scope or focus of the study (*e.g.* sections on fuelwood consumption) and expanding others that needed more detailed information to achieve the research aim and objectives (*e.g*. sections on *Jatropha* agriculture, land tenure and types of food crops grown within the household).

After the questionnaire structure had been refined, it was planned that 120 questionnaires would be carried out in field season two (Annex 1). However, as the research process evolved (after 10 full questionnaires were completed in field season two, all of which incorporated the changes made following the pilot and the first field season) it was realised that the questionnaire was less useful than expected in successfully explaining people's perceptions of *Jatropha* farming and livelihoods. This is in line with Chambers' (1994: 1443) observation that "*Questionnaires are only a single, peculiarly fallible, method; in their application, both local people and enumerators tend to be poorly motivated; and complex causality can be but dimly discerned, if at all*". Therefore, it was decided that only 80 questionnaires in total would be

carried out in field season two, rather than the planned 120. The remaining questionnaires (n=70) were conducted in a shortened version with the aim to gather more specific and focused information to achieve the aim and objectives. This meant focus was on household composition, land tenure, agricultural equipment and livestock (the following questionnaire sections in Annex 1 were covered: 1, 4, 5 and 7). This provided the necessary information to allow initial wealth ranking and informed final selection of n=30 households for in-depth interviews (see Section 3.3.6). Seven of the 30 households included in the shortened questionnaires and in-depth interviews overlapped with the questionnaire participants from field season one. The detailed findings presented in Chapter 5 are grounded in the data collected from the 30 in-depth interviews, supplemented and cross-checked with data provided in the questionnaires and by the other methods (i.e. cropping calendars and transect walks).

3.3.5 Wealth ranking

In stage five of research, wealth ranking of the 30 interviewed households was carried out to identify key links between wealth status, livelihood strategies and outcomes. Despite that the use of articulated wealth ranking and Income Generating Activities (IGA) assessments is widely promoted in the Participatory Rural Appraisal (PRA) literature, for example using card sorting (Chambers, 1994; Pretty and Vodouhê, 1997; Jefferies *et al.*, 2005) or community mapping (Mukherjee, 1993), the researcher decided to avoid these approaches as they were considered inefficient. Indeed, it is recognised that: "*There are many different ways of doing participatory... ranking and scoring*" (Chambers, 1994: 1442). While the use of cards or the creation of sketches and social maps to highlight the differences between well-being of different households certainly looks an appealing and creative approach, the researcher found that more precise, objective and comparable information could be gathered (in a more time efficient way) by an approach developed personally, recognising that: "*Experimenting, inventing, testing, adapting and constantly trying to improve have been part of the strength of PRA*" (Chambers, 1994: 1442). The adaptation of wealth ranking to understand the context-specific situation of Malian smallholder farmers was grounded in the following two points:

- The ranking carried out by villagers (*e.g.* by classifying their own neighbours) might create divisions and contrasts. It does not guarantee objective assessment and comparison among households. This issue emerged in previous sustainable livelihood research carried out in Mali (Brock, 1999);

- Analysis of scoping study data suggests that agriculture is the main livelihood activity in the study area. Availability of agricultural equipment within the household (which is objectively measurable through the household questionnaires and verifiable through in-depth interviews) plays a fundamental role in determining people's capacity to achieve their livelihood outcomes (including education, health and social status). Therefore, it can be considered as a key indicator of their wealth.

In light of these considerations, the participants' wealth ranking was conducted in line with the Malian Company for Textile Development (CMDT) definitions (Nubukpo, 2005), where farmers placed themselves into one of four categories (Table 3.2) according to the type and quantity of agricultural equipment possessed by the household (*e.g.* oxen, plough, mule barrow and seed drill) (see Figures 3.7, 3.8 and 3.9).

Table 3.2: Classification categories used for wealth ranking

A	The household owns: 2 pairs of oxen and 2 ploughs, 1 seed drill and 1 mule barrow
B	The household owns one complete basic farming equipment (1 pair of oxen and 1 plough)
C	The basic farming equipment (1 pair of oxen and 1 plough) owned is incomplete, but the household has experience is using these tools
D	All the crops are grown by hand

Source: adapted from CMDT (Nubukpo, 2005), assessed through household questionnaires and in-depth interviews

Figure 3.7: Basic agricultural equipment: on the left two types of plough (pulled by oxen) and on the right a seed drill, Zena village, 2011.

Figure 3.8: Oxen next to *Jatropha* tree, Kita village, 2011.

Figure 3.9: Mule barrow, N'gorola village, 2011.

The CMDT indicators were tested in pilot questionnaires and verified through interviews with key informants to assess their relevance in the assessment of different levels of household wealth. Information in the questionnaire was complemented with a table that lists all the income generating activities of the household. The testing process allowed the wealth indicators to be refined. The possibility of including the variable "owned livestock other than oxen" into the different wealth categories had been initially considered, as the analysis of scoping study data identified livestock as an important indicator of household wealth. Nevertheless, the testing and triangulation process indicated that the amount of livestock declared in the household questionnaires tended to notably differ to the values provided in the interviews. Therefore, it was decided to avoid this variable within the range of indicators in order to guarantee a more objective categorisation.

3.3.6 Semi-structured household interviews (in-depth interviews)

Guided by the SLF as an analytical tool, detailed household livelihood profiles with *Jatropha* growers were developed to understand (i) how the different livelihood assets and household members interact, (ii) the factors that affect household vulnerability, and (iii) the context

within which livelihoods evolve. Thirty case study households were purposively selected based on the initial analysis of the household questionnaires in order to (i) represent an equal proportion of best, average and low performers (in terms of yields and quantity of commercialised *Jatropha* seeds), (ii) represent households that come from varied wealth ranking levels, (iii) include households that are experienced with production and/or commercialisation of *Jatropha* by-products (*i.e.* white or black soap), and (iv) include some *Jatropha* farmers that are also cotton growers, as cotton is the main competing cash crop in the country (Theriault *et al.*, 2013).

Each livelihood profile involved the use of semi-structured interviews (n=30) subsequently complemented with and triangulated by using cropping calendars (n=30) and transect walks (n=30) with the same respondents. A question checklist was developed from the preliminary analysis of the household questionnaires and focus groups and was constantly revised during the research as long as new issues arose, in line with the Grounded Theory style of approach. A standard interview structure was used to allow comparability of the data among the different case study households and villages. The topics included: household demographics and composition, labour availability and distribution among different members, agricultural equipment, *Jatropha* farming (*i.e.* uptake reasons, type of support received from local organisations and national authorities, concerns about quality and frequency of communication with field staff, land use, soap production, trade-offs with cotton farming, utilisation of the revenues from *Jatropha*, main difficulties, incentives required for improving or extending the cultivation), household expenses and income generating activities.

3.3.7 Seasonal calendars

The establishment of a local supply chain of *Jatropha* requires several activities to be added to the household's cropping calendar, including the creation of tree nurseries as well as planting the trees during the first few years, looking after the crop, harvesting, and finally dehulling and transforming the seeds into oil or soap. Seasonal calendars have been widely used in livelihood studies as a PRA tool to learn about the seasonality of agricultural and non-agricultural workload (Chambers, 1994; Sontheimer, 1999).

Thirty calendars were developed to assess how respondents make decisions regarding their livelihood strategies, particularly in terms of:

- Types of crops that are grown;
- Labour intensity and availability, involvement of different household members through the year;
- Seasonal changes in food supply;
- Strategies to cope with food shortages, illnesses, or economic constraints.

These data were gathered through semi-structured interviews as part of the in-depth livelihood analysis. By complementing the information on land tenure, agricultural activities and income generating activities collected in the household questionnaires, the creation of farming calendars contributed to the achievement of objectives two and three by identifying the possible impacts of *Jatropha* farming on the diversification of the farmers' livelihood strategies and the trade-offs that might arise among different crops or activities.

3.3.8 Transect walks

Data gathered in the in-depth interviews using the methods described above were triangulated and complemented by collecting the same as well as additional information through transect walks (n=30). A walk through the land used by the participants (see Figure 3.10) allowed the researcher to observe the on-the-ground situation of the cultivated crops, verify the *Jatropha* acreage and conditions, ask further questions and learn more about the farmers' perspectives (cf. Binns *et al.*, 1997). Information was documented by taking notes and photographs of the *Jatropha* crops to allow comparisons with the views and crops of other farmers. Questions were raised on the reasons leading to the selection of a particular area for *Jatropha* farming, the previous land use and the main constraints to cultivation in different types of land or soil. The walk was normally held in the middle of the in-depth interview to break the monotony of interviewing inside the house and to stimulate the respondents to provide more detailed information. Indeed, the farmers were eager to showcase their land and felt honoured by the fact that the researcher made an "effort" to walk several miles in order to see the outcome of their work. This was also an occasion to be accompanied by other members of the family, particularly children, meet the field workers and improve the social interaction within the community.

Figure 3.10: Transect walk, Tandio, 2011

3.4 Limitations of methodology

This section reflects on how limitations in the methodology were considered and overcome through the design and implementation of this research.

The quality of data gathered through household questionnaires relies on the participants' willingness to provide truthful information. The use of focus groups early in the process provided the participants with a detailed understanding of the research aim, its target audience and expected impacts (Kumar, 1987). It allowed rapport to be built between the researcher and the local community towards the identification of the most willing farmers that were then prioritised in sample selection. This process is envisaged to have helped to elicit truthful data. Data quality also depends on the correct understanding of the questions (Harris and Brown, 2010). As discussed in Section 3.3.4, the replies were checked regularly and emerging issues (particularly with regard to the lack of clarity in some replies obtained) were discussed with the interpreter in order to constantly improve the way each question was formulated (Creswell, 2009). People sometimes struggled to remember quantitative information. This was found to be a major constraint that hampered the collection of reliable data (particularly on livestock numbers and size of areas cultivated) through the use of questionnaires. The flexible approach adopted allowed the use of shortened questionnaires so that the time spent on data collection in this way was minimised while expanding the use of

other methods (*i.e.* cropping calendars, transect walks and semi-structured interviews). The data gathered through multiple methods complemented each other, overcoming limitations of single methods (McKendrick, 2010) and enabled triangulation of data from different sources. Notably, as in-depth interviews took roughly a whole day to be completed, they allowed more time for the inconsistencies (*e.g.* in terms of over- or under-reporting) generated in the questionnaires to be cross-checked (Marton and Pong, 2005).

The shortened questionnaires (Section 3.3.4) provided the most useful output in terms of final selection of the 30 households that participated to the in-depth interviews. While the use of a smaller sample might limit the capacity to represent adequately the target population (Kumar A., 2002), such an in-depth approach allowed a deeper understanding to be gained of the livelihood strategies of the participants with a focus on the role of *Jatropha* cultivation.

It must also be considered that the questionnaires' unit of analysis (*i.e.* the interviewed person) was the household head, who is most commonly a male. As such, there was a risk that the perspective of female members of the household could be disregarded. In order to gain a more gender-balanced understanding, a range of questions on soap production from *Jatropha* and the management of Multifunctional Platforms (which are female activities) were directed to female household members during the in-depth interviews.

Only seven of the interviewees (out of 30) in field season two overlapped with field season one. It was therefore recognised that data could only provide an overview of the situation at a specific point in time, rather than an assessment of how *Jatropha* agriculture has evolved between the two field seasons. The quantitative analysis presented in Chapter 5 is grounded in the data from the 30 in-depth interviews, questionnaires, cropping calendars and transect walks from the same field season. While the methodology used does not capture dynamics, by focusing the analysis on one season and minimising the time gap between data collection points across methods, the probability of gathering inconsistent data was minimised.

3.5 Secondary data collection

As summarised in Table 3.3, secondary data from government departments, international organisations and online databases were gathered in order to complement the primary data collected during the fieldwork.

Table 3.3: Secondary data sources

Data	Year	Source
Current political situation	2012	AfDB, OECD, UNDP
Global Food Price Index	1990-2013	FAO
Ten Years Action Plan to Achieve the MDGs	2008	GoM
National Energy Policy	2006	Ministry of Energy and Water
National Strategy for the Development of Renewable Energy	2006	Ministry of Energy and Water
National Strategy for Biofuels Development	2008	Ministry of Energy and Water
Energy statistics	2009	Ministry of Energy and Water
National Environmental Protection Policy	1998	Ministry of Environment
UNCCD National Action Programme	1998	Ministry of Environment
National Climate Change Policy and Strategy	2011	Ministry of Environment
National Adaptation Programme of Action to Climate Change	2007	Ministry of Equipment and Transportation
Rural Development Master Plan	2002	Ministry of Rural Development
Administrative divisions	1999	Ministry of Territorial Administration and Local Communities
2007-2011 Poverty Reduction and Growth Strategy Paper	2006	Ministry of the Economy and Finance
Agricultural Orientation Law	2006	National Assembly
Average Rainfall data	1971-2000	National Directorate of Meteorology
Population Data	2005-2010	UNDESA
Human Development Index	2011	UNDP
Political map	2004	United Nations

The use of secondary data such as statistics on energy, population, socio-economic development and environmental trends is useful to crosscheck and complement the information reported by the interview participants (Creswell, 2009). Guided by the SLF, the

assessment of the social, economic and environmental vulnerabilities of Malian *Jatropha* farmers (Section 5.5) is grounded in these secondary data. Average rainfall data was used in field site selection (Section 3.1.5) to identify the regions where agro-ecological conditions are most suitable for *Jatropha* cultivation. Figure 3.2 has been created using the Adobe Photoshop CS2 software by overlapping the political map of Mali with one on annual rainfall patterns generated by the National Directorate of Meteorology. In the achievement of research objectives one and three (see Section 1.4), the integration of government policies and strategies in the energy, environment, agriculture and rural development sectors with the multi-level results from interviews and livelihood assessments allowed the identification of policy goals and implementation gaps. Details on how these data were collated and analysed are provided in Section 3.2.2.

3.6 Ethical considerations, positionality and foreign language cross-cultural research

This research was guided by a code of ethics developed in order to guarantee the participants that the researcher would act "*in accordance with principles of conduct that are considered correct*" (Collins, 1979: 502). It was informed by the Economic and Social Research Council (ESRC) research ethics framework and was conducted according to the University of Leeds research ethics guidelines, with approval provided by the University Ethics Committee (approval code: AREA 12-024). Once in the field, participants were provided with detailed information on: who I am (a student that is carrying out his PhD research), details of the university at which I study and funding body, subject and purpose of my project and details about what will happen with the results. For more formal interviews with institutional representatives, this information was given (see Appendix 2) and participants were asked to provide written informed consent before they engaged in the research (see Appendix 3). This included two-way agreements: (i) a personal commitment of the researcher to share any final report or document to keep the participant informed of the progress of the research, and (ii) the participants' right to comment on the emerging results (Sarantakos, 2005). The detailed information was orally discussed in the rural areas where the participants were not comfortable with reading or signing documents. Anonymity, as well as confidentiality and data protection, were guaranteed throughout the research (Dawson, 2009). It was made clear that while individuals would remain anonymous in future publications, data will still refer to particular villages or institutions.

When designing and conducting research, it was essential to consider the interrelations between society and the researcher that permeate all methods and phases of research. In a certain societal context, personal interactions are of critical significance when collecting and interpreting social information as they are strictly influenced by social norms, expectations of individuals and structures of power (Hay, 2005). The positionality of the researcher *vis* a *vis* the research participant, or in other words the way in which the researcher is perceived and interpreted by the researched (Visser, 2000), can significantly influence access to informants and information (Herod, 1999).

This study was heavily dependent upon a broad range of national, provincial and local government policy documents. Semi-structured interviews with international organisations, national policy makers, research institutions, private sector representatives and NGOs were conducted to both generate data, as well as aid the interpretation of documented information. In addition, in-depth livelihood assessments were carried out in the rural areas where the main *Jatropha* projects operate within the country. Consequently, informants come from a diverse range of backgrounds: racially (several ethnic groups reside in Mali), socially, culturally and economically. A critical reflection of my social role (a young, white, male research student in a developed country, registered at a foreign university) and my multiple positionalities allowed me to use different approaches to "positioning" myself within such contexts (Hopkins, 2007; Jackson, 1993).

Firstly, it was recognised that in the rural research context I would be perceived as an outsider, somebody that does not belong to the study group, and that this might limit access to certain types of information and informants (Mullings, 1999). I could not speak Bambara, which is the main language spoken by the interviewed communities, therefore the use of two interpreters (one in field season one and one in field season two) was required. I was also aware that the positionalities of my interpreters would have influenced my interactions with the locals and therefore the quality of the produced data (Rose, 1997). The fact that both of my interpreters throughout the study were male Malian students created suitable conditions for being accepted by the villagers, where important or official discussions concerning households issues (such as agricultural strategies and financial situation) are normally held amongst men. Apart from the translation job for which the interpreters were hired, their constant guidance during my stays in the villages ensured that my behaviour and actions would be fully respectful of the people involved in the research (Dawson, 2009).

Social values in the rural Malian context (dominated by traditional beliefs, magic rituals and religion) are not clearly outlined in any specific written document. Knowledge of local habits was essential to gain the respect of the interviewees and their availability to collaborate. In line with the research ethics, upon arrival in a new village I introduced myself and the project to the head of village (the most respected authority) by bringing him 10 "*noix de cola*" as a gift of respect (an edible nut of very high value in the Malian culture: it is exchanged at local weddings and also eaten by the elders because of its expected beneficial effects on their health) and asking for his permission to work in his village.

To avoid creating expectations, it was made clear with each interviewed household that I was not working for the government or project developers, that the interviews were not remunerated and that I could not provide any form of aid to the village at present nor in the future. I ensured that everybody clearly understood that I was an independent student who made the effort to reach their village fully moved by my personal motivation to truly learn about their situation and see though my own eyes something that I could not learn just by "reading books". I explained that my possible contribution to the improvement of their situation with regards to *Jatropha* agriculture would not manifest in the short run but that if they gave me the opportunity to understand their point of view which will always be kept anonymous, in the future, my research findings will help to inform all the *Jatropha* stakeholders that make decisions about these projects. I also highlighted the fact that, even after being informed, the stakeholders will not necessarily listen to my advice due to a variety of constraints that they face. Therefore, I can assume that the villagers that have accepted to answer my questions were genuinely eager to contribute to my research by providing the best information available because they understood the importance of the study with the hope to improve the future situation of their village without getting any immediate personal advantage.

Rice, chicken and vegetables to feed myself and my interpreter as well as the household members were provided to each of the thirty households that took part in the in-depth studies and dedicated an entire day each to answering my questions. When possible, gifts such as photographs of household members taken during the previous field season or other small presents (*i.e.* coca cola, peanuts, cigarettes and cookies) were given. By building a relationship with the respondents and providing them with some feedback after the previous visit, the positionality of the researcher evolved. As noted by Mullings (1999) and Twyman *et al.* (1999),

power relations are not frozen in place; “insider” or “outsider” is not a fixed attribute and positionalities are dynamic in time and through space. Also, to better learn about the local habits and create a greater empathy with the people I always adapted to the "local" way of doing things, for example by eating with my hands (even when offered a spoon as I was expected to be unable to eat without it), showering with *Jatropha* hand-made soap and learning how to make tea in the traditional way. I also participated in various village and household activities including wood collection (Figure 3.11), weddings, teaching some English at high-school to students enrolled on an English course, watering *Jatropha* in the tree nursery and dehulling the *Jatropha* seeds.

Figure 3.11: Wood collection, Garalo, Scoping fieldwork

In the semi-structured policy-related interviews, as an educated male conducting research in a local government and institutional environment where the majority of my informants have studied abroad and share similar attributes, I expected to be positioned more as an insider. I was conscious of the fact that the perception of my own positionality might differ to the way the participants perceived me (Herod, 1999; Mullings, 1999). Thanks to my previous work experience and professional links in the international development arena I started the interviews with the institution that was most close to me (UNDP), improving the chances to position myself as an insider. Once I had established the first contact, such an approach was repeated using snowball sampling techniques for the selection of the subsequent interviewees.

3.7 Summary

This chapter has outlined the research design, framework and methodology developed in this research. The variety of approaches to data collection and analysis incorporated in the research design have been described (including Sustainable Livelihood Approaches, stakeholder analysis, policy and discourse analysis) and linked to aspects of ethnography and Grounded Theory. Detailed information on the case study country background has been provided, together with justification for field site selection and sample design. Guided by the SLF, the variety of conventional social science and participatory methods used in the research have been discussed and justified, highlighting their advantages and weaknesses. The academic novelty of the detailed mixed-method, multi-level case study approach adopted here has been stressed, showing the leading role that participatory methods can play in integrating poverty and rural energy concerns into the more holistic analyses required for sustainable development. Such approaches will be applicable to other understudied rural regions of dryland Africa. Finally, research ethics have been discussed and the positionality of the researcher has been considered in light of the impacts that this may have on the outcomes of the research. Considerations associated with undertaking research in a foreign language have also been raised.

Chapter 4

Policy and institutional frameworks for the promotion of sustainable biofuels in Mali

"The problem is that the institutions have focused their goals on oil production without even doing research on the tree first. The only research they did is on the use of the oil on engines, but the oil comes from the tree ...how can you make an engine work if the tree is not producing enough oil?"

(Semi-structured interview, Malian Rural Polytechnic Institute (IPR/IFRA), 2012)

Outline

This chapter addresses research objective 1 ”to identify and analyse the stakeholders and policies concerned with biofuels in Mali taking into account policy motivations for prioritising *Jatropha*". It presents new, multi-level assessments of the implications of the Malian Strategy for Biofuels Development for the promotion of *Jatropha* as a sustainable development tool. It addresses knowledge gaps on the role of national policy instruments in the uptake of biofuel activities. The chapter has been published as a Working Paper (Favretto *et al.,* 2012). For the thesis, the headings and illustrations have been re-numbered and cross-references have been added. This chapter also addresses research question vi "To what extent is the NSBD achieving its intended outcomes and what are the key barriers to the achievement of policy goals?" within research objective 3 "Evaluate the drivers and barriers to the achievement of policy goals in relation to rural development and energy security, proposing policy recommendations and ways forward that better link the realities of policy and local practice". A more detailed analysis integrating the multi-level data generated at national and household levels is subsequently presented in the discussion chapter (Chapter 6).

4.1 Introduction

To reach energy and development goals in the context of rising global oil prices, scarcity of known petroleum reserves (Sorrell et al., 2010) and climate change (IPCC, 2007c), there has been growing pursuit of alternative energy sources. Biofuels represent one route towards renewable energy (Janssen and Rutz, 2012; UNDESA, 2007), particularly in developing countries such as Mali (Lengkeek, 2009; Palliere and Fauveaud, 2009). However, first-generation biofuels remain controversial and concerns have been raised regarding four key debates: i) "food versus fuel" (Nonhebel, 2012); ii) emerging threats from large-scale land acquisitions (Cotula et al., 2009; Fairhead et al., 2012); iii) indirect land use change (Searchinger et al., 2008; Berndes et al., 2011), and iv) the limited benefits of biofuels in terms of rural development and fossil fuel substitution (ActionAid, 2012; Nuffield Council on Bioethics, 2011) (see Section 1.1).

Cultivation of the oil-bearing, "drought resistant" non-edible tree *Jatropha* has been widely promoted in Mali by national policy, private sector and NGOs to foster rural development and substitute national consumption of fossil fuels (Gilbert, 2011; GoM, 2008). Nevertheless as outlined in Chapter 2, the *Jatropha* sector is still young and empirical analyses of the potential impacts on rural livelihoods and improved access to energy are lacking.

This chapter presents new, multi-level assessments of the implications of the Malian Strategy for Biofuels Development (NSBD) for the promotion of *Jatropha* as a sustainable development tool in Mali. It aims to advance understanding of the role of policy by answering the following research questions linked to objectives 1 and 3:

(i) What are the policy goals concerned with biofuels in Mali and why is *Jatropha* prioritised in the NSBD? (Objective 1)

(ii) Who are the main stakeholders supporting biofuels (particularly *Jatropha*) policy in Mali and what are their respective roles and responsibilities? (Objective 1)

(iii) To what extent is the NSBD achieving its intended outcomes and what are the key barriers to the achievement of policy goals? (Objective 3)

Multi-level approaches are adopted to understand complex multi-scale and multi-sector issues where "*a wide range of public and private actors ... operate at diverse jurisdictional levels*" (Termeer *et al.*, 2010). Multi-level analysis uses methods including interviews and policy

analysis to unravel the complexity within which the Malian *Jatropha* activities operate across local and national levels. A total of 76 semi-structured interviews have been carried out with major stakeholders at the three following levels of action: national (n=18), industry and NGO (n=20) and village (n=38) (see Table 3.1 and Section 3.3.2).

The national and local considerations emerging from multi-level assessments address existing knowledge gaps by providing a more in-depth understanding of the role of national policy instruments in the uptake of biofuel activities. Results are presented in Section 4.2 in relation to research question 1 and in Sections 4.3 and 4.4 in relation to research question 2, each informed by findings from across the different levels of analysis and drawing on data collected using multiple methods.

4.2 Policy review: fuelling Malian policy with *Jatropha*

This section provides an overview of the main policy drivers fostering the production and use of *Jatropha* within Mali.

4.2.1 Key policy goals and inter-policy coherence

Use of *Jatropha* oil has been fostered by several policy measures aimed at sustaining both rural and national energy development. Eleven key policies and strategic documents adopted by government in energy, environment, agriculture and rural development sectors were analysed using discourse analysis (Table 4.1). Coding and deconstruction of the analysed policies and documents (Apthorpe, 1996) allowed identification of 3 key themes and 9 sub-themes related to the socio-economic and environmental goals that the government aims to achieve through promotion of renewable energy sources. These link to the main debates surrounding biofuels and are:

(I) Socio-economic progress and development

1. Poverty reduction, rural development and gender empowerment
2. Renewable energy access and supply
3. Capacity building
4. Renewable energy governance
5. Renewable energy R&D

(II) Agriculture

6. Food security, agricultural diversification and productivity
7. Water use and irrigation

(III) Environment

8. Climate change and pollution
9. Desertification, degradation and soil infertility

Table 4.1: Key socio-economic and environmental themes tackled by selected policies and strategic documents on renewable energy, environment and development in Mali

Year	Acronym	Title	I Socio-econ. progress and dev. 1	2	3	4	5	II Agr 6	7	III Env 8	9
1998	**PNPE**	National Environmental Protection Policy *Politique Nationale de Protection de l'Environnement*	X	X	X		X	X	X	X	X
1998	**NAP**	UNCCD National Action Programme	X	X		X		X		X	X
2002	**SDDR**	Rural Development Master Plan *Schéma Directeur Du Secteur Du Développement Rural*	X				X	X		X	X
2006	**LOA**	Agricultural Orientation Law *Loi d'Orientation Agricole*	X	X		X	X	X		X	X
2006	**PEN**	National Energy Policy *Politique Énergétique Nationale*	X	X	X	X					
2006	**NSREN**	National Strategy for the Development of Renewable Energy	X	X	X	X	X		X		
2006	**G-PRSP**	2007-2011 Poverty Reduction and Growth Strategy Paper (2nd generation)	X	X	X		X				X
2007	**NAPA**	National Adaptation Programme of Action to Climate Change	X	X			X		X		X
2008	**MDGs Plan**	Ten Years Action Plan to Achieve the MDGs *Plan décennal pour la réalisation des OMD*	X	X			X				X
2008	**NSBD**	National Strategy for Biofuels Development	X	X	X	X	X		X	X	
2011	**PNCC/ SNCC**	National Climate Change Policy and Strategy *Politique Nationale Changements Climatiques*	X	X	X		X	X	X		
		International commitments (by year of ratification)									
1994	**UNFCCC**	United Nations Framework Convention on Climate Change	X						X	X	
1994	**UNCCD**	United Nations Convention to Combat Desertification	X	X	X		X	X		X	X
2002	**KP**	Kyoto Protocol		X	X	X			X		

Shared policy objectives and strategic orientations pursued under each sub-theme in relation to *Jatropha* promotion are identified in light of the story-lines that sustain the discourse and facilitate its institutionalisation. This analysis shows that the Malian government effectively embedded or mainstreamed (*cf.* Akhtar-Schuster *et al.*, 2011) international priorities on sustainable development and energy (UN, 1987, 1992 and 2012) into its national policies. In such a framework, and as supported by the private sector, academia and media, the "renewable energy" story-line has emerged with the underlying concept that sustainable development and energy security can be achieved through promotion of alternative energy sources, particularly biofuels. The "*Jatropha*" (sub)story-line has emerged with the assumption that positive impacts can be accomplished by prioritising aspects of rural and agricultural development, as well as environmental preservation linked to the establishment of a *Jatropha* industry. In the Malian debate, the formation of discourse coalitions comprising the various ministerial departments and stakeholders outlined in Figure 4.1 has led to the legitimisation and institutionalisation of the *Jatropha* story-line into the national policies in Table 4.1. These are formed around three priority areas that reflect the key policy themes identified earlier and detailed here:

(1) Socio-economic progress and development (fostering poverty reduction and rural development through improved renewable energy production and use). The 2007-2011 Poverty Reduction and Growth Strategy Paper (G-PRSP) highlights the cross-cutting role of energy in all rural production sub-sectors to ensure sustainable growth in rural areas and achieve the MDGs. Amongst its specific objectives, the G-PRSP aimed to increase by 8% the portion of renewable energy in the national production of electricity by 2009. The 2008 NSBD states: "*The use of vegetable oil* [from *Jatropha*] *will not only substantially contribute to the improvement of energy access ...but also to the increase of revenues and employment*" (GoM, 2008: 29). In this regard, considerable efforts have been put into the promotion of MFPs fuelled by locally produced *Jatropha* oil, with a strong focus on gender empowerment deriving from the implementation of the national PN/PTFM programme. The National Strategy for the Development of Renewable Energy (NSREN) aims to increase the share of renewable energy generation in national energy production from <1% in 2002 to 3% in 2007, 6% in 2010, 10% in 2015 and 15% in 2020. It calls for improvements in R&D on the technology needed to fuel MFPs through *Jatropha* oil, with the aim to process agricultural products, generate electricity and improve rural well-being. In the achievement of similar purposes, ambitious objectives are set in the Ten Year Action Plan to Achieve the MDGs, which aims to extend access to

mechanical energy to 100% of the rural communities by 2015, partially through the use of MFPs. Priority to the villages that are already equipped with MFPs is given by the National Adaptation Programme of Action to Climate Change (NAPA), which aims to foster revenue generating activities through the creation of women and youth *Jatropha* associations in the promotion of "*sustainable production of Jatropha oil – in terms of quality and quantity – in the regions of Kayes, Koulikoro, Sikasso and Segou*" (GoM, 2007: 83). In line with these priorities, the National Energy Policy (PEN), which sets renewable energy access targets similar to those set in the NSREN, supports the development of a *Jatropha*-based biofuels industry for uses including electricity generation, transportation and agricultural motorisation, and promotes the National Programme for the Energetic Valorisation of *Jatropha (*PNVEP), which is also a key component of the UNCCD National Action Programme (NAP).

(2) Agriculture (promotion of food security and agricultural diversification). Enhancing food security is a key cross-cutting concern in all development policies. The overarching objective set in the National Environmental Protection Policy (PNPE) is to "*ensure food security …to preserve and improve the population's living conditions*" (GoM, 1998: 17). In the achievement of this goal and of the country's economic growth, the Rural Development Master Plan (SDDR), Agricultural Orientation Law (LOA) and the Poverty Reduction and Growth Strategy Paper focus on the importance of increasing the role and contribution of the agricultural sector. Improvement of the sector's productivity is intended to be achieved through diversification of agriculture. The G-PRSP identifies the expansion of energy availability for rural uses as an essential pre-requisite to enable successful agricultural production. This vision is supported and strengthened by the National Adaptation Programme of Action (NAPA) and National Climate Change Policy (PNCC). In the achievement of these objectives, the *Jatropha* story-line has been institutionalised in the national strategies for renewable energy (NSREN) and biofuels (NSBD) development. As stated in the NSREN (GoM, 2006c: 28) "*the energetic valorisation of biomass and the Jatropha tree* [will directly contribute to the achievement of] *food security and diversification of agricultural products*". A similar statement is made in the NSBD.

(3) Environment. In attempting to meet international environmental commitments, a variety of environmental policy goals have been set with the aim to tackle key problems related to deforestation, climate change, desertification and land degradation. Promotion of renewable energy is envisaged in the achievement of these goals. The UNCCD National Action Programme (NAP), and similarly, Poverty Reduction and Growth Strategy Paper, promote substitution of

woodfuel through the "d*evelopment of new and renewable energy sources*" (GoM, 1998: 93) in order to decrease deforestation rates. The same goal is pursued by the MDGs Plan which calls for the improvement of household energy use by using *Jatropha*-fuelled MFPs and solar energy. Tackling any form of pollution is a key priority set in the National Environmental Protection Policy (PNPE). This is reinforced by the National Strategy for the Development of Renewable Energy and National Adaptation Programme of Action to Climate Change (NAPA) which aim to decrease national energy dependence on fossil fuels through "*Promotion of Jatropha oil*" (GoM, 2007: 83). Similarly, the NSBD promotes *Jatropha* cultivation to sequester carbon and also to restore degraded land. As concerns land degradation, *Jatropha* agriculture is promoted by the Rural Development Master Plan (SDDR) and NAPA with the aim to restore and maintain soil fertility and to combat soil erosion.

4.2.2 The National Strategy for Biofuels Development

The NSBD is the key policy document in the promotion of *Jatropha* production and use. It aims to increase local energy production by developing biofuels to meet the country's socio-economic needs and substitute imported oil (GoM, 2008). Three specific objectives include to: (i) increase vegetable oil-based biofuel production, (ii) create the village-level and industrial infrastructure required for biofuel production, transformation and commercialisation, and (iii) establish institutional, legal, regulatory and financial frameworks for biofuel development.

Quantitative targets for biofuel production are set in the NSBD, including the substitution of 20% of fossil fuel consumption with *Jatropha* biofuel by 2023, involving a production of 84 million litres/year of refined oil and a total cultivated surface area of 50,000-70,000 ha (Table 4.2).

Table 4.2: Quantitative targets for *Jatropha* production and fossil fuel substitution outlined in the National Strategy for Biofuels Development

Timeframe	Replacement of diesel with *Jatropha* oil	Quantity of *Jatropha* oil (million litres)/year	Seeds productivity (T/ha)	Equivalent *Jatropha* (ha)
2008-2013	10%	39	3.125	71,680
2014-2018	15%	56	6.25	53,760
2019-2023	20%	84	9.375	47,787

Source: GoM (2008)

The potential for achieving these targets (research question 3) is evaluated and discussed in sections 4.3 and 4.4.

4.3 Institutional framework and national level implementation of Mali's *Jatropha* activities

Stakeholders involved in biofuel production in Mali fall within four groups:

1. *Ministerial and technical central departments* that elaborate and implement national energy, agricultural and environmental policies as well as supervise renewable energy activities in the country.
2. *Multilateral development agencies* which, together with bilateral donors, constitute the most important source of financing for the development of public biofuels projects and programmes, with international funding for the implementation of *Jatropha* activities exceeding national spending. They also provide technical assistance and capacity building, supporting the Malian government in promoting pro-poor energy sector reforms and establishing appropriate legal and regulatory frameworks for the development of renewable energies.
3. *(a) Bilateral donors* which provide funding to public and private projects. These include the French Development Agency, Netherlands and Belgian Cooperation. *(b)* Substantive financial (and often technical) support is also provided by *private entities* such as the Bill & Melinda Gates Foundation, FACT Foundation, Eco-Carbone, Novartis, Total and Kia Motors. The start-up and implementation of the main pilot *Jatropha* activities depend on the monetary resources provided by these donors.
4. (a) *NGOs* (*e.g.* Mali-Folkecenter and GERES Mali) and (b) *private companies* (*e.g.* Malibiocarburant SA and Jatropha Mali Initiative). These organisations operate with varying approaches and motivations including fuel production, rural electrification, promotion of rural and agricultural development at the community and village levels, and carbon credit commercialisation. They have undertaken pilot activities – in direct collaboration with beneficiary communities – in production, extraction, transformation and utilisation of *Jatropha.* Their role is further explored in Section 4.4.

Figure 4.1 outlines the four groups that were identified. The arrows highlight the collaborative relationships among stakeholders with relation to the following types of links: funding, *Jatropha*-related research, policy elaboration (where the stakeholder affects the decisions

taken in the elaboration of energy policy) and policy implementation (where the stakeholder is directly in charge of implementing concrete actions in the achievement of energy policy goals).

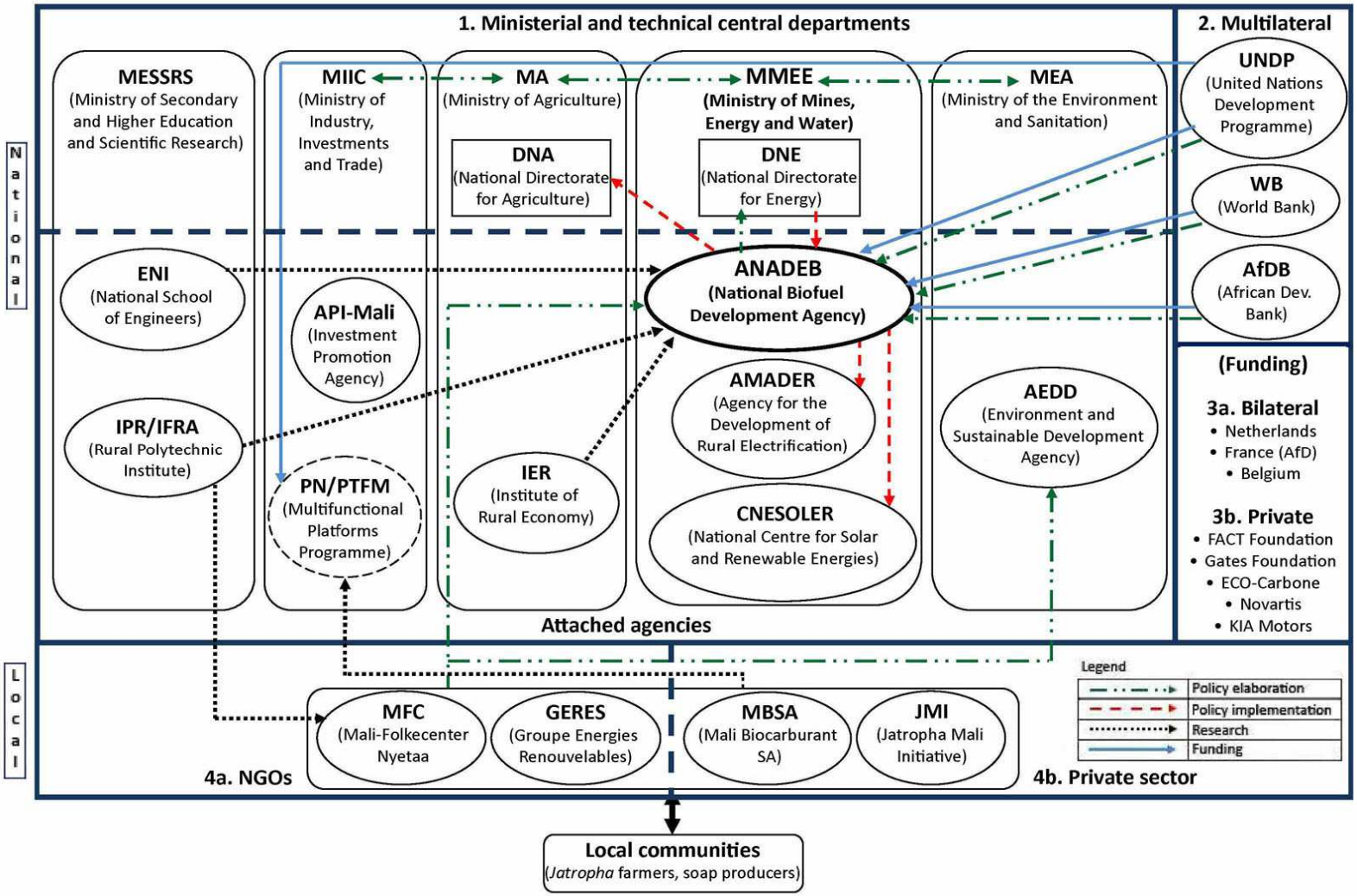

Figure 4.1: Key stakeholders in Mali's *Jatropha* activities. Arrow legend shows types of links identified

Since the 1990s the use of renewable energy sources to tackle fuel poverty and conserve the environment in Mali has been extensively promoted by the Ministry of Mines, Energy and Water (MMEE). The MMEE formulates energy policy, defines energy planning and controls the renewable energy sector (MMEE, 2012). It has played a leading role in the elaboration of the National Energy Policy, National Strategy for the Development of Renewable Energies and the NSBD.

By implementing the "Scaling up renewable energy program for low income countries" (SREP) (Table 4.3), the MMEE envisages to reduce national fossil fuel consumption, encourage low-carbon economic growth, and contribute to poverty alleviation, by fostering renewable energy development. From an environmental perspective, achievement of these goals is supported by the Ministry of the Environment and Sanitation (MEA) and its attached Environment and Sustainable Development Agency (AEDD). The MEA defines environmental policy and approves projects such as those funded through the Clean Development Mechanism (CDM) (MEA, 2012), where commercialisation of carbon credits is a major driver for the development of *Jatropha* pilot activities as detailed in Section 4.4.

Mali's biofuel operations are coordinated by the National Biofuel Development Agency (ANADEB), which was jointly created in 2009 by the ministries responsible for energy, agriculture, environment, industry and trade. In the implementation of the NSBD (Section 4.2.2), ANADEB's mission is to promote biofuels – largely from *Jatropha* feedstock – at a local level, in order to meet rural communities energy needs, and at a national level, in order to meet the country's energy needs and reduce the high dependence on oil imports (ANADEB, 2012). Prior to ANADEB's creation, all biofuel activities were under the supervision of the National Centre for Solar and Renewable Energies (CNESOLER), which, since the 1990s, has been the leading implementer of *Jatropha*-related projects and programmes. Its projects include the National Programme for the Energetic Valorisation of *Jatropha* (PNVEP) (GoM, no date) and collaboration with the German Technical Cooperation (GTZ) *Jatropha* System project (Table 4.3) (Wiesenhütter, 2003). In 1996, the United Nations Development Programme (UNDP) launched the Multifunctional Platforms National Programme (PN/PTFM) (Table 4.3) – which since 1999 has been the responsibility of the Ministry of Industry, Investments and Trade (MIIC). A Multifunctional Platform (MFP) consists of a source of mechanical and electrical energy provided by a diesel engine which can also run on pure *Jatropha* oil (UNDP, 2004). Since early 2013, UNDP has supported the formulation of appropriate regulatory, legal

and institutional frameworks for *Jatropha* by implementing the project "Promotion of the Use of Agrofuels from the Production and Use of *Jatropha* Oil in Mali" (Table 4.3).

Creation of the Agency for the Development of Domestic Energy and Rural Electrification (AMADER) in 2003 reaffirmed the will of the Malian government to develop a coherent institutional framework to address priorities in the fields of energy and improvement of human well-being set at the international level in the late 1990s. The twofold aim of AMADER is to contribute to socio-economic development by increasing public access to electricity and reducing poverty (AMADER, 2012). AMADER collaborates with the PN/PTFM by installing MFPs and the decentralised power grids needed to provide rural areas with electricity (AMADER, interview data, 2010). In 2011, AMADER signed an agreement with ANADEB which aimed to increase rural access to electricity through the use of *Jatropha*-based biofuel (ANADEB, interview data, 2011).

With regard to rural development, national promotion of *Jatropha* is linked to activities carried out by the Ministry of Agriculture (MA), which is in charge of defining agricultural policies including the Rural Development Master Plan and the Agricultural Orientation Law. The National Directorate for Agriculture (DNA) – attached to the MA – promotes *Jatropha* uptake through awareness raising, farmer support and improvement of the production at the village level (DNA, interview data, 2011). In this regard, a project to support the development of the *Jatropha* chain in five southern regions (PADFP) was launched by the DNA in 2008 (Table 4.3). At the national level, a variety of Research and Development (R&D) *Jatropha*-related activities are carried out partly under the supervision of the MA – through the Institute of Rural Economy (IER) (IER, 2012), the research of which focuses on ecotypes and production techniques – and partly through the Ministry of Secondary and Higher Education and Scientific Research (MESSRS), which orients the work of two high education schools: the IPR/IFRA and ENI. The Rural Polytechnic Institute (IPR/IFRA) is active in agronomic research on *Jatropha* (*e.g.* breeding, propagation and seed varieties) as well as in testing the use of the oil on engines (IPR/IFRA, interview data, 2011). The National School of Engineers (ENI) carries out engine performance testing under a formal collaboration signed with ANADEB (ANADEB, interview data, 2011). Table 4.3 summarises the key implementation activities promoted by these institutional stakeholders in the promotion of *Jatropha* as a source of biofuel in the country.

Table 4.3: Implementation of *Jatropha* activities by institutional stakeholders

Project	Objectives	Partners / Date	Achievements and challenges
Jatropha System project (Wiesenhütter, 2003)	To test the potential uses of *Jatropha* in an integrated approach to rural development. Its main components include (i) cultivation of the plant as a hedge to protect farmers' fields and reduce soil erosion, (ii) use of the oil for soap production and to fuel local grinding mills, (iii) organisation of women's groups for seed collection and management of the mills, and (iv) use of the pressing residue as fertiliser.	GTZ in cooperation with CNESOLER. (1993-1997)	Positive outcomes are derived by using *Jatropha* as a living fence and fertiliser. Its use for oil has been proven to be technically feasible. **Challenges:** the project evaluation showed negligible potential for achieving development impacts. The use of *Jatropha* oil was assessed as unprofitable. This system was found to be unsustainable as it could not survive without ongoing monetary subsidies.
PN/PTFM Multifunctional Platforms Programme (UNDP, 2004; Nygaard, 2009)	The programme's specific objectives include to: (i) alleviate the chores of women in rural areas by introducing new energy sources (*e.g. Jatropha* oil) and technologies, (ii) develop and build capacity to own and manage MFPs by decentralised structures under female ownership, and (iii) promote the development of income generating activities.	UNDP and MIIC – funded by the Bill and Melinda Gates Foundation, Norway, Denmark, the Netherlands and France. (1996-1999: phase 1. In 1999 transferred to the government)	Pilot experiments on the use of *Jatropha* oil on 10 platforms have been carried out for this programme by Mali Biocarburant SA (Rodriguez-Sanchez, 2010). About 10 ha of *Jatropha* plantation can produce enough oil to operate one platform each year (UNDP, 2011b). **Challenges:** inadequate village-level training left poor capacity to manage the platforms; lack of feedstock (due to farming difficulties) translates into low availability of *Jatropha* oil.

PNVEP National Programme for the Energetic Valorisation of *Jatropha* (GoM, no date)	Overall goal: to provide *Jatropha*-fuelled electricity to 350 southern villages. The main objectives are to: (i) assess and improve the potential for *Jatropha* oil production and use, (ii) install the equipment required for the collection, transformation and utilisation of *Jatropha* oil, (iii) train target groups of the population on cultivation and oil production, and (iv) enhance rural energy.	CNESOLER – funded by the GoM (2004-2008; extended by ANADEB from 2009 to 2010)	According to semi-structured interviews with ANADEB (Bamako, 2011), the programme has allowed the electrification of 5 villages by 50 KVA generators powered by *Jatropha* oil and the adaptation of a 4X4 vehicle to be fuelled by *Jatropha* biofuel. **Challenges:** the project reached a notably smaller amount of villages than initially planned due to lack of financial and organisational resources.
PADFP Project to Support the Development of the *Jatropha* chain (GoM, 2011)	To: (i) promote the cultivation of *Jatropha* in five southern regions, (ii) promote food security, (iii) provide training on farming techniques, (iv) facilitate the commercialisation of the seeds on the market, (v) promote local use of *Jatropha* oil and foster community level development, and (vi) organise local farmers' cooperatives.	DNA (2008-2013)	As of 2011, 65 DNA agents per region (n=325 in total) have been involved in the following activities: (i) provision of theoretical training (regional level) and technical training (village level) to farmers, and (ii) awareness-raising in non-grower villages (DNA, interview data, 2011). **Challenges**: inadequate financing mechanisms available to support activities in the field and expand the training. Poor communication with other directorates and ongoing activities in the field. Weak reporting and monitoring systems.

Mainstreaming Sustainability in the Agrofuel Sector in Mali	Study of sustainability criteria for the development of the biofuels sector in Mali and elaboration of a certification scheme.	ANADEB and MFC in collaboration with WIP (Germany) and Fact Foundation (Netherlands) (2011-2012)	As of late 2013 11 sustainability criteria have been approved by the Malian government (semi-structured interview with ANADEB, 2013). **Challenges:** the lack of a legal framework for biofuel investments limits the capacity to enforce these criteria.
SREP Scaling Up Renewable Energy Program for Low Income Countries (WB and GoM, 2011)	The SREP aims to help Mali use new economic opportunities to increase energy access through renewable energy use. SREP's project 2 "Hybrid Rural Electrification" seeks to electrify isolated low income populations. The use of *Jatropha* as a source of fuel to power productive rural uses for agricultural businesses (*i.e.* grinding machines and de-huskers) and create new jobs has been identified among the SREP's options.	Led by DNE with support of WB and AfDB. Funded under the WB's Clean Investment Fund umbrella. (2011-2016).	Work is being carried out to improve the regulatory and institutional framework in the renewable energy sector with the aim to attract an increasing number of local and international private investors. Emerging *Jatropha* business models for off-grid electrification in rural areas are under assessment (ANADEB, interview data, 2011). **Challenges:** the political upheaval has blocked SREP's activities which have started again in late 2013.
Promotion of the Use of Agrofuels from the Production and Use of *Jatropha* Oil in Mali	The overall goal of the project is to develop and promote a sustainable model for the production and use of *Jatropha* oil at the national level. The main objective includes reducing the use of diesel in the transport and energy production sectors through use of *Jatropha* oil in MFPs and vehicles (UNDP, 2011b).	UNDP and ANADEB (Start date 2013, for 4 years).	The project proposal identified key priorities, including to: (i) formulate a *Jatropha* development strategy, (ii) address private sector investment constraints by putting in place an appropriate regulatory framework, (iii) strengthen R&D, and (iv) remove constraints to rural actors' ownership. **Challenges:** political upheaval.

The multiple institutional stakeholders and implementation activities identified illustrate the commitment of the Malian government to promote *Jatropha* at national and local levels. The analysis also reveals a lack of coordination among these actors. Overlapping roles hamper the achievement of policy goals. Similar R&D activities are carried out by multiple stakeholders, through formal collaboration between different agencies and research institutes (*i.e.* ANADEB and ENI on engine's tests) as well as through independent work carried out in different directorates (*i.e.* IER and IPR/IFRA on agronomic research), but they often lack visibility. Information circulated among different institutions about their strategic orientations, objectives and ongoing activities was found to be "dispersed" (MA, interview data, 2011). ANADEB does not have comprehensive access to information on past activities (Table 4.3). This limits its capacity to draw on useful lessons learnt from the past to promote better practices. As regards current activities, ANADEB notes that despite being in charge of collecting, processing and storing statistical data, the data collection and analysis system is "still weak": "*We are facing some difficulties, our monitoring system is still weak, but it will be fully functional by next year*" (ANADEB, interview data, 2011). While the NSBD sets specific quantitative targets in relation to a desired amount of land covered by *Jatropha* (Table 4.2), ANADEB did not have access to up-to-date official figures on actual land cover. These constraints translate into a limited capacity to carry out harmonised on-the-ground activities in the achievement of common *Jatropha*-related goals (ANADEB, interview data, 2011).

More broadly, overlapping mandates on renewable energy among the MMEE, MA and MEA constrain the development and implementation of coherent frameworks of action. The MMEE promotes, controls and monitors, the renewable energy sector, whereas specific *Jatropha* activities are carried out by its specialised agencies. The MA aims to support the MMEE by carrying out independent activities with similar goals (*i.e.* improvement of agriculture through promotion of renewable energy) but which are not controlled by the MMEE. Promotion of renewable energies (*i.e.* biofuels) is also a priority action of the MEA. An effort to create a framework of cooperation and coordination for the promotion of biofuels, in line with the priorities set in the National Strategy for the Development of Renewable Energy as well as in the NSBD, was made in 2008, through the creation of ANADEB, but this institutional stakeholder is still in a learning-by-doing phase. Strengthening the data collection and monitoring system, the institutional framework, as well as clarifying the mandates of the main national directorates and agencies operating in the renewable energy, rural development and

environmental sectors, is essential for the successful promotion of *Jatropha* production and use.

4.4 Local level implementation: projects and modes of operation

Since 2007, local level project activities have been undertaken in the production, extraction, transformation and utilisation of *Jatropha* by different organisations. In 2011, *Jatropha* cultivation in Mali – excluding minor ongoing initiatives and the area covered by living fences – accounted for roughly 5,000 ha, involving the participation of approximately 5,000 smallholder farmers supported by four main initiatives located in the southern regions of Sikasso, Koulikoro and Kayes (Figure 4.2).

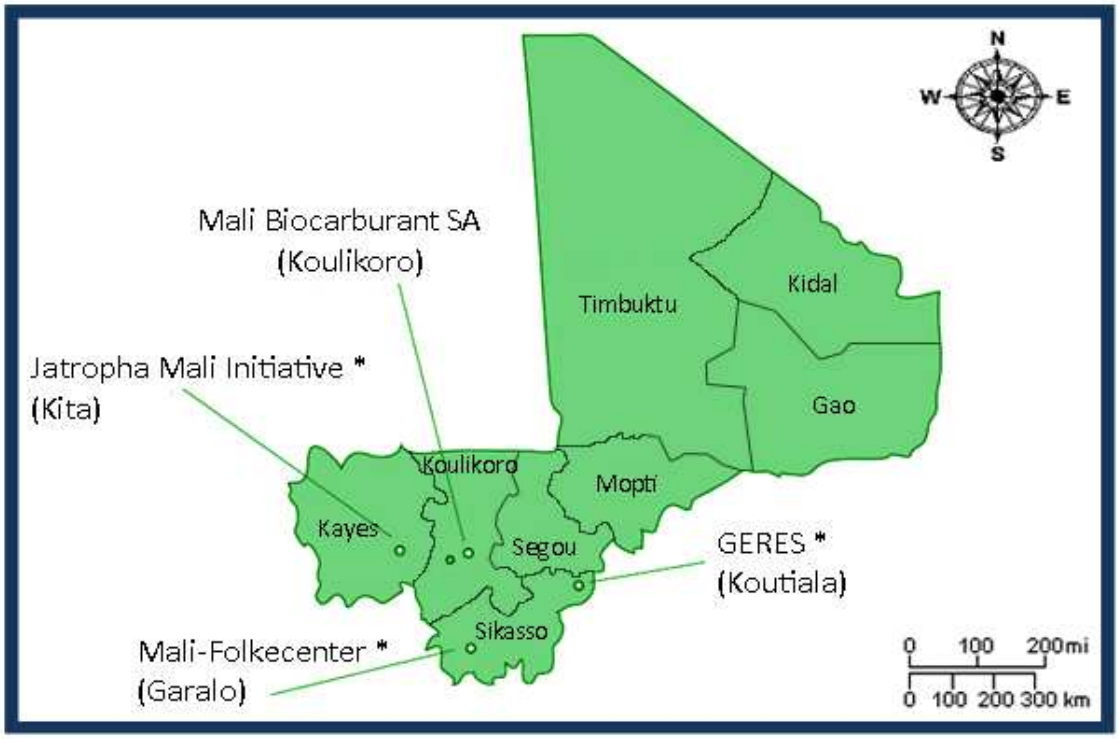

Figure 4.2: Location of the major *Jatropha* project activities (private sector and NGOs) in Mali.

Source: author. * Study sites where local empirical data collection took place

These comprise two private companies (Malibiocarburant SA and Jatropha Mali Initiative) and two NGOs (Mali-Folkecenter and GERES Mali). Their main objectives, characteristics and key challenges are summarised in Table 4.4.

Table 4.4: Characteristics and challenges of the major *Jatropha* project activities in Mali.

Initiative	Description and objectives	Progress to date and key challenges
MBSA Mali Biocarburant SA (MBSA, 2012)	MBSA is a private Dutch company which aims to produce refined biodiesel for the domestic market sourcing its stock from roughly 2,000 ha of *Jatropha* grown by 1,800 smallholders (MBSA, interview data, 2010). The farmers, organised in cooperatives and represented by the farmers' union, own 20% of the shares of the company. Technical training on farming techniques and agricultural diversification are promoted by the Malibiocarburant Foundation. The Foundation also works on the certification of carbon credits on the voluntary market, which in 2010 represented 40% of its total revenues (MBSA Foundation, 2010).	The farmers' union manages a centralised oil press and a soap production unit installed by MBSA. *Jatropha* oil is sold to the MBSA's biodiesel transformation unit, while leftover seedcake is sold to the farmers. Soap is produced from glycerine – a *Jatropha* by-product. The processed biodiesel is sold to local users. **Challenges:** Limited feedstock availability hampers the production of higher quantities of *Jatropha*-based biodiesel.
JMI The *Jatropha* Mali Initiative (ECO CARB0NE, 2012)	JMI is a French-Malian joint venture with the objective of producing pure *Jatropha* oil – promoting out-grower schemes – for local and national markets, alongside the commercialisation of seedcake, the pressing residue that can be used as organic fertiliser. As of 2011, 2,050 small-scale producers grouped in cooperatives in partnership with JMI have planted a total surface of 1,740 ha of *Jatropha* within the country. JMI's start-up funding was generated through *Jatropha*-based carbon credits earned in 2008 under voluntary schemes (JMI, interview data, 2011).	Village level training in the production of improved quality *Jatropha* soap have allowed revenues to be generated that are notably bigger than those derived by seed sales. The leftover seedcake sold at a preferential price to the farmers provides a cheaper source of organic fertiliser. **Challenges:** Small yields are a relevant constraint to the production and commercialisation of *Jatropha* oil and seedcake. Lack of oil on the market is a major constraint to improving local soap production.

GERES Groupe Energies Renouvelables (GERES, 2013)	GERES is a French non-profit NGO that promotes rural electrification through the ALTERRE (Local Biofuel, Rural Development and Energy) project. Its main goal is to facilitate establishment of a local *Jatropha*-based biofuel supply chain and produce the technical and organisational knowledge required for future replication. In 2011 GERES collaborated with 870 small-growers covering a total surface of 350 ha of *Jatropha*. GERES plans to construct three decentralised pilot oil extraction units – managed and owned by the villagers or local operators – with the aim of securing a local market for *Jatropha* oil (IRAM-GERES, 2009).	One pilot oil extraction unit was installed in the region of Koury in 2011 (GERES, interview data, 2011). **Challenges:** As of 2011 the extraction unit was not yet fully operative and remained in a "learning-by-doing" phase. GERES is facing limited feedstock availability due to low yields. This hampers the capacity to guarantee a regular volume of production to the operator of the extraction unit.
MFC Mali-Folkecenter Nyetaa (MFC, 2012)	MFC is a Malian NGO that targets the promotion of out-grower schemes for improving rural electrification through power generators that can run with pure *Jatropha* oil. Through the project "Garalo Bagani Yelen rural electrification using *Jatropha* oil", in 2011, MFC supported 320 farmers on a total cultivated surface of 550 ha of *Jatropha*. MFC has well established links with key institutional stakeholders in the energy, environmental and agricultural sectors as well as with international donors. In 2011 the MFC coordinated the elaboration of the National Climate Change Policy and in 2012 it supervised the study and elaboration of national biofuels sustainability criteria commissioned by ANADEB (Table 4.3).	A power generator and centralised oil press were installed in 2008 by MFC in the village of Garalo. This is managed by a power company called ACCESS, a subsidiary of MFC. The press functions under the supervision of ACCESS but is formally controlled by the farmers' union, which manages the purchase of seeds, oil extraction and sale, as well as the commercialisation of the leftover seedcake to be used as fertiliser. **Challenges:** Relatively small quantities of seeds have been commercialised and transformed into oil. As of 2011 the power generator is entirely fuelled by regular diesel (ACCESS, interview data, 2011).

Sources: (i) Descriptions: projects websites, (ii) Progress and challenges: semi-structured interviews at community and village levels.

As outlined in Section 4.2 (Table 4.1), a range of policy drivers have been promoted by the government to foster the *Jatropha* sector in Mali. However, interviews with the local level project developers indicate that market forces (rather than policy drivers) played a major role in their decision to invest in *Jatropha* activities (Table 4.4). Positive expectations on the potential for *Jatropha* cultivation to sequester carbon (Bailis and Baka, 2010; Basili and Fontini, 2012) in the overall effort to address global climate change have driven the NGO community and private sector to develop pilot activities aimed at fuel production and rural electrification. The establishment of *Jatropha* plantations is seen as a unique means to access sources of direct foreign investment provided by innovative market-based mechanisms such as the CDM (Schneider *et al*., 2010). However, as of 2011, none of the projects analysed was able to design an approved methodology that would allow commercialisation of the carbon credits through the compliance market (*i.e.* CDM). JMI's start-up funding was generated through carbon credits under voluntary schemes, which do not comply with formal CDM methodologies. Similarly in the case of MBSA, carbon credits on the voluntary market represented 40% of the total revenues of its Foundation in 2010 (MBSA Foundation, 2010). The formal methodologies that project developers are currently pursuing are diverse and reflect their operational objectives and overall aims: *e.g.* while JMI is targeting the AR-AM-0004 (version 2) "Reforestation or afforestation of land currently under agricultural use", GERES targets the SSC-NM009 "Substitution of fossil fuel in combustion engines through agrofuel from degraded land". In contrast, while interviews with the MFC indicate that efforts have been made towards the commercialisation of carbon credits: "*Of course, we all want to earn carbon credits*" (interview data, MFC, 2011), actions remain vague in terms of how these are outlined in the interview. No specific targeted methodology was identified and no concrete activities in this regard were found to be implemented or planned.

All of the analysed activities operate in collaboration with communities in the establishment of local *Jatropha* plantations. To various extents, farmers are provided with technical support on farming techniques and a guarantee that their seeds will be purchased at a fixed price (Section 5.6.1.1 provides a detailed outline of price variations and supply chain organisation among the operators). Semi-structured interviews reveal that the level and type of support provided varies across as well as within projects. JMI organises soap production training sessions at the village level, where farmers are taught how to produce a high quality, marketable white soap derived from the *Jatropha* oil (which is different than the black soap traditionally produced from the crushed seeds and used within the household). According to farmers' interviews only

2 of the 6 project villages visited received the training, but JMI indicates that a higher number of villages will be covered once the oil production is increased. This approach is in line with JMI's main objective (Table 4.4), to produce and sell the oil locally with the aim to generate profit. In contrast, while the MFC asserts that "*all farmers are encouraged to produce Jatropha soap*" (MFC, interview data, 2011), no training has been implemented as the farmers are expected to use their own initiative. A similar situation was observed in the GERES project area. This is due to the fact that the latter two operators privilege the use of the seeds for oil production, with a view to foster energy generation (Table 4.4). As a result, none of the interviewed farmers under MFC and GERES projects were aware of the possibility to produce high quality white soap that can be commercialised and used as shower soap. As such, the financial gains from soap production in the JMI area were reported to be notably higher than within the other projects (see Box 5.1, Chapter 5).

Semi-structured interviews with project developers and in-depth livelihood interviews (Section 5.6.1.1) indicate that agricultural training is provided by JMI and GERES throughout the different phases of the farming calendar. The villages are visited regularly to check the state of plantations and guide the farmers on key actions that should be implemented across different periods (*e.g.* setting up tree nurseries, pruning or cutting for propagation): "*Particularly in the first few years, if you do not remind the farmers what they should do, how and when, they will not grow Jatropha effectively. They will set up their seeds nursery too late and will not leave enough time for the plant to grow before it is planted in the field when the rain starts. Most of the times they will prioritise other activities in the household*" (JMI, interview data, 2011). In the case of MFC, agricultural training was delivered to all interviewees (n=10) in the first year of plantation. However, as of 2011 only the 3 farmers interviewed in Garalo (the MFC headquarter) reported to have kept regular contact with the MFC's field staff. In the most isolated and difficult to reach villages visited in the MFC area (e.g. Zena), 4 farmers revealed that since the start of plantation, they had no visit from the MFC staff in the village and their level of trust in the project has decreased: "*They have forgotten us, how do they expect us to grow Jatropha just for the benefit of a few people in Garalo?*" (male farmer, Zena, MFC, 2011). The villagers of Garalo have been found to be prioritised against the other villages under the MFC's activities. For example, through a programme aimed to "*support the Jatropha farmers*" (MFC, interview data, 2011) the MFC facilitates the distribution of fertilisers on credit through the controlled microcredit organisation Nyeta Finance. It was revealed that while "being a *Jatropha* farmer" is a formal condition to be eligible for the credit, in practice this is not

necessary as the key requirement is to be a registered customer of the ACCESS energy provider (MFC, interview data, 2011). These observations suggest that the MFC prioritises the production of electricity (as of 2011 almost entirely diesel-fuelled) for the village of Garalo, rather than the establishment of a *Jatropha* supply chain across villages. While the establishment of successful plantations of *Jatropha* is a major component of JMI and GERES work, this is a relatively minor driver of implementation in the case of MFC: "*We are not able to access the credit for fertilisers because we do not have an electricity meter, but we are growing Jatropha for them. This is unfair, only the villagers of Garalo are getting benefits out of this*" (male farmer, interview data, Sona, 2011).

Household level data from in-depth interviews show that those benefitting from NGO or private sector intervention reported difficulties in establishing successful plantations (Chapter 5). Farmers' incentives to invest adequate money, labour and time in *Jatropha* farming have been limited by the high incidences of termite attacks and low productivity under suboptimal agronomic conditions, the relatively small financial gains generated from the sale of the seeds and a perceived lack of project support. As a consequence, in the year 2011, yields were notably smaller than those foreseen by national policy (Table 4.2), the targets of which were revealed to be unrealistic. Towards the achievement of policy goals it is vital to recognise that *Jatropha* is not a wonder crop, and that in order to pursue effectively fuel substitution targets it requires adequate inputs (*e.g.* fertile land and water) and farmer support. Interviews with the NGOs and company representatives indicate that such problems perceived at household level are partly linked to the financial and organisational constraints faced by project developers, which limit their ability to adequately support the farmers (both technically and financially) in *Jatropha* agriculture. These activities are still in a learning-by-doing operational phase and their implementation relies on the limited financial support provided by bilateral donors and private entities. Thus, they have a limited capacity to meet the needs identified by farmers.

While these activities offer promising opportunities to improve the provision of rural energy, the challenges outlined above translate into low availability of feedstock on the market, which limits capacity to produce sufficient quantities of *Jatropha* oil. To date, *Jatropha*–based biofuel has been mainly used only for testing and demonstration. The MFC's power generator (Table 4.4) – which since 2007 has been providing rural electricity to the village of Garalo – still runs purely on regular diesel and estimates concerning the timeframe for substituting this with

Jatropha oil are unavailable. Similarly, the feedstock used to fulfil the needs of the 2,000 litre/day MBSA biodiesel plant (Table 4.4) – which currently works at its full capacity – comes only in small part from *Jatropha* while other vegetable feedstock is used (MBSA, interview data, 2011). Similar challenges are faced in the implementation of the Multifunctional Platforms National Programme (PN/PTFM). The total amount of MFP units installed by the PN/PTFM in Mali rose from 48 in 1999 to 1,000 in 2011 (UNDP, 2012). Improvements in the use of *Jatropha* oil in the platforms have been promoted by several policies including the National Strategy for the Development of Renewable Energies and NSBD, and in this regard, R&D has been carried out by national agencies (IPR/IFRA and ENI) and the private sector (MBSA). Nevertheless, despite the 15 years of experience gained in the implementation of MFPs in the country, according to UNDP, as of 2011, less than 30 units are operating on *Jatropha* oil, while the remaining are powered with regular diesel (UNDP, interview data, 2011).

A limitation in the implementation of local-level *Jatropha* activities was found to be the lack of a formal market where the plant's seeds can be commercialised. As reported in the household questionnaires and semi-structured interviews, the prices applied across different project areas vary, as well as the conditions applied to the farmers within single projects (Section 5.6.1.1). It was stressed by project developers that the current market structure favours opportunistic behaviours, where external buyers purchase the seeds in the villages at a higher price without delivering any additional socio-economic benefit. In the implementation of local projects, the operators commit to purchase any quantity of available seeds from their farmers with a view to processing them locally for the purpose of local energy and/or by-product production. Conversely, the benefits generated through seed processing by external buyers are delivered elsewhere. This harms the long term efforts and investments put in place by the local operators: "*Opportunistic people come to our villages and buy the seeds at a higher price. Obviously the farmers accept and criticise our project for paying a lower price. Then these occasional buyers leave the village alone. They screw up all our daily efforts made to support the farmers through agricultural training and by establishing long-lasting relationships*" (interview data, GERES, 2013). The production and sale of seeds is not considered profitable and other socio-economic benefits must accompany the development of a pro-poor *Jatropha* supply chain. In the implementation of national policy, the government should safeguard local markets so that the interests of the community and project developers are not hampered. According to interview data, promotion of local project cooperation through ANADEB is a

measure needed for sustainability to be enhanced: "*The government must privilege operations that are sustainable and promote cooperation across local operators*" (interview data, JMI, 2013).

While Section 4.2 shows that the establishment of a market for *Jatropha* under the guidance of ANADEB is a priority set in the NSBD, these inconsistencies indicate that policy is not adequately implemented. A concrete policy implementation strategy, which is currently lacking, is required: "*An implementation strategy is important in order to reach the targets set in the national biofuel policy*" (AMADER, interview data, 2010). The government should recognise that the establishment of a national strategy for the promotion of biofuels is a formal achievement that must be followed by concrete implementation measures in order for livelihoods and energy impacts to be delivered on-the-ground.

As discussed above, more coherent R&D activities are also required for the technological and organisational development of the *Jatropha* supply chain to be enhanced: "*If the state really wants to be involved with the promotion of Jatropha, it must support research*" (interview data, MBSA, 2013). The range of policy-led *Jatropha* activities implemented at the national level (Table 4.3) is found to be disconnected from the on-the-ground reality. These activities do not adequately foster the development of a successful supply chain that can deliver the expected benefits. The PADFP's main objectives include to: (i) facilitate the commercialisation of the seeds on the market, (ii) promote local use of *Jatropha* oil and foster community level development, and (iii) organise local farmers' cooperatives. Nevertheless, the findings presented in this section indicate that more concrete and better funded measures should be implemented to overcome local-level difficulties. Similarly, while the PNVEP overall goal was to provide *Jatropha*-fuelled electricity to 350 villages in the country, only 5 villages have been electrified due to the limited availability of financial resources. These observations further stress the need to establish an implementation strategy that translates the "on paper objectives" into "actual achievements". The strategy must set realistic measures that take into account not only the expected impacts of the proposed actions, but also the financial and technical capacity to implement them.

Win-win opportunities for fuel production and rural development are yet to be realised. Monitoring of village-level activities is essential to identify local barriers to *Jatropha* cultivation. The establishment of an implementation strategy for the NSBD, together with

policy investments supporting project developers and farmers are necessary to remove these barriers and create an environment conducive to the expansion of rural energy security.

4.5 Discussion: biofuel promotion and remaining policy gaps

By integrating the findings of sections 4.2, 4.3 and 4.4, this section evaluates the drivers and barriers to the achievement of policy goals in relation to *Jatropha* and identifies major gaps and challenges in policy implementation, towards the promotion of sustainable biofuels in Mali (research question vi). Since the 1990s, as the stakeholder and policy analysis reveal, the commitment of Mali to embark on expanding renewable energy production and use to fight the main environmental, socio-economic and energy challenges faced by the country has been expressed along various lines:

- Political: the role of renewable energy – particularly of *Jatropha*-based biofuel – has been formulated in key national and sector-specific policy papers (Table 4.1) such as the National Energy Policy, National Strategy for the Development of Renewable Energies, and National Strategy for Biofuels Development;
- Institutional: various specialised institutions integrating biofuel production have been created to achieve the policy objectives. These operate under the supervision of the Ministry of Mines, Energy and Water (MMEE) and include the National Centre for Solar and Renewable Energies (CNESOLER), the Agency for the Development of Domestic Energy and Rural Electrification (AMADER) and the National Biofuel Development Agency (ANADEB). Other major ministerial departments, including the Ministry of Agriculture (MA) and Ministry of Secondary and Higher Education and Scientific Research (MESSRS) support the MMEE in the promotion of biofuels;
- Technical: the institutional stakeholders identified in Figure 4.1 have been leading the implementation of a variety of ambitious programmes for rural energy access expansion through renewable energy (Table 4.3). Between 2008 and 2010 the national budget spending in the renewable energy sub-sector rose from USD 3.3 million to USD 6.7 million (representing 0.23% of the national budget) (WB and GoM, 2011). In this context, *Jatropha*-based biofuel has played an increasingly relevant role, with government spending accounting for roughly USD 2 million in 2010 (UNDP, 2011b).

These achievements demonstrate the capacity of the Malian government to effectively integrate the international priorities on sustainable development and energy (IPCC, 2007a;

Karekezi *et al.*, 2007; Kuchler and Linnér, 2012) into its national policies. The emergence of the "*Jatropha*" story-line in the international discourse (Section 4.2) has been a driver for Malian stakeholders to prioritise *Jatropha* in the national strategy. This has helped create a positive international reputation for Mali among international organisations and donors as a country that is committed to improving the well-being of its population through the diffusion of renewable energy. Such recognition placed Mali among the best candidate countries towards which the international community is willing to provide monetary, institutional and technical support towards the implementation of improved renewable energy activities. Mali was one of six countries selected to benefit from the "Scaling Up Renewable Energy Program for Low Income Countries" (SREP) under the WB's Clean Investment Fund. A total of USD 40 million funding has been allocated through the SREP (WB and GoM, 2011), exceeding 2010 national spending in the sub-sector 6-fold. In 2013 this was accompanied by the implementation of a UNDP project which aims to develop and promote a sustainable model for the production and use of *Jatropha* oil.

Gaps between policy targets (Table 4.2), land cover and actual yields are identified from the data. The national strategy aims to achieve a land cover of 71,680 ha by 2013. Assuming productivity of 3.125 T/ha *per annum* this would allow a 10% substitution of national fossil fuel consumption. Semi-structured interviews with government officials and research institutions, as well as village level data, reveal that as of 2011, actual yields are notably smaller than predicted (1.5 T/ha on average *per annum*) and the total cultivated surface of *Jatropha* – excluding minor ongoing initiatives and the area covered by living fences – did not exceed 5,000 ha. Concerning the low yields, the IPR/IFRA noted that the institutions have focused their goals on oil production without doing research on the tree first (interview data, 2011). While they promoted research on the use of the oil in engines, too little attention has been placed on the agronomic aspects of *Jatropha* and its capacity to produce enough oil. Village-level observations show that seed production is left to farmers' organisations which lack adequate support and face major constraints in *Jatropha* agriculture, achieving low yields (see Chapter 5). The observed limited capacity of project developers to adequately support the farmers in *Jatropha* agriculture is due to the financial and organisational difficulties linked to the early stage of development of these projects. The commercialisation of carbon credits potentially generated by *Jatropha* could provide new sources of income that can be used to better support project implementation (Bailis and Baka, 2010; Basili and Fontini, 2012). While this was found to be a major driver for the development of local *Jatropha* activities in the

country (*i.e.* MBSA, JMI and GERES), to date none of the analysed projects were able to establish a methodology that would allow CDM commercialisation through the compliance market. This raises concerns regarding the capacity of these activities to self-sustain and generate sufficient financial resources from the local promotion of *Jatropha.* This is particularly evident in the case of MFC. MFC is the only analysed operator that did not pursue a specific methodology and neither implement any assessment of its carbon sequestration potential, despite claiming that CDM commercialisation is a major goal. For this type of activity to be successful, investments are needed to enable monitoring of the state of plantations and scientific assessment of their potential for carbon sequestration (on which a successful CDM methodology must be based). The national level analysis informs that no support has been provided in this regard by the government so far. A potential role for the future development of CDM in the country linked to *Jatropha* agriculture could be played by the MEA through its attached AEDD agency, which is in charge of approving CDM projects.

The lack of a formal market for *Jatropha* seeds limits the capacity of the farmers to commercialise their production. The need to address market limitations and identify new avenues for access to financial resources towards an improved commercialisation and use of the seeds are important findings emerging from the data. Despite the range of national level projects being implemented with the aim to establish a market and support local production and use, on-the-ground impacts were found to be limited. This reveals a gap between the objectives set within national policy, programmes and projects ("*the stated aim of policies*" as defined by Jordan (1999:70)) and "*their practical impact on the ground*" (*ibid*). For livelihoods and energy impacts to be delivered, the establishment of a concrete and realistic policy implementation strategy is vital. The capacity to design a successful strategy is partially hampered by the lack of monitoring of *Jatropha* programmes and projects, which is needed to better inform policy making and target setting. The analysis presented here also highlights that better integration of the multiple national stakeholders as well as local project developers in the *Jatropha* sector must be achieved so that their activities can be implemented more effectively. Improved coordination under the guidance of ANADEB is needed to foster collaborative partnerships, advance R&D and develop successful markets. While current approaches to (and impacts of) project implementation have been found to be variable both across and within projects, the establishment of local level partnerships could help to identify a more standardised and replicable approach to *Jatropha* promotion.

The quantitative gaps identified indicate that the policy expectations are ambitious: "*(Jatropha) is a very fast growing tree and can start producing seeds in less than one year. It achieves maximum productivity within 3 or 4 years…requires almost no maintenance"* (GoM, 2008: 17) and that the quantitative targets should be revised. For targets to be met, the establishment of large-scale industrial plantations is required. Despite the claims being made by the NSBD and government officials regarding a commitment to attract large scale investments, a specific enabling environment to private investors in the biofuel sector is lacking (API-Mali, interview data, 2011). API-Mali highlights the need to urgently put in place adequate regulatory and fiscal frameworks (in terms of taxation, rules for site acquisitions and credit mechanisms) for the governance of private biofuel investments (*ibid*). ANADEB's Investment Promotion Department is in charge of doing this.

While as of 2011 no large-scale activities were reported and no cases of any *Jatropha*-related land acquisitions were observed, the potential establishment of large-scale activities could raise sustainability concerns. Interviews with ANADEB (2010) revealed that use of irrigation is envisaged in order to establish commercially viable plantations. This is in contrast with claims that *Jatropha* flourishes in marginal land with limited water supply and poor soil. As stated in the biofuels strategy: *"(Jatropha) can also grow on poor lands and has a good resistance to dryness*" (GoM, 2008: 17). Document analysis informed that a land acquisition pre-agreement between the Office du Niger (ON) – a public institution under the MA that manages the main area of irrigated land used for food production in the country – and a private agro-investor aiming to set up a 10,000 ha *Jatropha* plantation was signed in 2009 (UNDP, 2011b). The investor is not following-up with the expected activities due to unspecified reasons. Similar *Jatropha*-related concessions in the ON are observed by the Oakland Institute (2011). The establishment of agroforestry systems, intercropping *Jatropha* with food crops, allows agricultural diversification and guarantees the land used for food is not entirely shifted to biofuel production (see Chapter 5). Nevertheless, despite government officials stating that "*there is plenty of underutilised land*" available for energy crop cultivation in Mali (ANADEB, interview data, 2011), these observations raise concerns about the emergence of future food security and land acquisition threats. Access to land is legally regulated by the Agricultural Orientation Law (LOA) approved in 2006. USAID (2010) observes that due to the complexity of the tenure situation in Mali, large-scale agribusiness investments might threaten rural livelihoods when rules and obligations in terms of land and water use are weak. This reinforces broader concerns raised on "green grabbing", where "*'green' credentials are called upon to*

justify appropriations of land for food or fuel" (Fairhead, 2012: 238). Similarly, Woodhouse (2012) observes that large-scale foreign investments (such as those promoted by the Malian government) may compete with existing water use and intensify pressures on small-scale farmers. ANADEB envisages supervising future large-scale land acquisitions in order to guarantee the preservation of productive agricultural land as well as the socio-economic and environmental sustainability of biofuels operations. As of April 2012 prescriptive sustainability standards were being discussed and were planned to be approved by the end of 2012 (e-mail communication with ANADEB, 2012). Observations made during this research highlight the need for clear, binding rules supported by appropriate legal frameworks that set out the conditions for access to farm land and water linked to private biofuel investments.

Whether *Jatropha* will threaten food security or encourage unsustainable land acquisitions within the country will not depend on the presence of small-scale agroforestry systems but on the way in which the large-scale activities, fostered by policy drivers, develop. The establishment and enforcement of adequate regulatory, legal and institutional frameworks – a key priority in the analysed energy policies and for which support is being provided by various international organisations – will play a key role in avoiding unsustainable practices. Chapter 6 will integrate the implementation challenges identified here with the local level assessments presented in Chapter 5.

4.6 Summary

Through multi-level assessment of the Malian Strategy for Biofuels Development (NSBD), this Chapter has addressed policy and decision-making challenges related to biofuels and sustainable development in dryland sub-Saharan Africa. Research objective 1 was addressed, together with research question vi within research objective 3. Findings show that the use of *Jatropha* oil has been prioritised in national policy measures with the aim to achieve a variety of goals grouped under three key policy themes linked to the main debates surrounding biofuels: (i) socio-economic progress, (ii) agricultural development, and (iii) environmental conservation. The mainstreaming of internationally agreed principles into national policies attracted considerable monetary, institutional and technical support from international organisations and donors. The multi-level assessments identified implementation gaps between policy targets, land cover (uptake) and actual yields, raising concerns about the feasibility of policy goals. Major constraints in the achievement of policy targets at the village level include the limited capacity of project developers to adequately support their farmers

and produce sufficient quantities of *Jatropha* oil. At the national level, policy has been unable to attract the large-scale investments required to achieve ambitious fossil fuel substitution targets. This is due to the lack of coordination among state actors and a lack of adequate regulatory and fiscal frameworks to attract investment. Ambitious land cover targets set within national policies could risk land use shifts away from food production towards biofuels. Future threats from large-scale land acquisitions could emerge if an appropriate legal framework is not in place. The remaining analysis within research objective 3 is presented in Chapter 6.

Chapter 5

Unpacking livelihood challenges and opportunities in energy crop cultivation: perspectives on Jatropha curcas projects in Mali

"*Garalo, my beautiful village: Mali-Folkecenter, you know my beautiful village enlightened by the electric light that comes from Jatropha oil. It was lost in the darkness, now it shines like gold. My house smiles to me like heaven*"

(Poetry written by the President of the *Jatropha* farmers' cooperative, Garalo, MFC, 2011)

"I am aware of the possibility of transforming Jatropha into fuel, but have not seen the benefits here and am not sure if I will see any benefit in the future... if the project keeps disregarding us, I will abandon Jatropha"

(Male farmer, Sorona, MFC, 2011)

Outline

This chapter aims to address research objective 2: "Undertake a livelihoods analysis with focus on *Jatropha* at household level in rural Mali, exploring its role in livelihood diversification and its potential to contribute towards rural development". The chapter has been published by the Geographical Journal (Favretto *et al.*, 2013). It is structured around the published paper but to improve readability the headings and illustrations have been re-numbered according to the formatting style of this thesis and cross-references have been added where needed. Sections 5.1 and 5.2 have been shortened to avoid repetitions. New mixed-method assessments of the potential for, and initial impacts of, *Jatropha* projects that aim to improve livelihoods and energy security in rural Mali, are presented. Factors affecting the socio-economic and environmental vulnerabilities of smallholder farmers are assessed and capital assets available in the pursuit of different livelihood strategies are identified and evaluated. Comparative analysis of the information gathered through participatory methods allows evaluation of the

role played by *Jatropha* cultivation in the determination of different livelihood outcomes. On-the-ground challenges are identified, along with opportunities to better link policies to local-level practices.

5.1 Introduction

In contrast with concerns for large-scale biofuel plantation projects (see Section 1.1), small-scale cultivation of *Jatropha* has been identified as a promising livelihood diversification strategy for the rural poor and a route to help alleviate energy demands (Gilbert 2011; Palliere and Fauveaud 2009), restore degraded ecosystems (Garg *et al.* 2011) and generate income (Achten *et al.* 2010; Dyer *et al.* 2012) (see Section 2.3). This chapter provides empirical evidence on the role of *Jatropha* at village and household levels in rural Mali, paying particular attention to the ways it supports household livelihoods. It provides a new case study assessment of the potential of *Jatropha* to diversify livelihood strategies and enhance energy access in rural Mali, where roughly 99% of the population lacks modern energy services (COMPETE 2009a). Mali is one of the pioneers among sub-Saharan countries in *Jatropha* cultivation aimed at fuel production, due to pilot initiatives supported over the last decade by a variety of development agencies, government, private sector enterprises and NGOs (see Section 4.3).

Guided by the Sustainable Livelihoods Framework (SLF) (Section 2.4), after assessing the key socio-economic and environmental vulnerabilities of smallholder Malian farmers, comparative aspects of three selected pilot activities (Section 3.1.5) are drawn out in the analysis, in order to answer the following research questions:

(i) What are the opportunities offered by small-scale *Jatropha* agriculture to improve livelihoods and rural energy security?

(ii) Does small-scale *Jatropha* farming compete with land, labour and food production at the household level?

(iii) To what extent do people achieve their livelihood goals, and what barriers do they face?

5.2 Research methods

Mixed-method approaches were used to assess the potential of *Jatropha* to diversify

livelihoods and expand access to energy in rural Mali. These include semi-structured interviews undertaken with informants from government, international organisations, the private sector and NGOs (n=76), household questionnaires (n=40 in field season 1 and n=80 in field season 2), focus groups (n=17 in field season 1 and n=14 in field season 2) and in-depth livelihoods assessment including semi-structured interviews, transect walks, cropping calendars and wealth ranking (n=30 in field season 2) (see details outlined in Sections 3.2 and 3.3).

5.3 How do smallholder Malian farmers sustain their living? Illustrative livelihood portfolios

This section outlines the livelihood strategies pursued by case study households in light of the varied combinations of capital assets available. Household level data are provided from questionnaires, in-depth semi-structured interviews and seasonal calendars.

Crop production is the main livelihood activity pursued, and is strictly dependent on access to land. The average land area used by interviewees – including abandoned, fallow and cultivated land – was 19 ha (30 ha in Koutiala, 16 in Kita and 10 in Garalo). Only 4 households (13% of 30) were able to farm all the available land, while in the other cases, the actual cultivated surface was notably smaller than the total land area available, accounting for 18 ha (Koutiala), 10 ha (Kita) and 6 ha (Garalo) (Table 5.1)[5]. According to interviewees, limits in expanding the farmed land area are due to the insufficient labour, farm equipment, fertilisers and seeds.

Table 5.1: Differences in average surface of used and farmed land across case study areas

Project area	Average owned land (ha per household)	Average cultivated land (ha per household)
Koutiala (GERES)	30	18
Kita (JMI)	16	10
Garalo (MFC)	10	6

Source: 30 household questionnaires validated through in-depth interviews and farming calendars

[5] The average cultivated land in highly populated areas of Africa accounts for less than one ha, while in sparsely populated semi-arid areas it exceeds 10 ha (Salami *et al.*, 2010).

Differences in total cultivated land size are related to the household wealth status, which overall ranks across the following categories: (A) 33%, (B) 53%, (C) 10% and (D) 4%. Variations in wealth levels are noted among the 3 project areas (Figure 5.1).

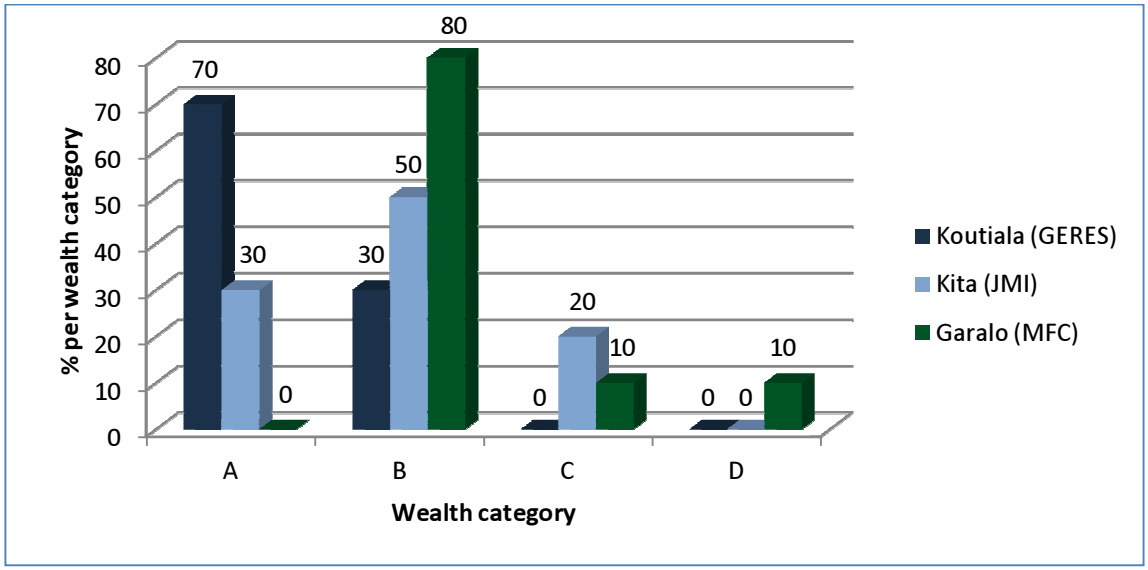

Figure 5.1: Wealth ranking across case study areas (% per wealth category)

Source: 30 household questionnaires validated through in-depth interviews and farming calendars

The wealthiest households (category A) cultivate a larger average area of land (21 ha) than categories B (7 ha), C (6 ha) and D (5 ha) (Figure 5.2).

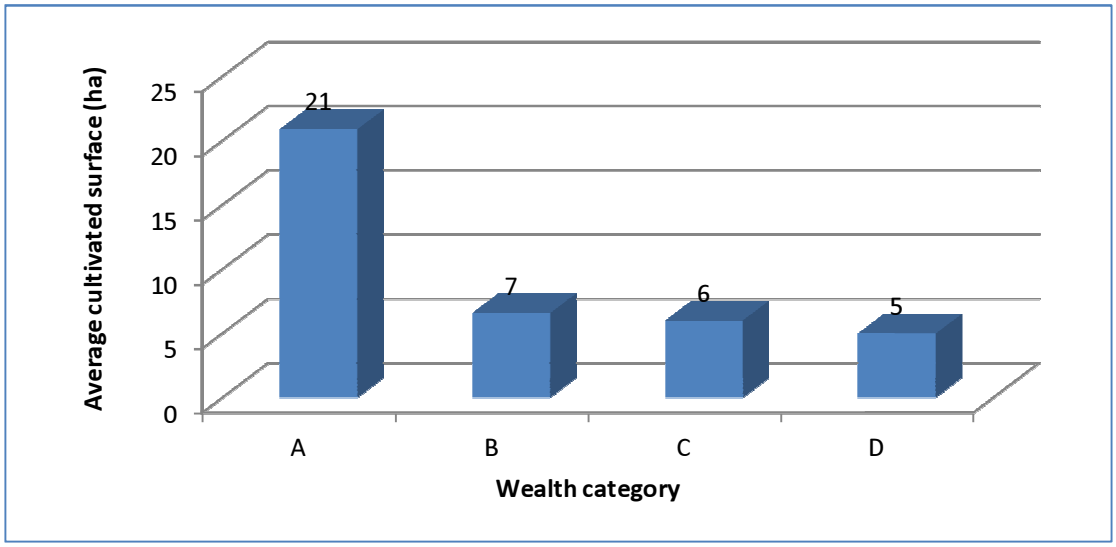

Figure 5.2: Average cultivated surface (ha) by wealth ranking category

Source: 30 household questionnaires validated through in-depth interviews and farming calendars

These observations highlight the importance of physical capital – on which the wealth ranking categorisation is based – in sustaining livelihoods of the poor, by allowing a larger acreage of land to be cultivated. These differences arise as wealthier households have more financial capital to hire labour, buy farm equipment and fertilisers. This translates into higher food production, therefore improved food security and the possibility to sell the surplus and generate revenues, offering an important diversification activity. Conversely, poorer households have less capacity to absorb labour shortages, and this negatively affects their other capitals. For example, this translated into lower attendance at school and higher vulnerability to child labour (human capital): "*I cannot afford to send my kids to school, fees are too expensive and I need to feed my family... who is going to work on my land?*" (Male farmer, Zena, MFC, 2011). Labour and agricultural equipment are often shared among relatives or neighbours to address this situation, with group work carried out with tools such as oxen and ploughs in rotation across different fields. This highlights the key role played by social capital in sustaining the livelihoods of poorest households.

Cultivated land is distributed among major subsistence crops, vegetables and cash crops (Table 5.2). These findings mirror those of Fofana *et al.* (2011) and Pasquini and Gamby (2007) who conducted household surveys to investigate trends in agricultural production of rural Malian households.

Table 5.2: Major subsistence and vegetable crops grown in the study sites

Subsistence crops	Vegetables	Cash crops
1. Sorghum	1. Gumbo	1. Cotton
2. Millet	2. Ethiopian eggplant	2. Peanut
3. Maize	3. Cowpea beans	3. Sesame
4. Rice	4. Sweet potato	4. Shea nut (Karité)
	5. Chilli pepper	
	6. Tomato	
	7. Onion	
	8. Salad	
	9. Cucumber	
	10. Cassava	

Source: 30 household questionnaires validated through semi-structured interviews, farming calendars and transect walks

The average land area cultivated for major crops grown across wealth categories is presented in Figure 5.3.

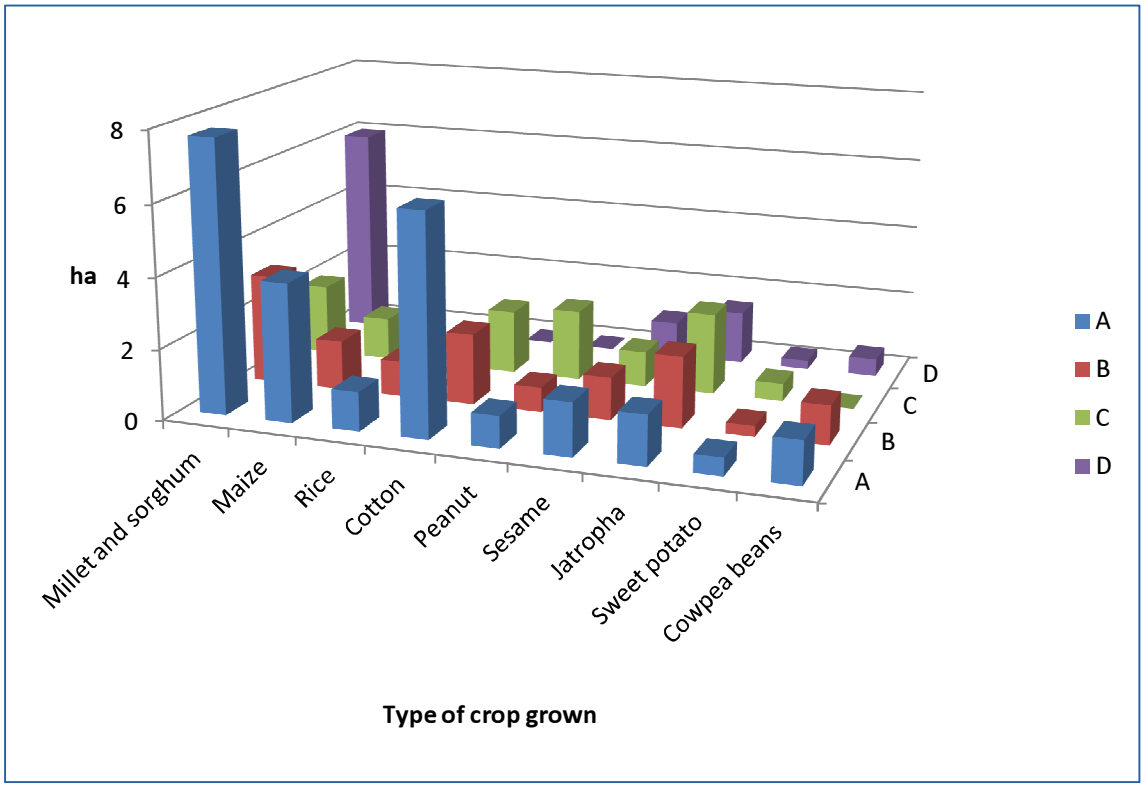

Figure 5.3: Average land area (ha) cultivated for different crops grown across wealth categories

Source: 30 household questionnaires validated through semi-structured interviews and farming calendars

Average land areas for single crops (particularly millet, sorghum and cotton) are higher for wealthier respondents (category A). This is particularly evident in the case of cotton, where a high level of inputs (*i.e.* chemical fertilisers and labour) is required. Differences in cotton uptake were observed across project areas. In Koutiala (where the overall wealth status is higher) 100% of the respondents grow cotton, while in Kita 60% and in Garalo (lowest wealth ranking) only 30% of the respondents are involved with cotton farming. As Figure 5.3 shows, diversification under the lowest wealth category (D) is lower, with no household growing maize, rice, cotton or peanut. A different trend is noted in *Jatropha* agriculture, where a larger average cultivated area was observed to be increasing at lower wealth categories (category A, 1.4 ha, category B, 2 ha, category C, 2.3 ha and category D, 1.5 ha). This suggests that *Jatropha* agriculture can be successfully integrated within the livelihood portfolio of poorer households.

This is due to the lower level of inputs required in comparison to the other crops: "*Jatropha is an easy to grow crop*" (Male farmer, Kona, GERES, 2011).

Resource-poor Malian famers rely on rainfed agriculture and traditional farming techniques (Fofana *et al.,* 2011; Pasquini and Gamby, 2007). Compost production is a common practice and access to chemical fertilisers is limited. Cotton is popular because it is perceived not only as a good source of liquidity (financial capital) but also of physical capital: at the beginning of each sowing season, cotton growers receive fertilisers on credit, with the promise of repayment at harvest time (Theriault *et al.*, 2013). This has positive impacts on other forms of capital (particularly human), by increasing food security: "*Cotton farming gives me access to fertilisers...this has improved my cereal yields*" (Male farmer, Douna, GERES, 2011).

Livestock production is the second major livelihood activity. Figure 5.4 outlines the average livestock ownership across wealth categories.

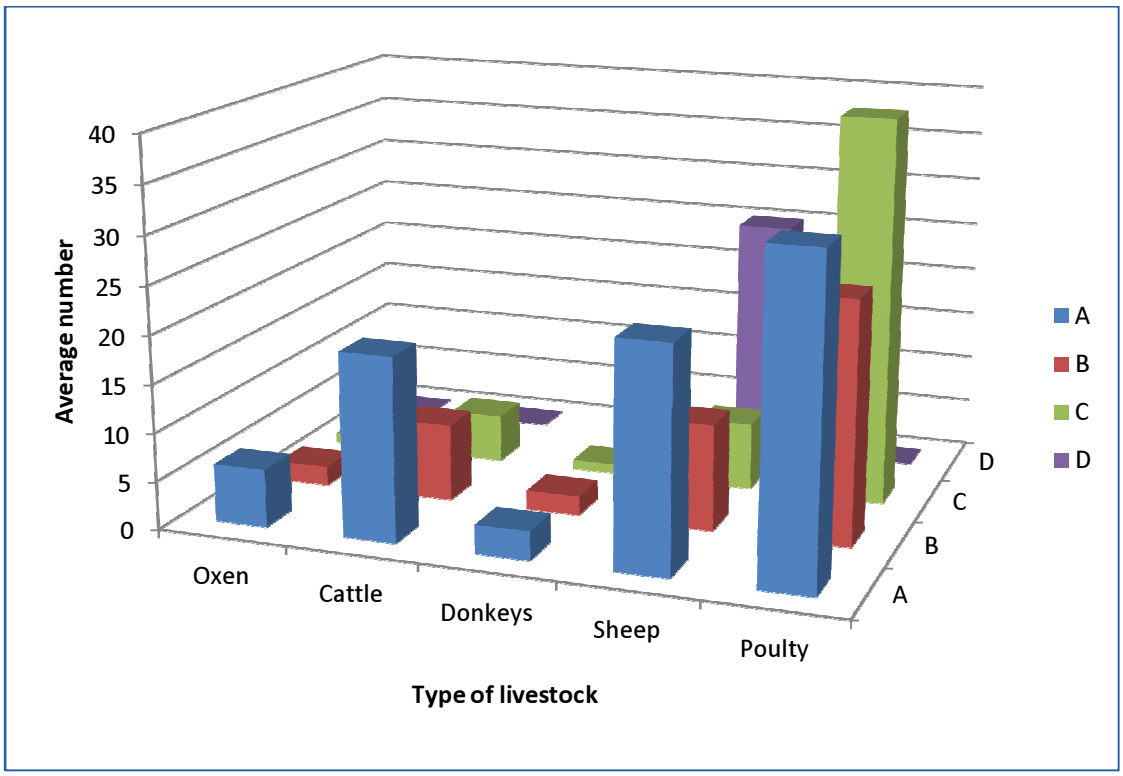

Figure 5.4: Average livestock ownership across wealth categories

Source: 30 household questionnaires validated through semi-structured interviews and farming calendars

Livestock ownership data indicate that wealthier households own a higher average number of oxen and cattle than poorer household. This links to the smaller cultivated areas of poorer households. Oxen are a key agricultural input required to cultivate more land and a notable difference in ownership is observed between categories A (6), B (2), C (1) and D (0). The latter category relies almost entirely on the help of the extended family when oxen are needed throughout the farming calendar: "*I have to grow with my own hands. Sometimes I can borrow a pair of oxen from my uncle but these are not always available as he needs them for his crops first*" (Male farmer, Zena, MFC, 2011). Similarly, higher cattle numbers can only be afforded by richer people (19 in category A, 8 in category B, 5 in category C and 0 in category D). In contrast, differences in small-stock (*i.e.* sheep and poultry) ownership across wealth categories were observed to be smaller (Figure 5.4). This indicates that small-stock farming is a more accessible form of livelihood strategy for poorer households. Livestock are mainly used within the household, where only 10 respondents (33%) belonging to the wealthier category commercialise farm livestock to generate a regular income. In most cases (n=20, 67%), livestock are sold only in exceptional circumstances, when immediate liquidity is needed (*e.g.* in case of illness, weddings or funerals). This creates a vicious cycle that shows how integrated the different forms of capital are: a loss in human capital (*e.g.* health) can lead to a decrease of financial capital (*e.g.* the oxen normally used for agriculture are sold to buy medicines), which ultimately reduces natural capital (*e.g.* cultivated land) and the overall livelihood outcomes of the household.

Households also pursue a variety of off-farm activities aimed at generating financial capital. These include seasonal labour, fruit sales, household manufacturing, handicrafts, micro to small-scale business (*e.g.* welding, tailoring and grocery sale), gold mining and remittances. When liquidity is urgently needed, interest-free money is borrowed from family, neighbours and friends, while microcredit is perceived as a less accessible option due to the limited capacity to provide a reimbursement guarantee. This shows again how access to safety nets (social capital) is essential to enhance diversification options. Table 5.3 outlines the range and frequency of the off-farm activities pursued across different wealth ranking categories.

Table 5.3: Range and frequency of the off-farm activities pursued across different wealth ranking categories

Wealth category	Off-farm types of employment (frequency and % in each wealth category)
A (n=10)	• Micro to small-scale business (*i.e.* welding, tailoring, grocery sale) (8, 80%) • Seasonal labour (2, 20%) • Transport and sale of diesel to the village (1, 10%) • Employed by the cotton cooperative (1, 10%)
B (n=16)	• Micro to small-scale business (*i.e.* welding, tailoring, grocery sale and local taxi service) (6, 38%) • Seasonal labour (5, 31%) • Remittances (3, 19%) • Household manufacturing and handicrafts (2, 13%) • Marabu (religious leader) (1, 6%) • Gold mining (1, 6%)
C (n=3)	• Seasonal labour (3, 100%) • Remittances (1, 33%) • Fruit sales (1, 33%) • Brick making (1, 33%)
D (n=1)	• Seasonal labour (1, 100%)

Source: 30 household questionnaires validated through semi-structured interviews and farming calendars

Wealthier households are able to afford higher financial investments, which allow the establishment of small-scale businesses such as a local taxi service, welding, tailoring and grocery sale (80% in category A, 38% in category B, 0% in categories C and D). Diversification options for less wealthy households are more limited, with the most common off-farm activities mainly being seasonal labour (20% in category A, 31% in category B, 100% in categories C and D) and remittances (0% in category A, 19% in category B and 33% in category C). While seasonal labour offers a source of income, it also reduces availability of labour on the farmer's own land, which means reduced human and natural capitals. This suggests that a smaller range of diversification options is available to poorer households to break their cycle of poverty (*cf.* Sallu *et al.* 2010).

This section has shown that the livelihood portfolios of the study households are highly variable and capitals are interlinked. While a high dependence on natural capital is evident, the limited availability of human and physical capitals restricts people's capacities to make effective use of natural capital and to cope with major shocks.

5.4 Social, economic and environmental vulnerabilities of Malian *Jatropha* farmers

Household questionnaires, in-depth semi-structured interviews and seasonal calendars allowed assessment of the vulnerability context, which is outlined in Table 5.4 and explained in this section. National level data on the trends and shocks that globally affect the agricultural activities of all the Malian farmers is linked to the local level data to show the relevance of these issues to the *Jatropha* farmers.

Table 5.4: Key social, economic and environmental vulnerabilities of rural households in Mali

Key vulnerability factor	Description
	1. Trends
Increase in population	• Total population: 15.8 million people; • Average annual rate of population change in the period 2005-2010: +3.1%, worldwide ranking 13th out of 196 countries in 2010 (UNDESA, 2011).
Increasing pressure on natural resources	• Caused by: (i) growing population, (ii) declining amount – and increased intensity – of rainfall, and (iii) delay in rainy season (GoM, 1998 and 2012). • Growing scarcity and degradation of natural resources – including deforestation – translate into reduced soil fertility and a high susceptibility to soil erosion and desertification (COMPETE, 2008; GoM, 1998 and 2012; IPCC, 2007c).
Increasing pressure on energy production	Growing population translates into a strong increase in energy needs: "*The rising demand for electricity might lead to power outages in the years to come if the generation capacity is not enhanced*" (WB and GoM, 2011: 1). Government capacity to provide basic energy needs is hampered by the relatively expensive costs of the transport and distribution of grid connected energy.
Increasing prices of oil and food	Petroleum is not produced in the country and the Malian energy sector is fully dependent on imported oil (GoM, 2007). Increases in oil prices affect food production and prices (AfDB *et al.,* 2012).

Increasing difficulties in cotton agriculture	Since the 2000s, significant reduction of acreage and production due to institutional constraints, including low credit recovery rates and delayed payments to farmers (Theriault *et al.*, 2013).

2. Shocks

Political instability	Security threats in the North – including trafficking, rebellious uprisings and terrorist activity –and military coup in March 2012: reduced access to food and fuel (AfDB *et al.*, 2012).
Climatic shocks	Uneven and delayed rains, droughts and water flows (GoM, 1998 and 2012).
Crop failures and drops in food production	Sharp fall in agricultural production in 2011, caused by climatic shocks (AfDB *et al.,* 2012).
Pests and diseases	These are one of the major causes of crop failures (GoM, 1998).
Loss of physical and human capitals	Death or loss of livestock and illness of family members negatively affect agricultural productivity (Fofana *et al.*, 2011).
External shocks	Libyan war, post-elections crisis in Ivory Coast, rising prices of oil and food (AfDB *et al.,* 2012).
Vulnerability of the energy sector to climate change	Climate change impacts on the production of hydroelectricity, which accounts for 55% of the energy mix (WB and GoM, 2011).

3. Seasonality

Labour shortages	Mainly experienced between June and November (cropping calendars and in-depth interviews, 2011)
Poor harvests	Linked to lack of labour and major environmental shocks.
Food shortages	Lowest food availability in August / September (cropping calendars and in-depth interviews, 2011)
High variability of food prices	Highest peacks in September (cropping calendars and in-depth interviews, 2011).

5.4.1 Trends

Mali is amongst the countries with the highest rate of population change and lowest per capita energy consumption in Africa (GoM, 2007). It is one of the world's least developed countries (UNDP, 2011a) and its growing population places additional pressure on energy production. From a climatic perspective, reduced annual rainfall since the 1970s (GoM, 1998), together with dramatic spatio-temporal variations and prolonged dry spells, have enhanced land degradation (Wong *et al.,* 2005), and disrupted the cropping schedule. Increased rainfall intensity was observed by 5 interviewees (17% of 30 households), who reported substantial food crop damages caused by heavy rains, particularly since the mid-2000s: "*In the past 3 years the rain was more intense than usual and it has destroyed some of my crops"* (Male farmer, Kona, GERES, 2011). Ten farmers (33%) reported a delay in the rainy season compared to 10 years before. To adapt to these changes, the sowing period has been gradually postponed: "*Every year I start sowing at a later date because the rain comes too late"* (Male farmer, Kala, JMI, 2011). As a consequence of postponed sowing, seasonal vulnerabilities such as food shortages are exacerbated.

Over the last decade cotton farmers have experienced increasing difficulties which have reduced their capacity to generate cash. The functioning of local cotton cooperatives has been hampered by increasing levels of debt. Delayed payments to farmers have hampered their capacity to reimburse creditors. This has had negative repercussions on successful farmers, who were responsible for reimbursing not only their own loan but also the overall debt of the cooperative. Many producers have therefore abandoned the cooperatives and cotton farming, with *Jatropha* gaining increasing relevance.

5.4.2 Shocks

The Malian economy's growth has been threatened by various shocks even before the major conflict since March 2012 (post data collection), which has led to reduced access to food and fuel particularly to the detriment of the poorest people in society. From an international perspective, the country suffered from the post-elections crisis in Ivory Coast, the Libyan war, and a rise in oil and food global prices. In 2011, this situation was worsened by a sharp fall in agricultural production due to drought. At the national level, increased climatic vulnerability exacerbates shocks in the energy sector, dominated by hydroelectricity. The cultivation and use of *Jatropha* as a fuel seek to reduce the impact of these shocks on the livelihoods of the

rural poor by improving fuel independence and providing a diversified source of income (in addition to the traditional ones outlined in Section 5.3).

5.4.3 Seasonality

Seasonality has critical impacts on the livelihoods of Malian farmers. Figure 5.5 outlines the agricultural workload of a typical interviewee during the year, as assessed through farming calendars.

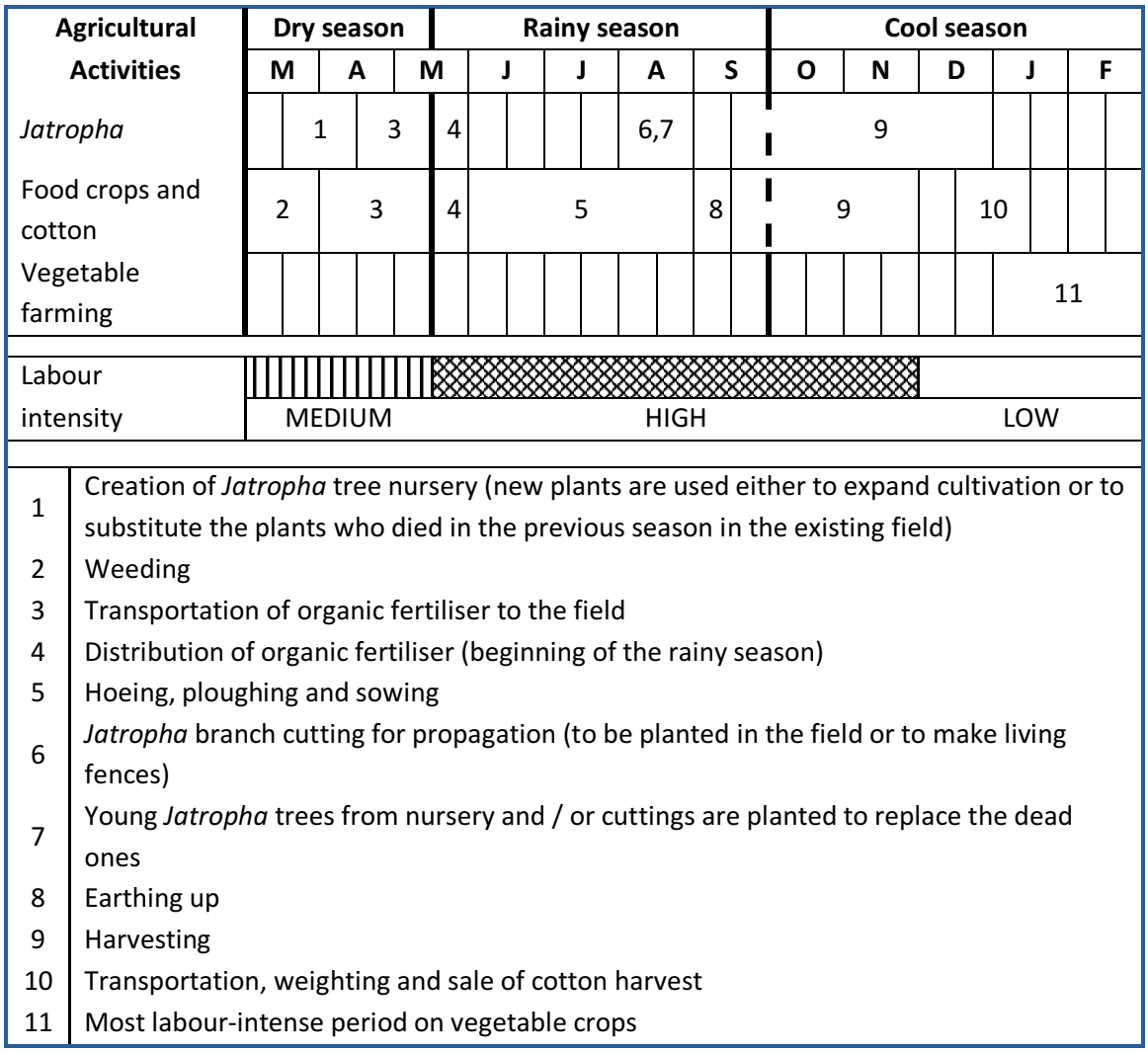

Figure 5.5: Example farming calendar, in-depth interview, Kita (JMI), 2011

Source: 30 farming calendars

Cropping calendars reveal that labour shortages occur between June and November, during the ploughing, sowing, and harvest periods of cereals and cotton. Labour shortages, together with limited access to farming equipment and fertilisers, limit the capacity to cultivate more

land and diversify livelihood activities. According to focus groups and household interviews across the three case studies, food shortages are a major seasonal stress. This situation is exacerbated by poor and postponed harvests, which increase the gap between cereal production and consumption needs. As a consequence, there is a high variability of food prices, which peak in September at the beginning of the harvest season (Figure 5.5). While the livelihoods of the less wealthy households are most vulnerable to these shocks, wealthier households are able to generate profits: "*I normally wait until September to sell my cereals surplus... food availability is very low at that time and I can sell at much higher prices*" (Male farmer, N'gorola, MFC, 2011). The poorest are often obliged to sell livestock or borrow money to afford food while waiting for the next harvest.

While *Jatropha* cultivation and use offers new opportunities to reduce the farmers' seasonal vulnerabilities by diversifying access to different capital assets, knowledge of the trade-offs that might arise is still limited and is discussed in the following sections.

5.5 Farmers' uptake reasons: expectations and priorities

Farmers' uptake reasons and priorities in relation to *Jatropha* cultivation are now assessed using the findings from SLF interviews and questionnaires. Findings are grouped according to the perceived contribution of *Jatropha* uptake to each of the five capital assets (Figure 5.6). *Jatropha* is mainly grown as a means for improving physical and financial capitals, while a smaller impact is perceived on natural and human capitals. No claims that social capital has been improved through *Jatropha* uptake were made.

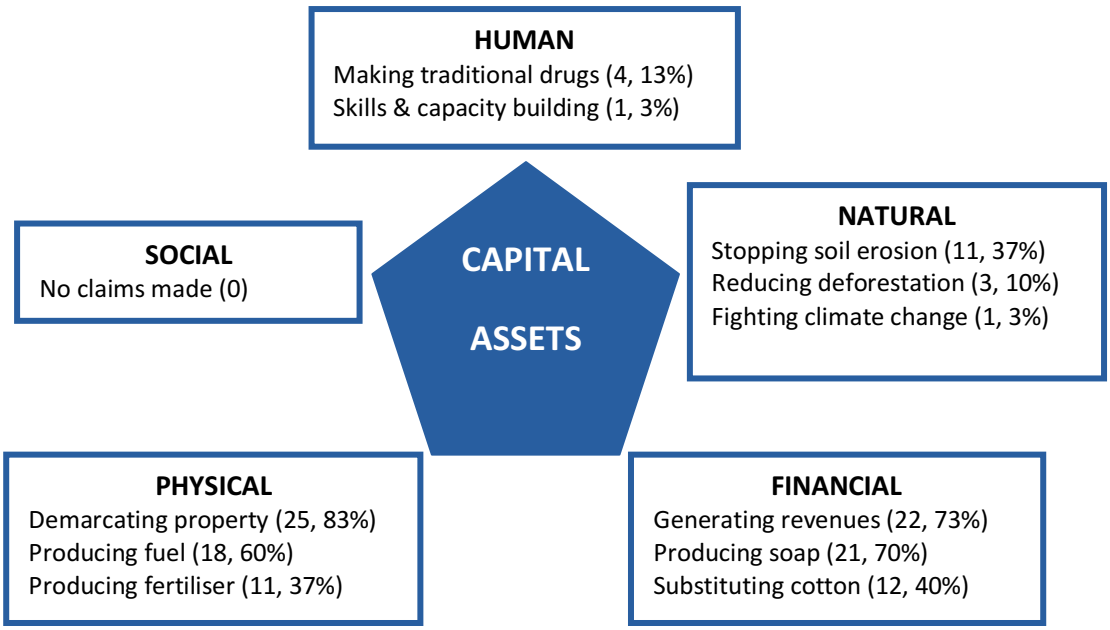

Figure 5.6: Reasons for uptake of *Jatropha* by farmers in the three selected study sites

(In brackets: number of people mentioning the asset, n = 30 household-level in-depth interviews)

5.5.1 Physical capital

Jatropha has been traditionally used as a living fence at the study sites (n=25, 83%) to demarcate property and manage environmental vulnerabilities by protecting food crops from water flows, soil erosion and grazing animals: "*For 50 years, Jatropha had delimited* [cereal] *crops in order to avoid conflicts among the farmers in the village*" (Male farmer, Karaya-Toumouba, JMI, 2011). Given promises made by the pilot activities established in 2007 with the aim to develop *Jatropha* as a biofuel crop, high expectations are also put on the use of *Jatropha* oil to substitute diesel consumption and improve electrification (n=18, 60%). With regards to productivity improvements, 11 interviewees (37%) hope to benefit from access to cheaper organic fertiliser produced by the pressing residue from *Jatropha*.

5.5.2 Financial capital

Twenty-two interviewees (73%) plan to generate revenues due to their involvement with *Jatropha* activities and the sale of seeds. The expected improvement in financial capital was seen as a strategy to secure cereal provision in periods of shortage: "*The project told us that we will gain a lot of money from Jatropha...In the future, revenues from Jatropha will pay food for my family*" (Male farmer, Garalo, MFC, 2011). Twenty-one interviewees (70%) have been using *Jatropha* seeds since the 1970s to produce black soap and reduce household expenses.

Jatropha is also perceived as easier to grow and less labour-intensive compared to cotton. Twelve interviewees (40%) hope to substitute cotton farming with *Jatropha* in the future: "*When the Jatropha price increases, I will quit cotton*" (Male farmer, Garalo, MFC, 2011). Only one interviewee (3.3%) has reported replacement of cotton with *Jatropha*. Five interviewees (17%) noted that the immediate cash liquidity coming from *Jatropha* can reduce the problems faced by the highly indebted cotton cooperatives. *Jatropha* cultivation is therefore a strategy to diversify livelihood strategies and is perceived as a new source of household income. Actual and prospective financial impacts of *Jatropha* cultivation and use on livelihood diversification are explored in Section 5.6.1.

5.5.3 Natural capital

Growing *Jatropha* as living fence is seen as a livelihood activity that can reduce environmental vulnerabilities by reducing soil erosion and restoring degraded land (11 interviewees, 37%). Only 3 (10%) respondents claimed benefits in the fight against deforestation, while one farmer noted that "*Planting Jatropha trees can help to fight climate change*" (Male farmer, Bendougouba, MFC, 2011). These data show that according to the farmers' perceptions, the environmental reasons related to *Jatropha* uptake play a less relevant role than those linked to enhancing physical and financial capital.

5.5.4 Human capital

Jatropha is perceived to contribute to human capital in terms of health care improvement, supporting findings in the wider literature (*cf.* Sabandara *et al.*, 2013). Four interviewees (13%) reported the use of *Jatropha* for making traditional medicines, where seeds, boiled leaves and branches residues are used for treating malaria, sore throat, headaches, wounds, skin diseases and intestinal worms.

5.5.5 Social capital

Despite none of the interviewees reporting perceived benefits from *Jatropha* uptake in this regard, the analysed pilot project activities appear to have fostered social capital improvements. In three villages, women have formed collective *Jatropha* farming groups. Such reinforced interaction among villagers can strengthen their negotiating power and generates a common financial interest based on cooperation.

5.6 Lessons learned in small-scale *Jatropha* projects: key opportunities and challenges

Drawing on evidence from this Malian case study, this section outlines the opportunities and challenges related to *Jatropha* as a biofuel crop and rural development tool. The lessons learned provide valuable perspectives on future *Jatropha* development, but it should be noted that projects remain relatively young and are still in a "learning-by-doing" phase. Operations of the pilot activities examined started between 2007 (MFC) and 2008 (JMI and GERES) and have been constantly evolving.

5.6.1 Revenue generation: the seeds of an economy or plant of unfulfilled promise?

Household level interview data show that *Jatropha* offers potential to generate revenues through the sale of seeds and soap. The major barriers described below need to be overcome in order to achieve more substantial impacts.

5.6.1.1 Sale of Jatropha seeds and market structure

All of the *Jatropha* pilot activities operate in collaboration with farming communities in establishing small-scale *Jatropha* plantations. Figures 5.7 and 5.8 outline the supply chain structure of MFC and JMI. This allows a better understanding to be gained of how *Jatropha* production and marketing are organised and supported. A detailed structure for GERES could not be drawn as the operator was still in the process of testing varied modes of supply chain organisation (*i.e.* use of cooperatives versus independent producers, use of centralised pressing units managed by independent economic operators versus local units managed by village committees).

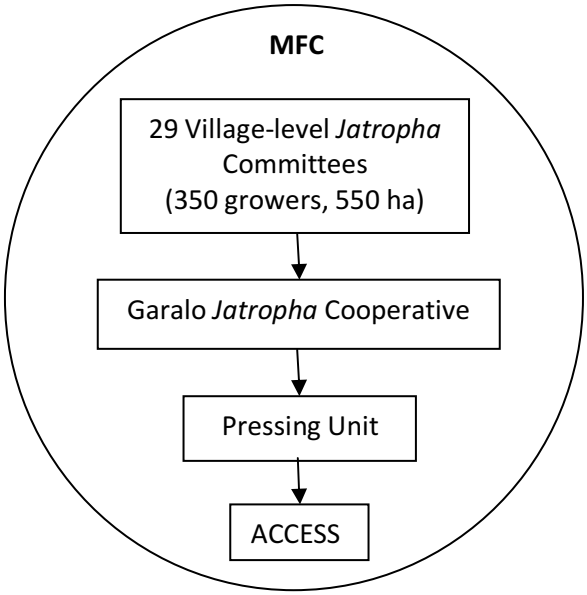

Figure 5.7: MFC's supply chain organisation

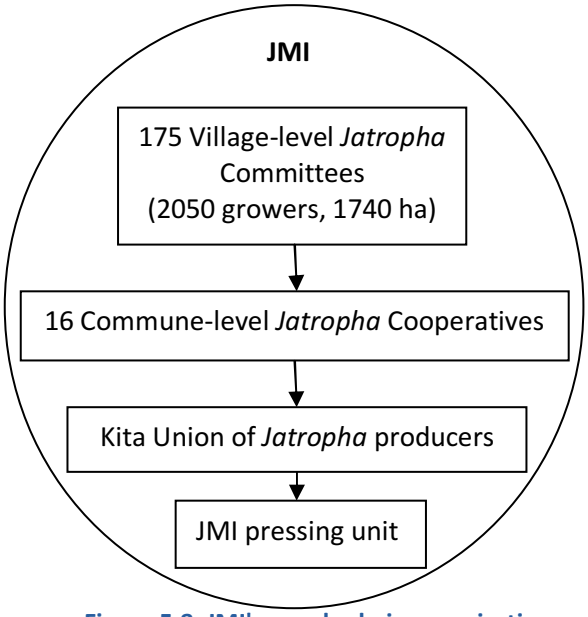

Figure 5.8: JMI's supply chain organisation

Source: semi-structured interviews with JMI and MFC

Both under the MFC and JMI technical support on farming techniques is provided through village level farmer cooperatives. Seeds are purchased by all projects (including GERES) either at their headquarters or directly in the villages. Under JMI seed collection is managed by the Kita Union of *Jatropha* producers (Figure 5.8). The seeds are then sold to JMI which is then in charge of oil extraction and sale. Farmers can also sell directly to JMI's headquarters. At the time of interview, MFC was in charge of seed purchase and pressing through ACCESS. It is

envisaged that in the future these activities will be controlled by the farmers' cooperative (Figure 5.7) which will sell the processed oil to ACCESS for energy generation.

All the projects provide the farmers with a guarantee that seeds will be purchased at a fixed price, which at the time of field observation ranged between FCFA 50 and FCFA 90 / kg[6] (Table 5.5). The price is not determined by formal authorities (*e.g.* ANADEB has no influence on price setting), but rather, the different operators tend to informally align with each other every year.

Table 5.5: Purchase price of *Jatropha* seeds applied by MFC, MBSA, JMI and GERES (FCFA / kg, year 2011)

Operator	Price of seeds (FCFA/kg)
MFC	50
MBSA	50
JMI	50
GERES	90

Source: 30 household questionnaires and semi-structured interviews with MFC, MBSA, JMI and GERES

Variations are not only observed across projects (with GERES paying the highest price, *i.e.* 90 FCFA / kg) but also within single projects. For example, the MFC pays a lower amount when the seeds are purchased by its field officers directly in the villages. Conditions are not standardised (the price ranges between FCFA 45 to 35 /kg) and depends on the bargaining skills of the farmer as well as whether the seeds are dehulled: "*When we collect directly at the village we have to cover transport expenses, so we pay a lower price. Each time we assess the quality of the seeds and if they are dehulled and we try to make a good deal*" (ACCESS/MFC, interview data, 2011). In contrast, JMI and GERES apply standard price conditions. They prioritise purchase at the headquarters but they also buy in the villages at the same price. Price fluctuations may also be induced by external operators. It was reported that up to FCFA 200 / kg were paid in the area of Koutiala (GERES) by a company called SudAgri. In the JMI area, womens' associations were found to pay up to FCFA 250 / kg with the purpose of producing soap from the purchased seeds. These price distortions reveal an inconsistency of the market structure which limits (i) the functioning of the projects: "*We need more seeds. Farmers are*

[6] Exchange rate FCFA / US$: 1 FCFA = 0.0021 US$. Source: www.xe.com, date: 25/02/2014.

reluctant to sell their production and they complain that other users pay higher prices" (MFC, interview data, 2011) and (ii) the capacity of farmers to benefit from the commercialisation of their seeds: "*We cannot travel so far* [to the project headquarters] *to sell just a few kg of seeds, it is not convenient. When they come to buy in the village they pay an even lower price which does not compensate the time spent for harvesting and dehulling*" (male farmer, Kona, MFC, 2011).

Semi-structured interviews with JMI, GERES and MFC indicate that different volumes of seeds are purchased and processed by these operators. The total number of *Jatropha* growers, surface cover, quantities of seeds purchased and processed and volumes of oil produced are summarised for each project in Table 5.6.

Table 5.6: Total number of *Jatropha* growers, surface cover, quantities of seeds purchased and processed, and volumes of oil produced in 2010 across projects

Operator	Number of growers	Total surface cover (ha)	Quantity of seeds purchased (tonnes)	Quantity of seeds pressed (tonnes) and % of the total	Quantity of oil processed (litres)
JMI	2,050	1,740	10.8	6 (56%)	1.2
GERES	870	350	7.5	3 (40%)	0.6
MFC	320	550	6	2 (33%)	0.4

Source: semi-structured interviews with JMI, GERES and MFC, 2011

Table 5.6 shows that a higher share of seeds (over the total quantity purchased in 2010) has been pressed by JMI in comparison to the other operators. JMI's approach (Figure 5.8) reflects its commitment to maximise extraction so that increasing quantities of oil can be commercialised (the oil content of 1 kg of seeds ranges between 21% and 23%). GERES pressed 40% of the seeds in order to test the pressing equipment which at the time of interview was still in the installation phase. In contrast with JMI, GERES does not prioritise oil production but focuses its research and operational efforts on the testing of different modes of operation, towards the establishment of a sustainable supply chain. GERES envisages that local operators

will be put in charge of oil extraction and sale: "*We have only extracted 3 tonnes of seeds just to test the press and the use of oil on engines. We are still organising the supply chain; we are in the process of identifying the most suitable operators that can manage the press in the future*" (GERES, interview data, 2010). In the case of MFC, only 33% of the seeds available have been pressed. While such limited quantity was partly justified by the need to test the new pressing equipment installed in 2010 (ACCESS, interview data, 2010), this also reveals that the MFC prioritises the achievement of growing levels of oil production less than is the case in other projects (*i.e*. JMI). This hampers a larger level of diesel substitution to be achieved for the power generator managed by ACCESS.

Profitability of these operations is linked to their capacity to achieve sufficient scales of production. According to JMI, between 200 and 400 tonnes of seeds must be processed to cover the expenses of the production unit and 1,000 and 3,000 tonnes are needed to cover the total investments (including R&D and village-level agricultural training) (JMI, interview data, 2013). For these conditions to be met, increases in productivity are needed. As discussed in Chapter 4, government support through an adequate implementation strategy is needed in terms of R&D, agricultural training and market protection against "opportunistic" competition. JMI and MFC (interview data, 2011) stress that in order to guarantee profitable oil production, the maximum price paid for the purchase of the seeds cannot exceed the actual prices outlined in Table 5.5 (*i.e.* FCFA 50 / kg). This is confirmed by GERES, which claimed to be generating losses when the price applied is FCFA 90 / kg. If production costs increase, the final price per litre of *Jatropha* oil (FCFA 550 / l in 2011) would exceed the one of regular diesel (FCFA 600 / l in 2011), hampering its substitution. As such, future increases of seed prices are subject to fossil fuel price trends. Interviews stress that government support is needed to overcome key barriers in terms of market structure and pricing. As stated by JMI, urgent financial incentives are needed. These may include tax exemption for *Jatropha* oil and the establishment of a subsidy for *Jatropha* oil similar to the one applied to diesel. Adoption of these incentives would not only make the *Jatropha* supply chain more competitive, but would also enable the operators to increase the price at which the seeds are purchased. Higher revenues for farmers would be generated if such support was possible.

At the village level, income from sales of seeds has been mainly used by households in all project areas for buying clothes for religious ceremonies (n=5, 17%), repairing agricultural equipment (n=2, 7%), buying school material (n=2, 7%) and reducing the expenses for animal

vaccinations and fertilisers (n=2, 7%). Nevertheless, revenues through seed sales remain low and farmers' perceptions of the viability of income from the plant remain negative (n=25, 83%).

While the production and sale of seeds alone are not yet profitable, they should be seen as a potential source of diversification, as long as communities can benefit from other uses of *Jatropha* such as soap production. This creates a safety net in relation to shocks and stresses. It adds a new option to the array of coping strategies most traditionally used, such as selling livestock, providing seasonal labour and borrowing money.

Economic benefits from *Jatropha* are linked to those in the cotton market. To date, profitability per ha of *Jatropha* is lower than for cotton but priority will be given to *Jatropha* in the future as long as prices and yields increase: "*Last year Jatropha was replacing cotton, but this year in light of the increased cotton price to FCFA 230, Jatropha will not be competitive anymore*" (Male farmer, Bendougouba, MFC, 2011). These findings suggest that to replace cotton and succeed as a livelihood diversification strategy, *Jatropha* cultivation must be accompanied by benefits other than the sale of seeds.

5.6.1.2 Soap production

Larger revenues than through seed sales have been generated by *Jatropha*-derived soap, both in terms of reduced outgoings and enhanced income. Malian families have 50 years of experience with black soap production (derived from the crushed seeds) which can contribute to reduce family expenses of up to US$ 48 annually according to interviews. Findings show that revenue generation opportunities come from production and commercialisation of improved-quality white soap (derived from processed *Jatropha* oil) (n=3, 10%) (Figure 5.9). A farmer case study is outlined in Box 5.1.

Figure 5.9: *Jatropha*-derived white soap for sale, Kita (JMI), 2011.

Box 5.1: Farmer case study: production and commercialisation of white soap from *Jatropha* oil

Bombo, Male farmer, 52 years old, is the president of a *Jatropha* cooperative associated with JMI, in a village located in the Kayes region. Since the early 1980s, his household – comprising 30 people – has been delimiting its own food crops with *Jatropha* living fences. Traditionally, *Jatropha* seeds produced by these fences used to be harvested by women and crushed to produce black soap to be used within the household.

Since the arrival of JMI in 2007, Bombo has established a *Jatropha* plantation (intercropped with cereals) with the intention to generate a stable source of income from the sale of seeds to JMI, and benefit from the future use of the oil as an alternative fuel. In 2011, his total cultivated surface of *Jatropha* accounted for 3.5 ha, with a plan to expand it to 5 ha in the subsequent year. Currently, all the harvested seeds are sold to JMI, including the ones produced by the living fences.

Bombo's family has been trained by JMI to produce white soap out of the *Jatropha* oil extracted and commercialised by the latter (Figures 5.5 and 5.6). Basic tools required to produce the soap and cut it into pieces of equal shape and weight have been provided by JMI (Figure 5.7). Since receiving this training, Bombo and his wife have been regularly producing and selling white soap: "*We always sell all our production very easily at the market"*.

Production of 50 bars of soap requires 2 hours of work and the use of 6 litres of *Jatropha* oil (cost: US$ 0.84 / litre), 1 kg of caustic soda (US$ 1.52) and 2.5 litres of water. One unit of soap is sold at US$ 0.24.

Calculations show that Bombo's net profit from the sale of 50 bars of soap accounts for US$ 5.44. Assuming a regular sale of 50 bars per week, the revenues that can potentially be generated annually account for up to US$ 261.

While Bombo is eager to expand his production, currently this potential cannot be reached due to the limited amount of oil offered by JMI: "*If I could buy more oil, I would drastically expand my production as there is so much demand for these soaps*".

Figure 5.10: Soap production, Karaya-Toumouba (JMI), 2011.

Figure 5.10: Soap drying, Karaya-Toumouba (JMI), 2011.

Figure 5.11: Basic tools required for cutting soap, Karaya-Toumouba (JMI), 2011.

Production requires a pressing infrastructure and basic tools to allow the household to cut the soap into pieces of equal shape and weight (Figure 5.11). The soap is sold to local markets at the competitive price of US$ 0.24 per unit, which according to the interviewees makes the product easily saleable. One interviewee reported that due to her involvement with the soap business her capacity to borrow money has increased: *"*[White] *soap production improved my life... if I want to borrow money, now it is easier because people know that I will be able to reimburse"* (Female farmer, Bendougouba, JMI, 2011). This improves not only the household's social capital (credibility and reputation within the community) but also access to financial capital.

The scale of such success stories remains small – 10% of the interviewees are able to produce and sell white soap. However they do show that *Jatropha* offers promising potential to increase financial capital through this activity. To achieve this goal, it is vital to provide adequate farmer support and training, otherwise expected benefits will not materialise. This mirrors findings from Basinger *et al.* (2012) who highlight the key role played by information provision in determining farmers' uptake decisions and implementation of optimal practices.

5.6.2 Improving rural energy security with *Jatropha* oil

At the village level, potential benefits from *Jatropha* oil include substitution of diesel consumption and improvement of rural energy access (Achten *et al.,* 2010; Gilbert, 2011). The analytical assessments carried out here confirm that establishment of local *Jatropha* supply chains can generate such benefits. Increases in physical capital fostered by improved access to *Jatropha*-fuelled decentralised electricity grids for energy supply (as promoted by MFC and GERES) favour income generation opportunities through the establishment of small-scale businesses. It can also improve human capital through better access to health: "*Since we have electricity the pharmacy has been able to keep medicines cool in a refrigerator*" (Male farmer, Garalo, MFC, 2011) and education: "*Thanks to public lighting, our kids can now study after dusk*" (*ibid*). *Jatropha* oil can potentially substitute diesel consumption in local grinding machines and fuel Multifunctional Platforms to provide mechanical power for agriculture and energy generation.

Concerns were raised, particularly that there is a lag time between initial investments and the derivation of benefits. Challenges faced by farmers in *Jatropha* agriculture translate into low availability of feedstock on the market, which limits capacity to produce sufficient quantities of *Jatropha* oil. To date, *Jatropha* oil has been mainly used only for testing and demonstration. The MFC power generator (Figures 5.8 and 5.9) has been delivering electricity to Garalo farmers since 2007; however the generator is diesel powered and estimates concerning the timeframe for substituting this with *Jatropha* oil are unavailable. This is in contrast with the positive outlook on biofuels (Gilbert, 2011: 18), which asserts that *"*[*Jatropha* in Garalo]*... provides electricity to 350 homes"*.

Figure 5.12: ACCESS/MFC oil press, Garalo, 2011

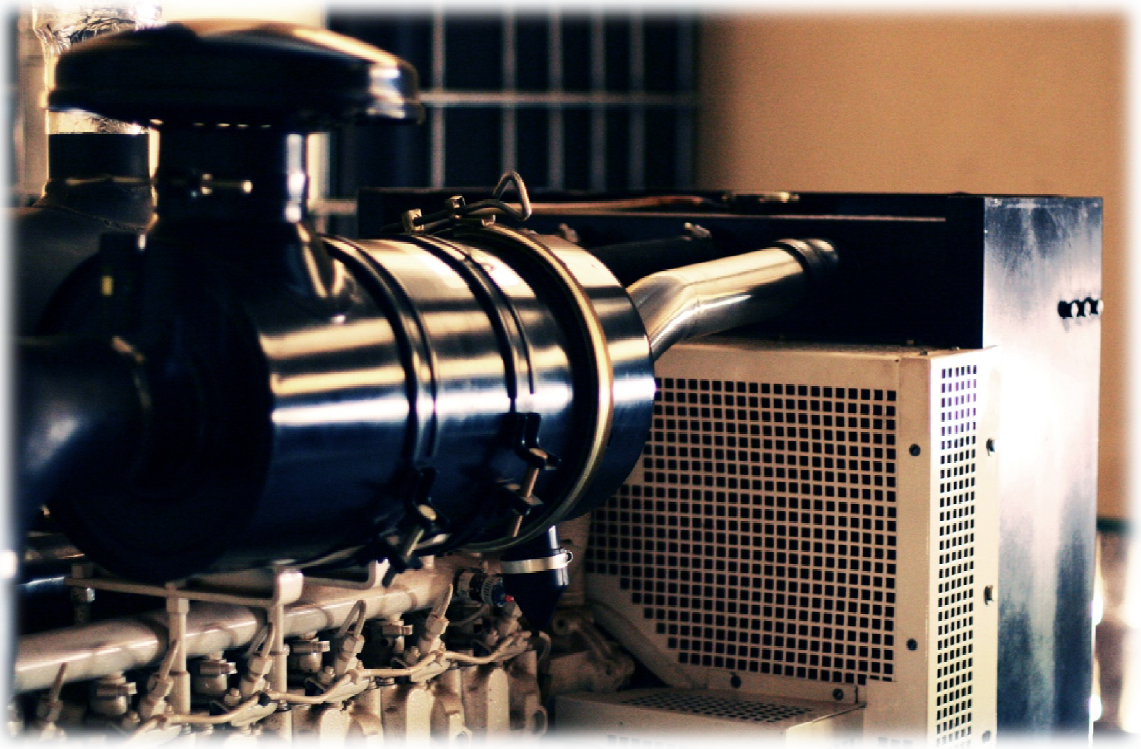

Figure 5.13: ACCESS/MFC power generator, Garalo, 2011

This study found that local extraction units installed by GERES are not yet fully operational. Interviews with government officials suggested that additional pressing units have been donated by the government to some villages. Data from focus groups in Bendougouba (May 2011) confirm this assertion, but reveal that the donated press has not yet been installed. Similarly, feedstock used to meet the needs of the Malibiocarburant SA biodiesel plant comes only in minor part from *Jatropha,* while other vegetable feedstock is used (Malibiocarburant SA, interview data, 2011). Similar challenges are faced in the implementation of the Multifunctional Platforms National Programme. After 15 years of experience gained in the implementation of Multifunctional Platforms – 1,000 units were installed as of 2011 (UNDP 2012) – less than 30 are operating on *Jatropha* oil (UNDP interview data, 2011).

These findings show that win-win opportunities for fuel production and rural development are yet to be realised. It remains vital to remove the barriers to cultivation faced by small-holder farmers and to improve yields. Facing these challenges would allow *Jatropha* to concretely contribute to the expansion of rural energy security and greater livelihood gains could be generated by the use of *Jatropha*-derived fuel. Increases of physical capital (through expanded access to electricity and mechanical power for agriculture) would allow transfers to other forms of capital: (i) access to mobile phones improves communications (social and physical capital), (ii) public lighting promotes after-dusk study (human), (iii) use of refrigerators allows medicines to be kept cool and improves health and food storage (human), (iv) business activities benefitting from electricity can generate increased revenues (financial), (v) energy used for agriculture increases productivity (financial), food security (human) and reduces the time spent by women on domestic chores (human).

5.6.3 Beyond food versus fuel?

As of 2011, *Jatropha* is only grown at a small-scale in Mali. Results from household interviews indicate that the maximum individual surface area planted does not exceed 4 ha and 77% of the plantations are <3 ha. Focus group discussions indicate that smallholder farmers will not replace food production with *Jatropha* farming. While this is mainly due to the cultural importance of cereal production, it also links to the use of *Jatropha* as living fence and the establishment of agroforestry systems.

5.6.3.1 Use of Jatropha as living fence

When grown as a living fence (Figure 5.13) it was reported that *Jatropha* can reduce land tenure conflicts among neighbouring farmers as well as protect their cereal crops from wind, floods, soil erosion and grazing animals. This supports findings from Brittaine and Lutaladio (2010), GTZ (2009) and Achten *et al.* (2010). In a transect walk, one farmer reported that the use of a *Jatropha* living fence allows him to grow food on land that would otherwise be flooded and damaged during the rainy season. This suggests that *Jatropha* cultivation can be a successful land management strategy that improves natural capital and food production.

Figure 5.14: *Jatropha* living fence, Kita, 2011

5.6.3.2 Land use and labour trade-offs

Only 2 respondents (7%) are growing *Jatropha* on land not previously under agricultural use. In 93% of cases the land now dedicated to *Jatropha* was used – in rotation with cotton farming – for cultivation of food. But small-scale *Jatropha* agriculture has not reduced food production in Mali. Indeed, 82% of the farmers interviewed intercrop *Jatropha* with peanuts, cowpeas, sesame, sorghum, millet, maize, sweet potatoes or cowpeas. Two respondents (6.7%) intercrop *Jatropha* with cotton, in rotation with other edible crops. It was explained that this strategy improves the yields of both *Jatropha* and the food crops that are grown on the same

land where chemical fertilisers are applied for cotton farming. Intercropping guarantees the land used for food is not entirely shifted to biofuel production (Magcale-Marcandog 2010; Lengkeek 2009) and according to the farmer experiences: "[intercropping] *is essential to avoid fires and weeds*" (Male farmer, Garalo, MFC, 2011).

Jatropha plant size is not affected by the farmers' income level. The wealth ranking showed that the poorest farmer out of all the interviewees performed better than some of the wealthier ones[7]. According to his perceptions, this is due to the good soil fertility and his knowledge of farming techniques. This suggests that availability of natural and human capital play a dominant role in the achievement of satisfactory livelihood outcomes. It also confirms that *Jatropha* can offer valuable diversification alternatives to poorer households.

Labour competition – particularly between the months of September and November (Figure 5.5) – may limit the expansion of *Jatropha* as farmers prioritise food and cotton. This is partly due to the cultural importance of food production, and partly due to the fact that at present, both cereals and cotton are more profitable than *Jatropha*. Such observations are in line with findings from Groom and Palmer (2012), who used labour allocations as an indication of the economic value of different activities, showing that labour is not assigned to an activity unless the farmer sees an economic value to do so. The establishment of agroforestry systems can reduce these problems, where the role of intercropping is highlighted as a core strategy for reducing labour trade-offs: *"If you intercrop there is no problem, otherwise there would not be enough labour to take care of Jatropha"* (Male farmer, Bendougouba, JMI, 2011).

5.7 Farmers' perceptions of difficulties surrounding *Jatropha* agriculture and measures proposed

This section describes the main difficulties and concerns associated with *Jatropha* production at the local level (Table 5.7), as identified through household-level interviews.

[7] Ranking is performed according to the household's availability of physical capital. The farmer lacks access to basic agricultural equipment such as oxen and plough.

Table 5.7: Main difficulties and concerns of *Jatropha* farmers in rural Mali

(n = 30 household-level semi-structured interviews)

Difficulties	No.	Illustrative quotations
Price is too low	25 (83%)	"*Harvesting Jatropha requires time and labour... It is not worth it if the price does not increase...The promised gains are not materialising*" (Male farmer, Sorona, MFC, 2011)
Lack of agricultural equipment and organic fertiliser	16 (53%)	*"We need fertilisers... they are more important than fuel"* (Male farmer, Tandio, GERES, 2011)
Young trees are attacked by termites	13 (43%)	"*The main problem are the termites, they eat the young trees... they* [the project developers] *should find a remedy for this*" (Male farmer, Karaya-Toumouba, JMI, 2011)
Lack of communication, insufficient support from the project developer	11 (37%)	"*3 years ago they* [the project developer] *came promising things, now they do not even come to collect the seeds. So, last year I did not even harvest.... If they keep disregarding us, I will abandon Jatropha*" (Male farmer, Sorona, MFC, 2011)
Lack of labour	7 (23%)	"*I have left my Jatropha* [mono]-*crop unharvested because I had too much work on my cereal and cotton crops*" (Male farmer, Zena, MFC, 2011)
Wild fires	5 (17%)	(observations from in-depth interviews across different villages, 2011)
Lack of / difficult access to water for tree nursery	4 (13%)	"*Water is a problem, the well is too far and very deep*" (Male farmer, Karaya-Toumouba, JMI, 2011)

Financial unprofitability of *Jatropha* production is a major concern reported by 25 (83%) interviewees, together with the lack of fertilisers and agricultural equipment (n=16, 53%). The majority of the *Jatropha* farmers initially identified from project lists and interviewed in focus groups were unsuccessfully cultivating the crop. Only a small share of them (the ones selected for in-depth interviews) had kept their crops alive in the first three years of plantation. This links to the fact that young trees are often attacked by termites, as confirmed by 13 interviewees (43%). Wild fires (n=5, 17%) were reported as a minor problem. While water

requirements are perceived as a minor issue at the household level, with difficult access to water for tree nurseries being reported by four (13%) respondents, considerations at the national level might differ. Literature indicates that water demands of *Jatropha* may intensify competition over water access (Ariza-Montobbio and Lele, 2010). Water use implications must be carefully considered particularly when industrial activities involving large scale land acquisitions are established (Woodhouse, 2012). A detailed overview of the national level implications of *Jatropha*-driven large scale land acquisitions for land and water use has been provided in Section 4.5.

Measures proposed by farmers to foster *Jatropha* production at the household level are outlined in Table 5.8 and include to: (i) provide agricultural equipment on credit, (ii) improve communication, (iii) increase the price of seeds, and (iv) establish a credit system for fertilisers.

Table 5.8: Measures proposed by *Jatropha* farmers to foster production

(n = 30 household-level in-depth interviews)

Measures	No	Illustrative quotations
Provide agricultural equipment on credit	16 (53%)	"*In order to gain a donkey cart, people would do everything possible, including increasing the Jatropha surface*" (Male farmer, Kona, GERES, 2011)
Improve communication between farmers and project	11 (37%)	"*If the project comes regularly to see the farmers, we would never disregard the Jatropha crops*" (Male farmer, Fakoumala, JMI, 2011)
Increase the price of seeds	10 (33%)	*"At the beginning there were only 4 cotton producers in the village, but after the price has increased all the farmers got involved... it will be the same with Jatropha... a poor farmer can do nothing without a revenue"* (Male farmer, Kouyou, JMI, 2011)
Establish a credit system for fertilisers similar to the one introduced in the cotton market	9 (30%)	"*We do not want fertilisers for free, donation is not good. We need a transparent mechanism of credit, with clear access conditions and eligibility criteria"* (Male farmer, Zena, MFC, 2011). This would increase farmers' motivation in growing successful *Jatropha* crops. In a intercropping system, both *Jatropha* and food crops would benefit from the inputs provided, which might improve cereal yields and, hence, food security: "*The credit system would be a stimulus to take care of our* [*Jatropha*] *crops and would also improve cereal production*" (Male farmer, Sorona, MFC, 2011)

Improving farmer support at the local level, facilitating access to credit and reinforcing extension networks is also required to address their difficulties in *Jatropha* cultivation and would bring livelihood benefits.

5.8 Discussion and conclusions: what future role can *Jatropha* play in fostering rural development?

Case study research on *Jatropha* uptake and benefits is needed to better inform ongoing academic debates (*cf.* Hodbod and Tomei, 2013), biofuel policy making and project implementation. By integrating participatory approaches and through mixed-method analytical assessments in Mali, this work addresses key challenges related to biofuels development in dryland Africa.

Limited availability of human and physical capitals (in the form of labour shortage and limited access to farming equipment and fertilisers) are key barriers that translate into a limited capacity of poorer households to diversify their livelihoods. In line with Achten *et al.* (2010), Brittaine and Lutaladio (2010) and Dyer *et al.* (2012), findings show that at community and household levels, *Jatropha* offers the potential to contribute to rural development and diversify farmers' livelihood strategies to face key socio-economic and environmental vulnerabilities. *Jatropha* cultivation offers an alternative source of liquidity that can create a safety net in relation to a variety of shocks and stresses, allowing a shift between different capital assets and helping to make livelihoods more sustainable. *Jatropha* is perceived as an "easy-to-grow" crop that could substitute cotton farming, providing a diverse and more immediate source of liquidity to face the problems experienced in the cotton sector (Theriault *et al.*, 2013).

Nevertheless, the harvest and sale of seeds alone is not perceived as profitable. The lack of human and physical capitals, together with high incidence of pests and diseases hamper achievement of optimal yields. Seed sale prices remain low. Some farmers have already abandoned their plantations and others have left their crops unharvested due to a perceived lack of support and insufficient financial returns. It must also be considered that the evolution of the cotton market – in which revenues are currently higher than those from *Jatropha* – plays an important role in determining the uptake of *Jatropha*. Bigger revenue generation potential is currently offered by production and commercialisation of soap, a *Jatropha* by-product. Household-level analysis indicates that provision of adequate farmer support, training and improved communication are vital to allow the expected benefits to materialise (Palliere and Fauveaud, 2009; Achten *et al.,* 2010; Garg *et al.,* 2011; Gilbert, 2011) and to enhance livelihood outcomes. These key concerns need particular attention in the initial phase of implementation of pilot project activities, when the trees have not yet reached maturity.

Project developers and policy makers need to acknowledge this issue and recognise that actual or potential growers may be reluctant to invest in a crop that does not bring obvious, immediate livelihood gains.

Community level analysis shows that projects promoting the use of *Jatropha* oil offer potential to enhance rural energy. Project developers in Mali attempt to achieve this goal by providing local pressing facilities, power generators and Multifunctional Platforms, yet these are not currently powered by *Jatropha* oil. Increases in both physical and financial capitals derived by promotion of *Jatropha*-fuelled energy could favour transfers to other forms of capital and offer new opportunities to reduce seasonal vulnerabilities. However, local-level benefits in terms of diesel substitution and energy generation are still lacking and the potential has not been realised. Barriers identified at the household level translate into low feedstock availability on the market. Current supplies of *Jatropha* oil remain insufficient for benefits to materialise and, to date, *Jatropha* oil has been used in Mali only for testing and demonstration. It is vital to recognise that *Jatropha* is not a wonder crop: adequate support from project developers and extension networks is required to expand access to electricity and mechanical power for agriculture.

Climatic shocks lead to food shortages, which are reported as a major seasonal stress in Mali. Findings from this study show that smallholder farmers look unlikely to replace food production with *Jatropha* farming at household level thanks to the establishment of agroforestry systems. No land trade-offs were observed. While productive plantations require this crop to be grown on fertile land, *Jatropha* cultivation is widely used as a land management strategy to reduce soil erosion, demarcate field boundaries and avoid land tenure conflicts. This mirrors findings from Brittaine and Lutaladio (2010), GTZ (2009) and Achten *et al.* (2010). Farming calendars indicate that labour trade-offs occur as the harvest period of *Jatropha* overlaps with that of cereals and cotton. Labour competition limits the expansion of *Jatropha* agriculture. Promotion of intercropping is essential to allow the minimisation of labour trade-offs with food crops. It should be recognised that availability of natural and human capital (*e.g.* fertile soil and knowledge of farming techniques) plays a dominant role in the achievement of satisfactory livelihood outcomes with relation to *Jatropha* cultivation. Wealth ranking shows that these factors are more important than farmers' income levels, suggesting that *Jatropha* can offer valuable diversification alternatives to poorer households who have limited capacity to expand their livelihood portfolio.

This study has outlined key aspects that should be considered in the establishment of small-scale *Jatropha* supply chains. Despite the promising claims surrounding *Jatropha*, there are a variety of barriers that project developers and policy makers need to overcome in order to achieve successful outcomes. The research has provided empirical evidence on the role that *Jatropha* cultivation can play in fighting poverty and fostering rural development if locally-appropriate support is provided by both local and national institutions.

Chapter 6

Jatropha: a sustainable development tool for Mali? Discussing the drivers and barriers to the achievement of policy goals

"*The expectation that Jatropha can substitute significantly for oil imports will remain unrealistic unless there is an improvement in the genetic potential of oil yields and in the production... the main pro-poor potential of Jatropha is within a strategy for the reclamation of degraded farmland along with local processing and utilization of oil in a way that can improve and diversify rural livelihoods*"

(Brittaine and Lutaladio, 2010: 88)

Outline

This chapter integrates the multi-level analysis from the results chapters 4 and 5 to address research question vii "What considerations are needed to achieve policy goals and promote *Jatropha* as a sustainable development tool for Mali?" within research objective 3 "Evaluate the drivers and barriers to the achievement of policy goals in relation to rural development and energy security, proposing policy recommendations and ways forward that better link the realities of policy and local practice". Findings are discussed and linked to elements of theory presented in Chapter 2 to assess whether *Jatropha* is a suitable sustainable development tool for Mali. Research objectives 1 and 2 (Table 1.3) are revisited and key lessons learned are summarised before addressing objective 3. Drawing on the integrated multi-level results presented throughout the course of the thesis, policy recommendations and ways forward are proposed to help improve policy coherency and achieve a sustainable path for biofuels promotion in Mali.

6.1 Research objectives revisited

Research objective 1 and research question vi within objective 3 have been addressed in Chapter 4. Research objective 2 has been addressed in Chapter 5. Major findings under each objective are here revisited with respect to their policy significance to inform this discussion chapter.

6.1.1 Objective 1: To identify and analyse the stakeholders and policies concerned with biofuels in Mali

The analysis presented in Chapter 4 identified a variety of stakeholders involved in biofuel production in Mali. These include ministerial and technical central departments, multilateral development agencies, bilateral donors, NGOs and private companies. Table 4.3 summarised the major *Jatropha* national programmes and projects implemented by these stakeholders since the early 1990s with a view to advance technical knowledge and policy. A central role in the promotion of *Jatropha* production and use in the country is played by the Ministry of Mines, Energy and Water through its specialised National Biofuel Development Agency (ANADEB). ANADEB promotes biofuels at both local and national levels and coordinates the activities of all stakeholders with relation to funding, *Jatropha*-related research and policy implementation (Figure 4.1). ANADEB's work is guided by a range of government policies elaborated by the relevant ministries in the fields of energy, environment, agriculture and rural development (Table 4.1). These support biofuel production (mainly from *Jatropha* feedstock) with the twofold aim to meet rural communities energy needs and reduce the high dependence on oil imports to meet the country's energy needs. Discourse analysis identified three key themes related to the policy goals that the government aims to achieve through promotion of biofuels, including socio-economic progress, agricultural development and environmental conservation (Section 4.2.1).

Ambitious quantitative targets for *Jatropha*-based biofuel production are set in the National Strategy for Biofuels Development (NSBD), which aims to substitute 20% of fossil fuel consumption with *Jatropha* biofuel by 2023 (Table 4.2). Moved by these policy drivers, four major pilot activities in the production, extraction, transformation and utilisation of *Jatropha* have been implemented since the mid-2000s in the southern regions of Mali. These include two NGOs that promote *Jatropha*-fuelled rural electrification for local communities, and two private companies that target oil extraction and sale to local and national markets (Table 4.4).

Nevertheless, data show that *Jatropha* oil supplies remain insufficient for improving access to fuel and substituting national consumption. Implementation gaps are identified through the multi-level assessments between policy targets, land cover (uptake) and actual yields. Gaps in the implementation of national projects aimed at establishing a market for the local sale and use of *Jatropha* are also observed, with the lack of an adequate market for the sale of seeds being a major limitation. The findings stress the need to integrate village level livelihood assessments of the impacts of biofuel production with national level measures in order to overcome constraints in *Jatropha* oil production and attain policy goals.

6.1.2 Objective 2: To undertake a livelihoods analysis with focus on *Jatropha* at household level in rural Mali

An understanding of the household level implications of *Jatropha* agriculture for livelihoods is critical to achieve policy targets. This research used the Sustainable Livelihoods Framework (SLF) to assess the major livelihood components of *Jatropha* farmers and their key vulnerabilities in terms of trends, shocks and seasonality. The framework integrated data gathered through participatory methods and was expanded by carrying out a stakeholder and policy analysis aimed at identifying and understanding those institutional and policy aspects that may influence the SLF dimensions (see Section 6.1.1). Data show that *Jatropha* offers the potential to generate revenues through the sale of seeds and soap. Nevertheless, the production and sale of seeds alone are not considered as profitable, while they are perceived as a potential source of diversification. The findings suggest that economic benefits from *Jatropha* are linked to those in the cotton market and indicate that to succeed as a livelihood diversification strategy, *Jatropha* cultivation must be accompanied by benefits other than the sale of seeds. Promising revenue generation opportunities come from production and commercialisation of white soap, a *Jatropha* by-product. Adequate farmer support, training and effective communication with project developers were identified as vital conditions to allow the expected benefits of *Jatropha* to materialise and livelihood outcomes to be enhanced. Food security is not threatened by small-scale cultivation of *Jatropha*. The plant is effectively used to demarcate property and to reduce soil erosion with positive impacts on food production. Farming calendars revealed that the harvest period of *Jatropha* overlaps with the harvest of other crops, causing labour competition. Labour shortage may limit the expansion of *Jatropha* as farmers prioritise food and cotton. The benefits of *Jatropha* use for rural electrification were found to be hampered by the limited availability of current supplies of *Jatropha* oil due to difficulties in production at the household level. This stresses the need

for adequate support to be provided in order to improve farmers' productivity and enhance livelihood gains.

6.2 Drivers and barriers to the achievement of policy goals

Results from the previous two objectives are brought together in the following sections and linked to elements of theory of Chapter 2 to address objective 3. The role of *Jatropha* as a rural development tool for Mali and the role that the state could play in supporting a pro-poor biofuel industry are discussed.

6.2.1 *Jatropha*: a rural development tool to fight energy poverty in Mali? Combining local needs with national priorities

The literature review in Chapter 2 outlined the "trilemma" faced by the global energy system on the interplay between universal energy access, climate change mitigation and sustainable development (World Energy Council, 2012; Gunningham, 2013; SEI, 2009; Scott, 2012) and discussed the potential of biofuels to modernise agriculture, promote development and enhance energy access (Janssen and Rutz, 2012; Lynd and Woods, 2011; Ejigu, 2008; Sagar and Kartha, 2007; Mol, 2007; Molony, 2011; Clancy, 2008; Arndt *et al.*, 2010; Yan and Lin, 2009; Peters and Thielmann, 2008; Reddy *et al.*, 2008). The policy analysis detailed in Chapter 4 indicates that the Malian government has effectively integrated the major international priorities on sustainable development and energy into its national policies supporting biofuels. Therein, *Jatropha* is promoted through the National Strategy for Biofuels Development (NSBD) with the aim to meet the country's socio-economic needs and substitute expensive imported oil. Some authors stressed the need to implement country-specific analyses of biofuel activities (Jumbe *et al.*, 2009) and to situate biofuel research within broader agricultural livelihood strategies (Mitchell A., 2008). The present research provided case study evidence on the implications of *Jatropha* cultivation as a "pro-poor" strategy for rural livelihoods in Mali. It addressed major gaps in literature, where claims on the plant's impacts on poverty and rural development are found to be contrasting (*cf.* Hodbod and Tomei, 2013).

Figure 6.1 summarises the key findings of this research. It outlines the multi-level sustainability challenges identified in the Malian *Jatropha* farming system and the success variables for the attainment of policy goals.

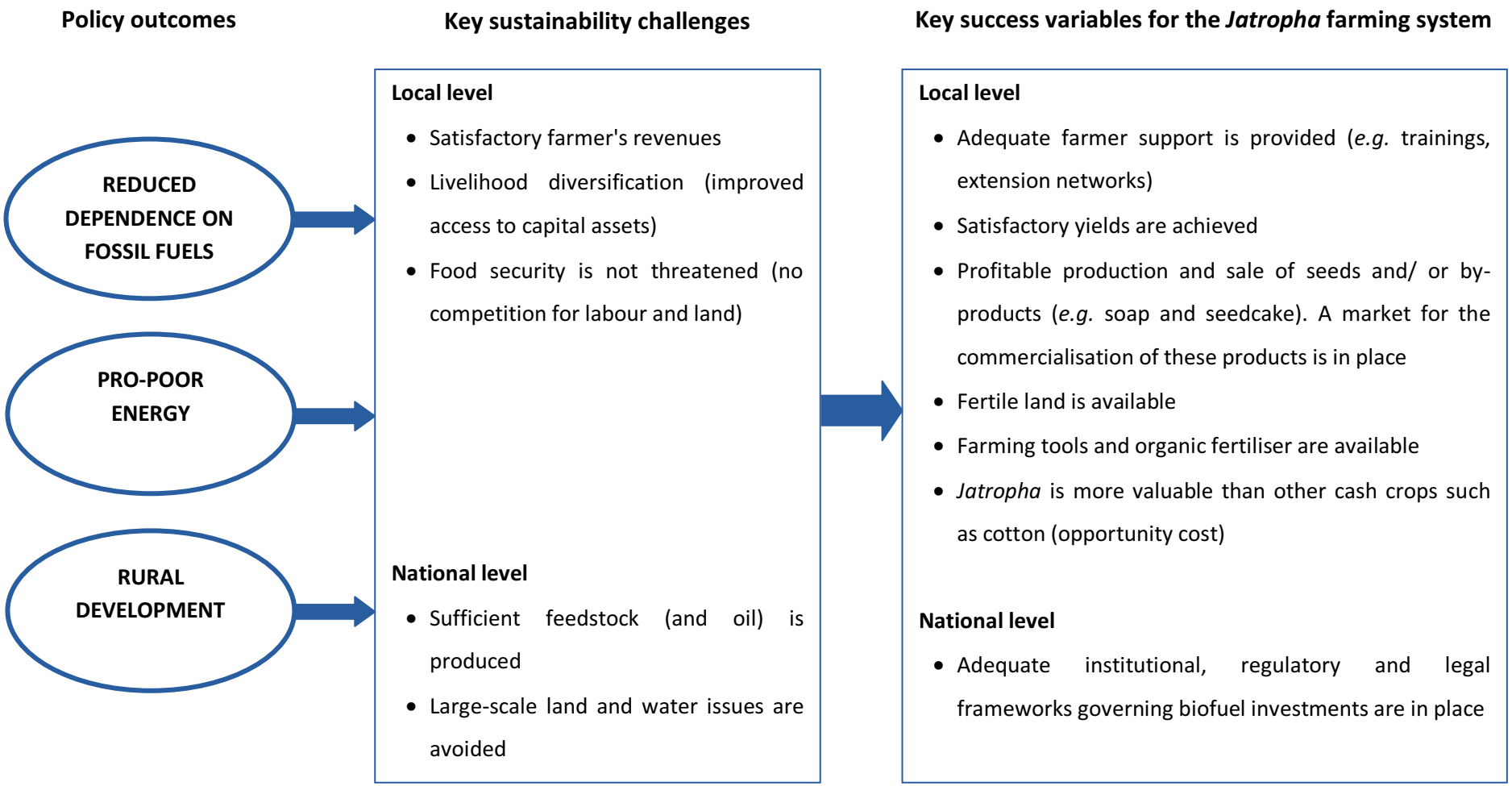

Figure 6.1: Key sustainability challenges of *Jatropha* farming system in the attainment of Malian policy targets

The livelihood analysis described in Chapter 5 showed that the interviewed households manage a wide portfolio of livelihood activities characterised by highly interlinked capital assets and pronounced seasonality. According to Ellis (2000a), diversification is a major survival strategy adopted by rural households to reduce their vulnerability to the negative effects of shocks and seasonality. Poor Malian farmers are largely dependent on natural capital, the effective use of which is hampered by the limited availability of human and physical capitals. Findings here show that *Jatropha* agriculture offers new opportunities to reduce farmers' seasonal vulnerabilities by diversifying their access to different forms of capital, particularly physical and financial capitals (see Section 5.5). In line with findings from Reubens *et al.* (2011), Henning (2004) and GTZ (2009), when grown as a living fence *Jatropha* improves physical capital by allowing property demarcation and protection of arable land against soil and water erosion. As a result, natural capital and food production are enhanced and, as reported by Tomomatsu and Swallow (2007), small amounts of revenue are generated. In Kona (GERES) for example, one interviewee reported that the use of *Jatropha* as a living fence allows him to cultivate land that would otherwise be flooded during the rainy season. This suggests that when used as a living fence *Jatropha* can contribute to "*ensuring food security*" (GoM, 1998: 17), an objective set in a number of policies including the National Environmental Protection Policy (PNPE), Rural Development Master Plan (SDDR), Agricultural Orientation Law (LOA) and the Poverty Reduction and Growth Strategy Paper (G-PRSP) (see Chapter 4).

As stated in the NSBD, *Jatropha* is promoted not only to improve energy access but also to "*increase revenues and employment"* (GoM, 2008: 29). Mirroring findings from Achten *et al.* (2010) and Nelson and Lambrou (2011), evidence from Chapter 5 shows that income sources are diversified when small-scale production of *Jatropha* is added to the current set of farmers' activities. Data gathered across the three project areas (Section 5.6.1) confirmed that improvement of financial capital, which supports asset building and poverty reduction (Elliot *et al*, 2001; Ellis and Allison, 2004), arise from the revenues generated through the production and sale of the plant's seeds and/ or by-products (*e.g.* soap and seedcake). This mirrors findings from Brittaine and Lutaladio (2010), Dyer *et al*. (2012) in sub-Saharan Africa and Weyerhaeuser *et al.* (2007) in China. In Garalo, the oil press installed by the MFC and controlled by the farmers' union offers the potential to produce revenues through the extraction and sale of oil to the decentralised power company ACCESS and through commercialisation of the leftover seedcake (which is used as fertiliser). Similar benefits are expected to be generated by the extraction unit provided by government to the region of

Koury, which as of 2011 was not yet operative. As observed by Clancy (2008), the farmers' engagement with small-scale decentralised oil extraction can also bring important benefits to local communities by improving physical, financial and social capitals.

Constraints in seed commercialisation are identified in Sections 4.5 and 5.6.1.1. The price variability observed across different project areas, as well as the varied purchase conditions applied within single projects, reveal the need to improve the structure of the seed market, for livelihood impacts to be delivered. The long term commitments of local projects to support farmers through agricultural training and infrastructure investments are hampered by opportunistic behaviours in the market, where external buyers pay higher prices for the seeds while not delivering additional socio-economic benefits to the villages. The establishment of a market for *Jatropha* and the support of the plant's local production and use are key policy priorities pursued by a range of national level projects (Table 4.3). Nevertheless, a gap between their objectives and "*their practical impact on the ground*" (Jordan, 1999:70) is observed. Nationally implemented activities are found to be disconnected from the on-the-ground reality. Promotion of local cooperation and protection of the market through ANADEB are needed for the policy objectives to be translated into actual achievements on the ground. The establishment of local level partnerships will strengthen the local market, towards the identification of standardised and replicable approaches to *Jatropha* promotion. However, the lack of a concrete policy implementation strategy at the national level hampers adequate support from provided to local operators and policy targets from being achieved. It should be noted that adequate implementation measures cannot be designed as long as a monitoring system for *Jatropha* programmes and projects is not in place.

The initial income made by those farmers who had harvested and sold small quantities of seeds after the third year of plantation has been used for buying clothes and school material and repairing agricultural equipment. Nevertheless, as discussed in Chapter 5 revenues through seed sales remain low and, similarly to what observed in Tanzania by Grimsby *et al.* (2012) and in Mexico by Skutsch *et al.* (2011), most farmers remain reluctant to venture into harvesting *Jatropha*. Project developers and policy makers should recognise that adequate support is needed to overcome farmers' barriers to local production and allow policy targets to be met. This situation is similarly observed by Dyer *et al.* (2012: 110) in Malawi, who call for actions focused at the local level "*in order to realise developmental, sustainability and climate change benefits across a range of scales*".

Table 5.7 indicates that local level constraints in *Jatropha* production are due to the low price at which the seeds are sold (Table 5.5), lack of agricultural equipment and organic fertiliser, termite attacks and insufficient support received from the project developers (with the problem particularly visible under the MFC). These issues translate into low yields and quantities of oil produced, limiting the generation of economic returns, as similarly observed by Ariza-Montobbio and Lele (2010) in India. However, while the latter authors argue that *Jatropha* is not pro-poor and impoverishes the farmers, the findings from Section 5.6 contrast with this view. The interviewees who have access to natural capital (*e.g.* fertile soil), as well as human and physical capitals (*e.g.* labour, information on farming and processing techniques, support from the project developer) reported higher livelihood outcomes.

Ariza-Montobbio and Lele (2010) state that *Jatropha* could potentially compete with other crops. Mirroring findings from the use of agroforestry systems in the Philippines (Magcale-Marcandog, 2010) and Mali (Lengkeek, 2009), evidence from this study (Section 5.6.3.2) shows that when *Jatropha* is grown at small-scale using intercropping, food security is not threatened. This proves that *Jatropha* is a suitable crop to be included in an Integrated Food Energy System (IFES) where food is simultaneously produced with energy on the same land (Bogdanski *et al.*, 2010; Sachs and Silk, 1991). Good soil fertility is reported as a vital variable for satisfactory yields to be achieved, particularly when the plant is grown with the purpose of producing oil for energy generation. In line with concerns raised by Jongschaap *et al.* (2009) and Hoekstra and Gerbens-Leenes (2009), this is in strong contrast with the most optimistic claims on the plant's suitability to produce satisfactory yields on marginal, degraded and unproductive lands (Holl *et al.*, 2007; Jain and Sharma, 2010).

The livelihood analysis (Section 5.6.1.2) confirmed the importance, as stressed by COMPETE (2009b), of promoting research on value-added products for livelihood gains to be improved from biofuel cultivation. Promising impacts on financial capital, both in terms of reduced outgoings and enhanced income are offered by the production and sale of soap from *Jatropha*. This supports findings from Dyer *et al.* (2012) in Malawi and Openshaw (2000) who identified soap making as one of the most profitable plant's uses. In Karaya-Toumouba village (JMI) the livelihood analysis indicates that household's potential annual revenues from soap production account for up to US$ 261 (see Box 5.1). In order for these benefits to materialise adequate farmer support and training are needed. Basinger *et al.* (2012) highlight the key role played by information provision in determining implementation of optimal practices.

Lack of access to electricity is a major dimension of energy poverty (Sovacool, 2012: IEA, 2010b; Gaye, 2007; Masud *et al.*, 2007). Community level analysis shows that use of *Jatropha* oil can contribute to reducing energy poverty in the three study sites by enhancing access to rural energy. Such a shift from traditional to modern use of biomass for energy production is key to the development of economic activities, as also observed by Hall and Matos (2010), particularly in energy poor African countries such as Mali (see Section 3.1.2). Once operational, the manual press provided by government extension to Bendougouba village will allow local energy needs to be satisfied by decentralised oil extraction. The pressing facility provided by GERES and managed by a local operator in Koury is an example of how the *Jatropha* supply chain can empower local community through business. If adequately managed, the implementation of the national Multifunctional Platforms Programme (PN/PTFM) could generate livelihood gains in terms of energy production and women empowerment through local provision of *Jatropha*-fuelled platforms managed by women associations. Interviews carried out in field season 1 with MFPs' women associations in Kodjoukou and Dongorona villages (Sikasso region) revealed that the platforms installed in the early 2000s have delivered a range of benefits including power generation, cereal grinding and revenue generation. The PN/PTFM is promoted by the National Strategy for the Development of Renewable Energies and NSBD. The programme is also in line with the goals set in the National Adaptation Programme of Action to Climate Change (NAPA) to foster revenue generating activities and empower women through promotion of "*sustainable Jatropha oil*" in MFPs in the southern regions of Mali (GoM, 2007: 83). However, the limited amount of platforms operating on *Jatropha* oil as of 2011 (less than 30 over a total of 1,000 installed in the country) reveals that the capacity to achieve this potential remains limited due to the poor management of the platforms and difficulty in producing enough oil. Since the late 2000s, the entire amount of revenue generated by the women associations in Kodjoukou and Dongorona villages (saved in collective bank accounts and managed collectively) have been used for repairs and no financial benefits have been distributed to the platform's members. Use of *Jatropha* oil was reported as difficult due to lack of feedstock.

As discussed earlier (Section 4.2.1), the policy analysis indicates that while a myriad of national plans and strategies for the improvement of rural energy through renewable energy are in place (see Table 4.1), an implementation strategy is lacking. For example, it is not clear how the government is going to reach its ambitious target (to expand access to mechanical energy

to 100% of the Malian rural communities by 2015, partially through the use of MFPs) set in the Ten Year Action Plan to Achieve the MDGs. Similarly, as of 2011 the MFC has not been able to support its farmers to produce sufficient *Jatropha* feedstock to fuel the power generator in Garalo village, which since 2007 has been run purely on regular diesel (apart of one public demonstration with *Jatropha* oil). These findings contrast with the widespread view describing the Garalo project as one of the most successful examples of *Jatropha* rural electrification worldwide, as discussed by Practical Action Consulting (2009) and Gilbert (2011: S18) who asserted that "*The Garalo project is a testament to how biofuel production can greatly improve the lives of poor people in developing countries*". Section 4.5 identifies barriers to local level project implementation, where the actual prioritisation of *Jatropha* production and use varies across projects. In line with JMI's operational objectives, the agricultural training provided and the high volumes of processed oil prove the operator's commitment to achieve higher quantities of *Jatropha* oil. In contrast, actual investments of MFC towards the support of *Jatropha* agriculture remain limited. A low level of agricultural support is provided in the villages outside Garalo (where the MFC and ACCESS's headquarters are located) and little investment is provided to adequately support the farmers in increasing their yields and levels of seeds collection. Fertilisers on credit are provided by a microcredit organisation controlled by the MFC (Nyeta Finance) with the formal purpose to support the *Jatropha* farmers. Nevertheless, interviews with the MFC reveal that access to this credit is available only to those that are registered customers of the power company (ACCESS), even if they are not *Jatropha* growers. Prioritisation of diesel-powered energy generation in Garalo and little commitment to improve the conditions of the *Jatropha* farmers located in the 29 surrounding villages limit the future capacity to use *Jatropha* oil as a source of fuel and to deliver substantial livelihood benefits that are directly linked to the use of *Jatropha*.

Observable livelihood benefits to the farmers will be brought only if cultivation of *Jatropha* is accompanied by multiple uses of the plant beyond the purpose of just producing energy (see Figure 2.5). This view is supported by numerous authors including Openshaw (2000), Jongschaap *et al.* (2007) and Grass (2009). In moving forward, it is vital to recognise that *Jatropha* is not a wonder crop; adequate support from project developers and extension networks is needed to remove the production barriers identified at the household level and expand energy access. As observed by GTZ in Mali (Wiesenhütter, 2003) (Table 4.3), Grimsby *et al.* (2012) in Tanzania and Skutsch *et al.* (2011) in Mexico, generous subsidies are needed for *Jatropha*-based rural electrification activities to be sustained. In the case of the MFC in Mali,

no estimates were provided in the semi-structured interviews on the expected timeframe for achieving financial sustainability of the MFC's operations and becoming independent from donor support. Due to financial constraints, in the area of Garalo only one extension officer is employed by the MFC to supervise roughly 700 farmers located in a number of scattered and isolated villages. As confirmed by the MFC employee and the interviewed farmers, the former is not able to provide the adequate individual support needed by hundreds of households outside Garalo (where the power plant is located). A slightly improved situation is found in the JMI and GERES activities, where overall, farmers' perceptions were found to be more positive on the support provided by extension officers to overcome their daily problems. Interviewees reported that both JMI and GERES staff regularly visit their villages to carry out training on farming techniques and, in the case of JMI, on soap production. However, financial and operational constraints are equally faced by all project developers, who largely depend on the monetary support provided by international donors.

Conversely, the national level analysis indicates that the *Jatropha* "story line" is successfully used in the Malian policy discourse and by project developers as a driver for achieving higher levels of financial support (see Section 4.5). The policy analysis shows that Mali was able to mainstreaming internationally agreed principles surrounding the "energy trilemma" and sustainable development into its national policies as a way to attract monetary, institutional and technical support from international organisations and donors. However, concrete efforts still need to be made by policy makers and project developers to support farmers locally towards the achievement of a sustainable production of energy from *Jatropha*. While interviews reveal that the MFC has been able to secure enough funding to replicate the "*successful example*" (MFC, interview data, 2011) of *Jatropha*-fuelled rural electrification in Garalo to ten more sites across the country, the livelihood analysis shows that the most isolated farmers around Garalo (*e.g.* in Sorona village) keep being disregarded. Many of them have declared that they will leave the plantation if benefits do not increase. This leaves the research and policy communities, as well as international donors, wondering to what extent the MFC will be able to fuel its new power plants with *Jatropha* oil (rather than regular diesel) in the future, and whether more effective actions will be taken to support the successful creation of a local *Jatropha* supply chain. As stressed by many authors (Tomomatsu and Swallow, 2007; Lahiri, 2009; Brittaine and Lutaladio, 2010; Clancy, 2008; Achten *et al.*, 2010, Jongschaap *et al.*, 2007), more research on the socio-economic impacts of the crop on smallholder farmers is needed before scaling up and establishing large scale activities,

following the route defined by Weyerhaeuser *et al.* (2007: 10) as "*First understand, first take initial steps, first see results*". The case study research provided by this study offers valuable contributions towards this route. By assessing the initial impacts of *Jatropha* as a rural development tool to fight energy poverty in Mali, it has increased understanding of the challenges and ways forward that should be considered in taking further steps and expanding production to larger scales.

In moving forward, it should also be considered that long-term impacts of increased livelihood and income derived by *Jatropha* cultivation and use might increase future demands for energy in the country. This may negatively impact on climate change as it has been widely shown that higher income and HDI levels bring exponential increases in CO_2 emissions (Steinberg and Roberts, 2010; Costa et al., 2011). This does not represent a short-term concern for Mali as the country still lies in a "domain of fairness" (Reusser et al., 2013: 199), where increases in emissions are dispensable to reach a "decent living" (Rao and Baer, 2012: 656) and can be justified by the need to achieve minimum standards of development (*e.g.* in terms of HDI and MDG achivement). However, a longer term policy perspective for biofuel promotion should ensure that the country develops through a Climate Compatible Development (CCD) trajectory which "*minimises the harm caused by climate impacts while maximising the many human development opportunities presented by a low emissions, more resilient future*" (Mitchell and Maxwell, 2010: 1). Reusser *et al.* (2013: 199) suggest the use of livelihood-based indicators (grouped under the three following categories: subsistence, infrastructure and social structure) to identify an adequate point of development beyond which increases in emissions should no longer be allowed as a country shifts from a "fairness domain" to a "domain of responsibility". In the move of the energy system towards a more renewable basis through biofuel programmes and policies, these issues should be addressed jointly, combining climate change mitigation and adaptation measures with energy and rural development initiatives. In the successful development of CCD policies, Stringer *et al.* (2013) stress the need for strong coordination at the institutional level, to be accompanied with the development of multi-stakeholder partnerships (with the engagement of local communities) and the creation of learning and knowledge-sharing networks. This route requires adequate government resources to be mobilised and highlights the importance of establishing an integrated system for the successful promotion of *Jatropha* as a development tool for Mali.

6.2.2 Towards the achievement of policy goals: what considerations are needed?

Organisational and financial constraints throughout the supply chain are identified by Hall *et al.* (2009) and Da Silva Césa and Batalha (2010) as a major challenge faced by developing countries to the effective substitution of relatively large shares of fossil energy with biofuels. By integrating national-level policy analysis with local level data on production, such constraints are confirmed in Mali by this study, which identified gaps between the ambitious policy targets (aiming at substituting 20% of fossil fuel consumption with *Jatropha* oil by 2023, see Table 4.2), are planted with *Jatropha* and actual yields (see Section 4.5). Difficulties are observed in local level production of relatively small quantities of oil needed to fuel Multifunctional Platforms and power generators. As of 2011, the vast majority of these engines in the country remained diesel powered (Section 4.3). This suggests that, for the ambitious national fossil fuel substitution targets to be met, a strong increase in the production capacity through the establishment of large-scale industrial plantations is required.

However, the viability of large scale operations is questioned by a number of factors. In the first instance, current knowledge on *Jatropha*'s agronomic qualities is highly controversial (see Section 2.3.4) and the plant's production and use are limited by its lack of profitability. This research mirrors findings from Ouwens *et al.* (2007), who stress that there is a risk of disappointment when the expected performance of the crop is not achieved. It is recommended that governments and investors base their plans on realistic goals (in terms of land cover, yields, and oil production) based on conservative estimates. This requires an effective data collection and analysis system to be in place for monitoring programmes and projects in order to assess the actual achievements. Section 4.3 reveals that such system is currently lacking in Mali and ANADEB's monitoring and analytical capacity remains limited. The development of coherent operations is constrained by the multiplicity of stakeholders in *Jatropha* promotion (including private companies, NGOs, national directorates and agencies operating in the energy, rural development and environmental sectors), the overlapping roles of government actors and their lack of effective dialogue. The establishment of a framework of cooperation and coordination for the promotion of biofuels in the country is not only a priority set in both the NSREN and NSBD, but also a concrete measure needed to overcome these constraints that are limiting national production.

Despite Chapter 5's findings indicating that the plant can potentially generate positive

livelihood outcomes, the capacity to concretely improve smallholder farmers' livelihoods through *Jatropha* agriculture remains poorly understood. In Mali this is partly due to the fact that project activities are relatively young and there is a lag time between initial investments and the derivation of benefits. This research has provided useful assessments of the initial achievements of major *Jatropha* activities in the country, as well as insights into their potential future benefits and challenges. Successful outcomes will not only depend on the capacity of the plant to reach maturity, but particularly on how the supply chain is managed. At the time of interview GERES was in the phase of testing varied modes of supply chain organisation, JMI and MFC opted for the organisation of their farmers into cooperatives (Figures 5.7 and 5.8). Sections 4.4 and 5.6.1.1 stressed the government's need to support an adequate policy implementation strategy that can foster R&D, agricultural training and market protection against "opportunistic" competition (Section 4.1). Financial incentives are needed to favour the development of local *Jatropha* supply chains that can compete with the subsidised fossil fuel industry. These incentives include tax exemption for *Jatropha* oil and the establishment of a subsidy to *Jatropha* oil similar to the one applied to diesel. By improving the competiveness of *Jatropha* production and transformation and increasing the price paid to the farmers for the purchase of seeds, the socio-economic impacts of the *Jatropha* could be enhanced.

Findings stress that more research is needed on the use of different production systems and substantial financial and technical support is required to foster alternative uses of the plant in order to enhance income generation and livelihood diversification. As observed by Achten *et al.* (2010), Dyer *et al.* (2012) and Hunsberger (2012), the socio-economic implications of small-scale outgrower approaches must be better understood before establishing large-scale commercial activities. While the NSBD aims to pursue both local and national level benefits through promotion of *Jatropha* at small and large scales, findings (Sections 4.3, 4.4 and 5.6) show that complementary targets of energy production and livelihood improvements are unlikely to be achieved until an adequate implementation strategy is in place. Mirroring findings from Thomson (2001), it is vital to elaborate a policy framework that clearly outlines the measures the state aims to implement to enable livelihood improvements and achievement of oil production goals. These measures should be coherent with the overall strategies put in place in the fields of poverty reduction, rural development and environmental conservation. Despite having approved a national strategy for biofuels development in 2008, the lack of concrete implementation measures has hampered the achievement of the Malian energy policy goals.

This research suggests that there is no "one-size-fits-all" policy to promote sustainable biofuels in sub-Saharan Africa, and that poverty reduction efforts will require to be tailored according to country-specific economic, social and institutional challenges. For example, in Mali this would require research to advance towards the adoption of more coherent institutional, regulatory and fiscal frameworks to support biofuel development. Similar research needs in other parts of Africa are identified by Jumbe *et al.* (2009) and Amigun *et al.* (2011).

Some authors question the capacity of smallholder feedstock production systems to address problems associated with large-scale land acquisitions (German *et al.*, 2011; Findlater and Kandlikar, 2011). They stress that the high risk of failure of a relatively poorly understood crop such as *Jatropha* is borne by the most vulnerable smallholder farmers. The research presented in this thesis confirms these concerns and stresses that clear rules on the conditions for access to land and water resources are needed to attract private investments and avoid emerging threats posed by large scale land acquisitions to existing customary land rights, land and water use. While Chapter 5 suggests that outgrower production through agroforestry systems does not negatively impact land and water access in Mali, Chapter 4 identifies emerging food security and land acquisition threats posed by future large scale operations. In line with findings from the Oakland Institute (2011), these threats are exemplified by the *Jatropha*-related concessions observed in the "Office du Niger", which is the main area of irrigated land used for food production in the Mali. ANADEB is responsible for the socio-economic and environmental sustainability of the Malian biofuels operations; however, ANADEB's claims on the need to use irrigation in the establishment of productive large-scale plantations (semi-structured interview, 2010) raise concerns on the environmental sustainability of future operations. Woodhouse (2012) similarly observes that these kinds of threats are often underestimated in land deals. By promoting a competitive business environment through the establishment and enforcement of motivating regulatory, legal and fiscal frameworks, the state can play a crucial role in securing satisfactory volumes of biofuel production that is both socially and environmentally sustainable. Interviews suggest that fiscal measures should include tax and custom incentives to attract large-scale biofuel investors.

Despite *Jatropha* having been used for decades by Malian households as a living fence and to produce black soap (reducing household's expenses), farmers still have limited knowledge on the establishment of successful plantations aimed at fuel production. Also, the capacity to

make effective use of the plant's by-products (*e.g.* improved production of white soap that can be sold in the market to increase financial capital) remains limited. Chapter 5 shows that project developers face serious difficulties in adequately supporting their farmers due to financial and organisational constraints. In line with findings from German *et al.* (2011) and Birkhaeuser *et al.* (1991), this research indicates that government support in the form of agricultural extension can help to overcome these barriers to local level production. Extension has been widely used in sub-Saharan Africa to foster agricultural development through improvement of knowledge, adoption and productivity (Davis, 2008; Birkhaeuser *et al.*, 1991). Farmer Field Schools (FFS) are being used by practitioners in Mali to train their *Jatropha* farmers (MBSA, 2010) and according to JMI they have proved a useful tool that allows the effective exchange of knowledge on farming techniques and the enhancement of social capital (through creation of social networks of *Jatropha* farmers). These experiences are relatively new and ongoing monitoring is needed to assess the future degree of success of this approach. As of 2011, the Malian Ministry of Agriculture employed 325 extension officers across the 5 southern regions of the country (n=65 per region) with the aim to provide the farmers with theoretical trainings on *Jatropha* farming at the regional level and technical trainings at the village level (DNA, interview data, 2011). These officers are also in charge of raising awareness of the expected benefits of *Jatropha* cultivation in non-grower villages. However, interviews reveal that the weak reporting and monitoring system, together with the difficult communication with the other directorates involved with *Jatropha* promotion and the lack of adequate financing mechanisms, hamper the effective development of extension activities. In order for agricultural extension to be successful, consistent financial and organisational support is required. Given the limited amount of resources available to the government to support biofuel activities, it is therefore vital to strengthen state partnerships with international organisations and donors to improve access to financial and technical support. Since the early 1990s, the integration of renewable energy and *Jatropha* "story-lines" (see Section 4.2) into the national policy discourse has allowed the Malian government to successfully attract the attention, and funding, of the international community (see SREP programme and UNDP project, Table 4.3). While the political upheaval faced by the country since 2012 has temporarily diminished Mali's status as the optimal recipient country for the development of bioenergy projects and policies in the decade of the "Sustainable Energy for All" initiative, the future success of *Jatropha* activities will be linked to the government's capacity to regain and maintain this status.

The 2013 government programme outlines the vision of the recently elected President Ibrahim Boubacar Keïta (Boubacar Keïta, 2013). It identifies sustainable agriculture and the promotion of food security as key priorities for the future development of the country. Emphasis is given to the need to promote activities that preserve the environment and the scarce natural resources available for future generations. The importance of developing and reinforcing synergies across sectors, such as agriculture and energy, is recognised. The programme envisages the elaboration of a new energy policy focused on enhancing Malian energy production and restructuring the actual institutional framework in the energy sector. In line with the recommendations made by this thesis (Section 6.3), it calls for the redefinition of the roles and mandates of the institutional actors involved with energy production, particularly AMADER. It also calls for the promotion of renewable energy, with special focus on solar and wind. While biofuels are not explicitly mentioned in the programme, the restructuring of the Malian energy sector will certainly contribute positively towards regaining the international status of Mali as a country proactively involved with the promotion of an effective energy production system. Similarly to what has been previously observed (Section 4.5), this will once again foster future funding opportunities in the renewable energy sector. The extent to which *Jatropha*-derived biofuel will play a role in this scenario will strictly depend on the future willingness of the government to implement concrete actions to make the *Jatropha* supply chain work for both the nation and the rural poor.

6.2.3 Links and complementarities between *Jatropha* and cotton farming

Looking at the future of *Jatropha* as an energy and cash crop in Mali, it will be important to consider the market trends and livelihood benefits of other cash crops in the country. Table 5.2 indicates that these include cotton, peanut, sesame and shea nut (Karité). As indicated in household level interviews, the three latter crops are considered as minor, and are predominantly grown, harvested and commercialised by women. They offer relatively small but stable cash inflows that can help cover personal expenses and children's school fees. Data suggest that these crops are not likely to compete with *Jatropha* agriculture.

Different considerations are made for cotton, which is the main cash crop competing with *Jatropha* in the country. As reported by Theriault *et al*. (2013) cotton plays a big role in the livelihoods portfolios of over three million smallholder Malian farmers, accounting for 90% of the total value of annual agricultural export (FAO, 2011). As outlined in Chapter 5, 100% of the respondents grow cotton in Koutiala (GERES), 60% in Kita (JMI) and 30% in Garalo (MFC). The

popularity of cotton is due not only to its capacity to generate revenues, but also to the opportunities offered by its credit system to enhance physical capital. The cotton credit system has been promoted since the 1970s by the Malian Company for Textile Development (CMDT). At the beginning of each sowing season it provides smallholder farmers with fertilisers, pesticides and seeds on credit which should be repaid at harvest time (Theriault *et al*., 2013). As indicated by interviews, increased access to agricultural inputs has been a key driver of uptake and has brought tangible benefits in terms of yields improvement and increased food production. This mirrors findings from Theriault *et al*. (2013) and (Tschirley *et al*., 2010), who reported historical benefits of cereal production from the cotton system. Interviewed farmers in this research largely claimed that the establishment of a similar credit system for *Jatropha* would increase their motivation in growing successful plantations simultaneously improving food security.

However, since the 2000s the Malian cotton sector has experienced a significant reduction of acreage and production due to institutional constraints and inefficiencies at the cooperative level (*i.e.* low credit recovery rates and delayed payments to farmers) (Theriault *et al*., 2013). Also, cotton farming is labour intense and, as detailed in the farming calendars in Figure 5.5, labour trade-offs between *Jatropha*, cotton and cereal production occur mainly between June and November. Eighty percent of the *Jatropha* growers interviewed in this study reported a decrease (and sometimes abandonment) of the total cultivated surface of cotton in the same period due to problems experienced with the producers' cooperatives. A joint liability rule forces the successful cooperative members to pay for the loans of other member in case the latter are not able to reimburse. As a consequence, interest in *Jatropha* (with increasing uptake levels) has been driven by the willingness to cope with the problems experienced in the cotton sector and diversify the revenues, particularly with a crop that is perceived as easier to grow and less labour-intensive than cotton.

Increases in cotton market prices in the early 2010s once again raised interest in this crop, as confirmed by the interviewees across the study sites. Future policies, projects and strategies surrounding *Jatropha* promotion must take into account the evolution of the cotton sector, in which revenues are currently higher than those from *Jatropha*. The future success of *Jatropha* will therefore be strictly dependent on the economic benefits offered by the cotton market. These considerations further stress the vital importance of accompanying the cultivation of *Jatropha* with benefits other than the sale of seeds so that a comparative advantage is

generated. The effective production and use of by-products, together with the capacity to concretely expand access to rural energy are essential variables for the promotion of a successful *Jatropha* supply chain.

6.3 Policy recommendations and ways forward

This research has carried out multi-level assessments of the Malian Strategy for Biofuels Development. It addressed key policy and decision-making challenges related to *Jatropha* and sustainable development in Mali transferable across dryland sub-Saharan Africa. Policy recommendations and ways forward are proposed in Table 6.1 in order to address the gaps and implementation challenges that have been identified across the government and local-level project developers (including NGOs and private sector). These challenges could be addressed in various ways that could help improve policy coherency and achieve better impacts in the promotion of a sustainable path for biofuels in Mali.

Table 6.1: Major implementation challenges in Mali's biofuel development and proposed ways forward

Major implementation challenges	Proposed ways forward
• Constraints in seeds commercialisation (inconsistent market structure). Weak implementation of national level projects aimed at strengthening the local market • Opportunistic behaviour of external operators causes distortions of the market price of seeds and hampers the local-level delivery of long-term livelihood outcomes • Revenues from the sale of seeds remain limited	• Elaborate an implementation strategy that outlines the role the state expects to play in the achievement of the policy goals • Regulate the seeds market and promote cooperation among local actors so that opportunistic behaviours are avoided • Prioritise the integration of smallholders production and sale of seeds with the production and use of *Jatropha* by-products to improve overall added value
• Limited feedstock availability hampers the production of higher quantities of *Jatropha*-based biodiesel used to fuel rural power generators • Low yields are due to major challenges faced by smallholder farmers (*e.g.* lack of project support, high incidences of termite attacks, suboptimal agronomic conditions and small financial gains generated from the sale of the seeds)	• Improve farmer support at the local level to increase village-level productivity (e.g. reinforcing extension networks) • An adequate number of field officers should be available throughout the different phases of the farming calendar to provide technical help and motivational support. • Facilitate access to agricultural inputs. As farmers suggest, this could be achieved through the establishment of a credit system similar to the one designed in the cotton market by the CMDT
• Poor data collection and analysis system for monitoring the implemented *Jatropha* activities	• Put in place a data collection and analysis system for monitoring programmes, projects and the achievement of policy goals.
• Multiplicity of institutional stakeholders in *Jatropha* promotion, overlapping roles and lack of coordination	• Strengthen ANADEB's capacity to create a framework of cooperation and coordination for the promotion of biofuels • Improve integration and communication among stakeholders and clarify the roles of the national directorates and agencies operating in the energy, rural development and environmental sectors

• Weak capacity to project developers to design successful CDM methodologies and generate financial resources needed to expand investments and support local farmers	• Support R&D through an integrated approach aimed at sharing the benefits of research across operators • Strengthen AEDD's capacity to support local operators with the establishment of successful CDM methodologies
• Gaps between policy targets, land cover and actual yields	• Revise ambitious energy policy targets in relation to land cover, yields and fossil fuel substitution based on actual achievements and feasibility of achieving future goals
• Large-scale plantations are required to meet land cover and fossil fuel substitution targets • Unattractive business environment to investors: lack of regulatory and fiscal frameworks for biofuels	• Promote a competitive business environment: ANADEB's Investment Promotion Department, in cooperation with the API-Mali, should establish and enforce motivating regulatory and fiscal frameworks governing private biofuel investments
• The elaboration of a national strategy and prescriptive sustainability criteria alone do not guarantee the sustainability of operations: large-scale plantations driven by ambitious land cover targets set within national policies could risk land use shifts away from food towards biofuel production	• Providing clear rules on the conditions for access to farm land and water resources will help to attract investments as well as to ensure the socio-economic and environmental sustainability of the biofuels operations (for which ANADEB is responsible)

6.4 Summary

By integrating research findings from Chapters 4 and 5, this chapter has evaluated the drivers and barriers to the achievement of policy goals in relation to rural development and energy poverty in Mali (research objective 3). After revisiting research objectives 1 and 2 and summarising the key lessons learned, this chapter discussed the priorities and challenges identified at both national and local levels in the development of a pro-poor *Jatropha* supply chain. Considerations for the state to further support *Jatropha* and possible intervention modes were outlined. The integrated multi-level results were linked to elements of theory from Chapter 2. Trade-offs and complementarities between *Jatropha* and cotton farming were explored. It was stressed that the development of *Jatropha* as an energy-cash crop in Mali will be closely linked to the future market trends and livelihood benefits of the main competing cash crops such as cotton. Policy recommendations and ways forward towards the reduction of policy gaps and implementation of a successful *Jatropha* supply chain have been proposed. These target a range of stakeholders across the government and project planning (*i.e.* NGOs and private sector).

Chapter 7

Conclusions

"In literature and in life we ultimately pursue, not conclusions, but beginnings"

(Tanenhaus, 1986, page number not available)

Outline

This concluding chapter provides some brief recommendations for further research, together with a review of the key academic contributions made by this study and a reiteration of the main findings.

7.1 Concluding remarks

This thesis aimed to assess the Malian Strategy for Biofuels Development and its impacts on energy production and livelihood diversification in rural Mali through the cultivation of *Jatropha*. It has advanced academic understanding of the opportunities and challenges surrounding biofuels promotion for sustainable development. Key evidence has been provided that contributes to major biofuel debates, including food versus fuel, land access threats, rural development and fossil fuel substitution potential. Since the deposition of President Touré in a military coup in March 2012, the political instability faced by Mali has challenged the functioning of the state and the livelihoods of the poorest people. A number of ongoing and planned *Jatropha* activities (including the financial support granted by donors) have been partially suspended until the political situation is more stable. While this situation might have a temporary impact on the institutional and regulatory frameworks analysed in this research, Mali remains a sub-Saharan leader in the elaboration of biofuel policy initiatives. Country-specific lessons on these energy and development issues provide the empirical evidence needed to inform the replication of successful approaches and practices to other sub-Saharan countries that are committed to the development of a pro-poor biofuel industry. In the decade

of the United Nations' "Sustainable Energy for All" initiative, case study analysis on these issues is more than ever relevant.

Detailed mixed-methods have been used at multiple levels of analysis to improve the understanding of the impacts of *Jatropha* promotion and use in Mali. Participatory methods have played a leading role in integrating poverty and rural energy security concerns into the more holistic analyses required for sustainable development. The Sustainable Livelihood Framework (SLF) has guided the household and village level assessments of the implications of *Jatropha* cultivation for rural livelihoods. A detailed understanding of the integration of different forms of capital under varied households' livelihood portfolios has been gained. The use of the SLF has been extended by a policy and stakeholder analysis which provided an advanced understanding of the role of policy and stakeholders in biofuels promotion. The use of a mixed-methods, multi-scale focus allowed not only cross-checking and triangulation of data in the field, but also the integration of perspectives from a range of stakeholders in energy and agricultural plans in Mali at different decision-making levels (*i.e.* national to household).

Key findings at the household and village levels are summarised as follows:

- Food security in Mali is not threatened by small-scale cultivation of *Jatropha*;
- When grown as a living fence, *Jatropha* successfully demarcates property, controls grazing and stops soil erosion, contributing positively to food production;
- *Jatropha* cultivation can improve financial capital through the sale of seeds and soap. While the production and sale of seeds alone are not considered as profitable, they offer a potential source of diversification. A formal market for the commercialisation of seeds must be in place for financial and livelihood benefits to be delivered;
- For consistent livelihood impacts to be achieved, it is vital to actively support the farmers in the production and use of *Jatropha* by-products. Promising revenue generation opportunities come from production and commercialisation of white soap (derived from the extracted oil);
- Economic benefits from *Jatropha* are linked to those in the cotton market. Labour shortage may limit the expansion of *Jatropha* as farmers prioritise food and cotton;

- Projects focusing on *Jatropha* use for rural electrification offer potential to improve energy access through *Jatropha*-fuelled power generators and Multifunctional Platforms. However, oil supplies remain insufficient for these benefits to materialise;
- Farmers' difficulties in establishing successful plantations limit the production of adequate quantities of feedstock and the achievement of livelihood benefits. Main constraints perceived at the household level include the low price at which the seeds are sold, the lack of agricultural equipment and organic fertiliser, termite attacks and insufficient technical and moral support received from the project developers.

Major findings at the national level:

- Major implementation gaps are observed between policy targets, actual yields and land cover;
- The plant's production and use are limited by the uncertainty surrounding its agronomic qualities and lack of profitability. The limited availability of *Jatropha* oil supplies hampers the substitution of national fossil fuel consumption. Quantitative policy targets cannot be met without a clear implementation strategy and large-scale industrial plantations;
- The elaboration of national biofuels strategies and prescriptive sustainability criteria alone do not guarantee the sustainability of the operations and industrial activities to be implemented in the achievement of ambitious fossil fuel substitution targets. Appropriate regulatory and legal frameworks can guide the sustainability of large-scale biofuel activities (in terms of land and water use) and avoid threats to food security and land tenure disputes;
- There is no "one-size-fits-all policy". A cohesive mix of country-specific policies that integrate rural development concerns with private sector needs and international policy / donor priorities is required to address a variety of climatic, environmental and socio-economic development needs;
- Measures proposed at the national level include improving coordination among state departments, enhancing monitoring of programmes and projects and investing into agricultural extension network;
- Mainstreaming internationally agreed principles into national policies is key to attract monetary, institutional and technical support from international organisations and donors;

- Long-term rebound effects of increased income and energy consumption on climate change must be avoided. A Climate Compatible Development trajectory for biofuels development should be followed by linking energy planning to climate change mitigation and adaptation measures. This requires adequate financial and organisational resources to be mobilised.

7.2 Recommendations for further research

Since the completion of the field research for this thesis, Mali has faced an unprecedented socio-political turmoil which has dramatically challenged the functioning of the government institutions and the livelihoods of the Malian population. As such, some of the institutions outlined in this study may have stopped functioning, and some of the ongoing and planned *Jatropha* activities may have been halted or postponed. The international community has become reluctant to release bioenergy-related funding to a country that is now considered politically unstable. A peace accord between the Tuareg nationalist rebels and the government was signed in June 2013, while the new president, Ibrahim Boubacar Keita, was elected through democratic process in August 2013. Nevertheless, the battle between the national army and Tuareg rebels in September 2013 indicates that the country has not yet reached stability (Reuters, 2013). Further research will be needed once the political situation has stabilised to update the policy and stakeholder analysis presented in Chapter 4. The overall list and description of the different stakeholders should be revisited, while the status of the *Jatropha* projects, their impacts and the farmers' perceptions should be updated.

More broadly, the increased production of biofuels driven by the policies adopted by the European Union and a number of developed countries between 2004 and 2008 has raised a range of concerns, particularly with regards to the large-scale land acquisitions deriving by these investments. An increasing body of literature has been produced on the risks posed by biofuels production on land tenure and on the competition for arable land, scarce water and food (Sulle and Nelson, 2009 , Cotula *et al.*, 2009; Fairhead *et al.*, 2012; Matondi *et al.*, 2011; Von Braun and Meinzen-Dick, 2009; Schoneveld *et al.*, 2011; Lahiri, 2009; Findlater and Kandlikar, 2011). After the dramatic increase in global food prices experienced in the 2007-2008 crisis, the price peak reached in 2011 further increased these concerns. While this research indicates that large-scale biofuel activities are needed for the Malian policy targets to be achieved, it also stresses the potential land- and water-related threats that these operations may create or exacerbate. Further research is suggested in order to identify

concrete action plans and outline detailed legal and regulatory frameworks to safeguard the socio-environmental sustainability of future operations. Specific lines of investigation could focus on the following issues: identification of optimal supply chain organisation modes to improve profitability and livelihood benefits, farming models and management, links between energy-agriculture-food production through intensified systems, and options for different state intervention modes. For livelihood benefits to be maximised and diversification options to be improved, more research is also needed on the promotion, production, use and markets of *Jatropha* by-products such as soap and seedcake fertiliser.

Future biofuel investments in Africa will depend on the major changes experienced in the global economy and the evolving power relations, with an increasing role being played by the Global South or growing middle income countries such as Brazil, Russia, India, China and South Africa (Schoeman, 2011). In line with this trend, emerging funding opportunities are made available by the international community (*e.g.* United Nations, World Bank and European Commission) and national research councils to foster energy-related research that targets groups of countries such as these. There is much scope for further research that outlines the drivers for action of these emerging powers, investigates their different approaches, and assesses the local perceptions of the impacts of biofuel activities on local economies, particularly in Africa, and on people's livelihoods.

Since the late 2000s the international discourse on biofuels promotion (mainly focused on first-generation liquid biofuels) has gradually shifted towards the broader concept of "bioenergy" and "sustainable energy". This is exemplified by the number of multilateral and bilateral agreements or MoUs signed between growing middle income countries and African countries, where the term "biofuel" is no longer in use and has been replaced by "bioenergy". This change is also reflected in a number of recent policy documents (*e.g.* Master Plan for Bioenergy, Agriculture and Rural Development of the West African Economic and Monetary Union) (Kimble *et al.*, 2008) and international conferences that are leading the African continent towards the development of sustainable energy (*e.g.* 4th International Conference on Biofuels and Bioenergy in Africa, Ministry of Mines, Quarry and Energy of Burkina Faso, Burkina Faso, November 21st-23rd 2013). The role of *Jatropha* as a sustainable development tool should be further explored in the broader context of the United Nations "Sustainable Energy for All" Initiative and the academic discussions surrounding the energy, poverty and climate nexus (World Energy Council, 2012; Gunningham, 2013; SEI, 2009; Scott, 2012). The

case study, multi-level mixed-method analysis used in this study could be expanded to other case study sub-Saharan countries. A broader bioenergy-focused research project which explores the use of *Jatropha* in combination with other feedstock could provide the detailed level of empirical knowledge required for cross-comparison to address questions on the role of pro-poor energy and identify challenges and factors of success.

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Appendix I: Exploratory household questionnaire

QUESTIONNAIRE ENQUÊTE

Date de l'enquête:	
Numéro de série du questionnaire:	

Région:	Cercle:	Commune:	Village:

Section 1: DÉMOGRAPHIE,COMPOSITION DU MÉNAGE, ÉDUCATION

1	Nom du chef du ménage					
2	Nom du répondant (Préciser lien de parenté avec le chef de ménage)					
3	Sexe du chef de ménage	M	F			
4	Combien de personnes figurent sur le carnet de famille ?					
5	Depuis quand avez-vous votre présent carnet de famille ?	Depuis moins de 1 an	1 an à 2 ans	Depuis plus de 2 ans		
6	Combien de personnes mangent dans votre famille ?					
7	Les enfants scolarisables (6 à 12 ans) ont-ils tous été inscrits à l'école lors de la dernière rentrée scolaire?	O	N			
8	Si no, combien de non inscrits?					
9	Pour quelle raison n'ont-ils pas été inscrits ?	Pas de moyens	Besoin de travailler	Distance de l'école	Abandon	Autres raisons

Section 2: ACCÈS AUX SERVICES ÉNERGÉTIQUE

10	Où trouvez-vous les services suivant pour vos besoins ?					
		Dans le foyer familial	Dans le village	Dans la commune	Hors de la commune	Je ne utilise pas ce service
	Poste de soudure					
	Charge de batterie					
	Moulin					
	Pompage de l'eau					

Section 3: JATROPHA

11	Pourquoi avez-vous commencé sa culture?					
12	En quelle année avez vous commencé à cultiver la Jatropha ?					
13	Avez-vous produit du savon en utilisant de la Jatropa avant 2008 ?			O	N → 13b	
13a	Si oui, avez-vous utilisè le savon pour…	Consommation familiale	Vente	Tous les deux		
13b	Avez-vous delimite' votre propriete' en utilisant de la Jatropa avant 2008 ?		O	N → 14		
13c	Si oui, avez vous delimité des terres…	Cultivé	Pas cultivé	Tous les deux		
14	D'ou avez-vous entendu parler de la possibilité de cultiver de la Jatropha?		Famille	Amis	Voisins	Autre:
15	Où avez-vous appris les techniques de culture de la Jatropha ?	Famille	Amis	Voisins	Autre (préciser)	

	Pensez-vous que:	O	N	Préciser
16	Cultiver de la Jatropa est plus facile que d'autres cultivations			
17	Vous allez bien gagner en vendant des graines de Jatropha			
18	La Jatropa peut arreter l'erosion de sol et ameliorer la fertilité			
19	La Jatropa fournira energie plus economique a votre village			
20	La cultivation de Jatropa peut tres bien remplacer celle du coton			
21	La Jatropa est utile pour delimiter votre propriete par rapport aux voisins			

22	Quelle est la superficie totale CULTIVEE (avec des plantes vivantes) de votre champs de Jatropha ?			
23	Avez-vous fait des champs collectifs ?	O (quantifier ha)	N	
24	L'associez vous à d'autres cultures?	O (quantifier ha)	N → 26	
25	Isi oui, lesquelles?			
26	C'etait laquelle la superficie totale de votre champs de Jatropha en 2008?			

27	Pour les cas de diminution de superficie cultivée de 2008 è 2011, quelles sont les raisons de la diminution ?	Manque de main d'oeuvre	Manque d'équipement/animaux de trait	Manque d'intrants	Manque de terre	Culture pas profitable	Climat défavorable
		Trop des termites/ feux de brousse	Autre (préciser)				

28	Quels sont les membres de la famille qui ont des champs individuels de jatropha ?						
			Superficie cultivée individuellement				
		Chef de ménage					
		Epoux/se					
		Enfant(s)					
		Autre					
29	Quelle est l'écartement de votre champ ? (distance en mètres entre les arbres)		3x3	5x2	Autre:		
30	Avez-vous une source d'eau dans votre ferme ?	O	N				
31	Reduiriez-vous la surface cultiveé par des cultures vivrieres pour cultiver de la Jatropha dans le futur?				O	N	
32	Quelle est la plus intensive periode de travail en cultivant la Jatr.?	Jan-Fev	Mar-Avr	Mai-Juin	Jul-Août	Sep-Oct	Nov-Dec
33	Cette periode se superpose-t-elle avec les periodes de travail intensif sur les culures vivrieres ?			O		N → 35	
34	Quand ?						
35	Avez-vous employé des travailleurs sur votre champ de Jatropha la derniere recolte ?			O		N → 38	
36	Si oui, combien de travailleurs (specifier salaire journalier) ?	Individuel:			Groupement:		
37	Combien de jours ?	Individuel:			Groupement:		
38	En quel anné avez-vous fait votre prèmiere récolte des graines de Jatropha dans votre champ?			Anné:	Je n'ai pas encore récolté → 44		
39	Avez-vous vendu les graines de Jatropha la derniere recolte?	O	N				
40	Si non, pourquoi ? → 44						

41	Si oui, combien de kilos ? (spécifier si vous avez aussi vendu des graines provenant des haies vives)					
42	A qui?					
43	Prix ?					
44	Est-que vous pensez que dans le future vous pourrez…		Cultiver la meme surface de J.	Augmenter la surface		Diminuer la surface cultiveé
45	Si "diminuer" o "arreter", pourquoi?	Manque de main d'oeuvre	Manque d'équipement/animaux de trait	Manque d'intrants	Manque de terre	N'est pas rentable
		Trop des termites	Autre:			

Section 4: CARACTERISTIQUES DES CHAMPS ET LE REGIME FONCIER

46	Quelle est la superficie totale disponible (champs + jachère) de votre ménage ?			
47	Cultivez-vous les terres dont vous n'etes pas proprietaires ?	O (quantifier)	N	

48 Par rapport à l'année précédente, la superficie cultivée en 2011 a-t-elle augmenté, diminué ou été identique ?

	Superficie totale (ha) 2011	Augmenté → 50	Diminué	Identique → 50
Sorgho et mil				
Maïs				
Riz				
Coton				
Arachide				
Niebé				
Sesame				

49 Pour les cas de diminution de superficies cultivées, quelles sont les raisons de la diminution ?

	Manque de main d'oeuvre	Manque d'équipement/animaux de trait	Manque d'intrants	Manque de terre	Intérêt pour autre culture	Autre (préciser)
Sorgho et mil						
Maïs						
Riz						
Coton						
Arachide						

50	Est-ce que votre unité de production emploie des travailleurs (en plus des membres de l'unité de production) ?				O	N
51	A quelle période de l'année ?					
52	Pourquoi ?					
53	Fertilisez-vous vos champs avec ... ?					
			Du compost	Du fumier	Des engrais fournis par la CMDT	Des engrais achetés
		Jatropha				
		Céréales				

Section 5: ÉLEVAGE

54	Combien d'animaux d'élevage possédez-vous à ce jour ? Par rapport à 2008, votre cheptel en 2011 a augmenté, diminué ou été identique ?				
		Cheptel actuel	Augmenté	Diminué	Identique
	a) Boeuf(s) de labour				
	b) Autres bovins (Cheptel)				
	c) Ane(s)				
	d) Cheval				
	e) Caprin(s) / ovin(s)				
	f) Volaille				

Section 6: ACTIVITÉS GENERATRICES DE REVENU:

55	Est-ce que des membres de l'unité de production ont des activités … ?	Vente de récolte	Vente d'animaux	De commerce	Fabrications artisanales	D'autres activités génératrices de revenu:	
56	Quelle est l'activité la plus grand?						
57	Votre revenu total a-t-il augmenté ou diminué depuis de 2008 ?			Augmenté	Diminué	Identique	
58	Lors de l'année écoulée, avez-vous subi/connu des dépenses exceptionnels ?	Investissements pour vos activités productives (cultures, élevages, commerce, artisanat, etc.)		« Cassara » (maladie, accident, décès d'un animal de trait, obligation sociale)			No → 60
59	Pour faire face à cette situation, avez-vous dû… ?	Recourir à une aide	Vendre du cheptel	Vendre des avoirs	Emprunter	Placer un enfant	Autres:
60	Depuis de 2008, avez-vous emprunté de l'argent ?	O	N → 63				
61	Auprès de qui avez-vous emprunté de l'argent ?	Des membres de la famille	La CMDT	Une/des organisation(s) paysanne(s)	Une/des caisses de crédit/banques		Autres:
62	Pour quelle raison ?						

Section 7: AVOIRS ET CONDITION SOCIALE

63	Indiquer si le ménage possède les articles suivant et combien:						
		a) Voiture		d) Television		f) Charrue	
		b) Mobylette		e) Radio		g) Multiculteur	
		c) Velo				h) Semoir	
64	Considérez-vous que, par rapport à 2008, les conditions d'existence de votre ménage …					Se sont améliorées	Sont pareilles	Se sont détérioréés

Section 9: SECURITÉ ALIMENTAIRE

65	Avez-vous eté autosuffisantes pendant la dernière campagne ?			O →Fin du questionnaire	N
66	De quel mois a quel mois avez-vous acheté de céréales ?				
67	Dans cette periode, avez-vous...	Réduit le nombre de repas quotidiens		Diminué les quantités servies aux repas	Pas changé
68	Avez-vous demandé à emprunter des céréales pour vous nourrir ?		O	N	

Appendix II: Short brief for interview

School of Earth and Environment

University of Leeds
Leeds LS2 9JT

Tel. No: (*removed)*
E-mail: n.favretto@see.leeds.ac.uk

UNIVERSITY OF LEEDS

08th March 2010

Can Biofuels Improve Mali's Environment and Household Energy Security?

Dear Sir/Madam,

I am a PhD student at the University of Leeds, United Kingdom undertaking a PhD research on "Can Biofuels Improve Mali's Environment and Household Energy Security?".

This research seeks to improve our understanding of the links between biofuels production systems, environmental restoration and rural energy provision in drylands, thereby increasing household energy security in Mali.

You are being invited to take part in this research by granting an interview.

All the information that will be collected about you during the course of this research will be kept strictly confidential and will only be used for the purpose of this PhD research.

You will not be able to be identified in any reports or publications that result from this research.

I must emphasise that your participation in this research is voluntary.

For any clarification on this research you can either contact me or any of my supervisors below.

Thank you.

_____
Mr. Nicola Favretto (Student)

Contact Details
Mr. Nicola Favretto:
(removed) (UK mobile), E-mail: n.favretto@see.leeds.ac.uk

Supervisors
Dr. Andy Dougill *(removed)*, Dr. Lindsay Stringer *(removed)*

Appendix III: Informed consent form

Consent Form

Title of Research: "Can Biofuels Improve Mali's Environment and Household Energy Security?"

Name of Researcher: Mr. Nicola Favretto

Please initial box

- I confirm that I have read and understand the information sheet dated 08th March, 2010, explaining the above research project and I have had the opportunity to ask questions about the project. ☐

- I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline. I will also be free to withdraw data after it has been analysed. ☐

- I understand that my responses will be kept strictly confidential. I understand that my name will not be linked with the research materials, and I will not be identified o identifiable in the report or reports that result from the research. ☐

- I agree for the data collected from me to be used in this research. ☐

- I agree to take part in the above research project. ☐

_____	_____	_____
Name of Participant (*or legal representative*)	Date	Signature
_____	_____	_____
Lead Researcher	Date	Signature

Contact Details
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