

## RE-IMPACT: FOREST BASED BIOENERGY FOR SUSTAINABLE DEVELOPMENT IN DEVELOPING COUNTRIES

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**ABSTRACT:** Re-Impact "Rural Energy Production from Bioenergy Projects" is a project funded by the European Union Aid Cooperation office which is promoting a sustainability assessment framework for bioenergy project focussed on rural development in developing countries. The project has case studies in China, India, Uganda and South Africa. This paper provides an overview of the analysis of regional bioenergy policies in the case studies. In China the focus of attention has been the transition to modern biomass in Yunnan Province, looking both at *Jatropha* and forest; in India, the implementation of the biofuels strategy in the State of Chhattisgarh; in South Africa, the potential for biofuels in the SADC region; and in Uganda the potential for biomass power plants based on short rotation plantations. The case studies show the need for more evidence-based policies that take into account land use and equity issues in rural development. Bioenergy projects need to be based on sound management models with technical and economic viability.

**Keywords:** policies, developing countries, rural development, *jatropha curcas*; biofuels; biomass; forestry

### 1 INTRODUCTION

Energy security, global warming and, until recently, rising fuel prices have been driving a renewed interest in developing countries in biomass based electricity production schemes and in schemes for the production of biodiesel from tree borne oilseed (TBO) crops like *Jatropha curcas*. However, in spite of the high potential of bioenergy as a mechanism for rural development, its sustainability has become an issue of global debate. On the wood-fuel supply side existing forest resources are often poorly managed, highly degraded and extraction rates are routinely not sustainable. On the liquid fuels side, high import costs of petroleum and increasing per capita energy demand are behind national drives for self sufficiency which are not always backed by a proper impact analysis. Large scale plantation programs for wood-fuel or biodiesel have environmental and social costs and benefits which, if not properly taken into account, may result in perverse outcomes. For example, where water resources are already scarce, the availability for downstream users and the environment can be seriously affected; and enforced land use changes can have negative impacts on the livelihood of the local population.

Re-Impact "Rural Energy Production from Bioenergy Projects" ([www.ceg.ncl.ac.uk/reimpact](http://www.ceg.ncl.ac.uk/reimpact)) is a project funded by the European Union Aid Cooperation office. Re-Impact is working to promote a sustainability assessment framework to evaluate whether appropriate bioenergy projects are a viable rural development alternative in developing countries. This program, which commenced in May 2007 and is scheduled to run for 40 months, focuses on the impacts to water resources, greenhouse gases emissions, biodiversity and society of

plantations for bioenergy in four countries: South Africa, India, China and Uganda. Re-Impact has a bottom-up approach to help strengthen the national scientific-based discussion in these countries. The project is producing policy analyses of biofuels programs to be used directly in the case study countries, and a cross country overview for more global application. This paper provides a summary overview of the findings of the project. Original project papers are mentioned in each section and should also be quoted when referring to the information here provided.

### 2 CHINA

#### 2.1 Re-Impact in China

The Re-Impact project in China is led by the Centre for Mountain Ecosystem Studies (CMES), a joint centre of the Chinese Academy of Sciences (CAS) and the International Centre for Research in Agroforestry (ICRAF). Re-impact in China has paid particular attention to the transition from traditional biomass to modern biomass and taken Yunnan Province as their focus, with an especial interest in rural energy provision and carbon sequestration. The team produced early in the project a base line assessment of bioenergy policy in China with a focus on rural use in the Southwestern provinces [1] and an analysis of opportunities and challenges for *Jatropha curcas* [2]. The analysis of *Jatropha* has been subsequently discussed in a Provincial level workshop. They also undertook a thorough survey to understand household land, energy and biomass use in 5 villages representing different agro-systems in the province, which is currently under analysis. This study has been complemented with a comprehensive analysis of

China's bioenergy future through the lens of Yunnan Province [3] and the role of forest as a carbon resource [4].

## 2.2 Jatropha in China

China's increasing dependence on foreign oil has positioned transportation fuels as a growing focus of the country's energy policy. As the world's second importer of oil, policy makers have reasons to be concerned about future geopolitical and economic consequences. Over the past decade the Chinese government began to support research and development efforts on a range of potential supply-side alternatives; biofuels are one such alternative. As a consequence, China quietly emerged as the world's third largest biofuel producer in 2005. However, due to concerns over rising food prices, in June 2007 China's central government banned the use of grain-based feedstocks for biofuel production and reoriented the country's bioenergy plans toward perennial crops grown on marginal land. One such crop, *Jatropha curcas*, emerged initially as a high potential biodiesel feedstock because of its adaptability to the diverse growing conditions where China's marginal land is abundant.



**Figure 1** Map of Southwest China

Southwest China, including Guizhou Province, Sichuan Province, and Yunnan Province, which are some of the country's poorest regions, became the official target area for *Jatropha* production in China. Provincial governments in Southwest China drafted ambitious plans to increase *Jatropha* by over one million hectares in the next decade. Earlier National Development and Reform Commission strategies focused primarily on Sichuan and to a lesser extent Guizhou because of the provinces' comparatively early efforts in *Jatropha* research and development. However, surveys at the provincial level revealed that Yunnan has significantly more land available for *Jatropha* production than either Guizhou or Sichuan. Yunnan was then designated the national *Jatropha* demonstration province and most central government funds for *Jatropha* research and development were channeled to Yunnan.

In Yunnan Province *Jatropha* can typically grow at an altitudinal range of 600-1400 meters above sea level (masl). *Jatropha* commercialization in China is fairly recent, with commercial seedling production beginning in 2005, and most of the existing *Jatropha* trees are used for fencing. In spite of this traditional use, an analysis of current knowledge shows that sufficient research has not been conducted in China to estimate commercial yields in different ecological zones and with different levels of

rainfall, and to determine a more specific range of fertilizer and pesticide inputs required for commercial *Jatropha* production. Additionally, provenance research on *Jatropha*, including seed trials and establishment of certified nurseries, is lacking in China. For most new plantations there is no valid record of where the seeds or seedlings come from, how suitable they might be for different ecological zones, and what best practices for silvicultural management (e.g., spacing, pruning) should be. Publicly- and corporately-funded research and demonstration efforts with *Jatropha* germplasm and tissue culture are ongoing. For instance, China National Petroleum Corporation (CNPC) provided 5 million RMB (US\$658,000) to initiate 4 demonstration projects in Yunnan as part of a 5-year program focusing on seed selection, tree improvement, and management practices (although this project seems to have been discontinued in 2009). Much less attention has been given to *Jatropha* economics in China, and particularly how *Jatropha* biodiesel markets might be shaped and regulated.

Re-Impact research has contributed to show that although often justified from a national security and climate policy perspective, under realistic nearer-term assumptions about oil content and seed yields the planned 1 million hectares of *Jatropha* will not contribute to either a meaningful reduction in China's oil imports or its petroleum-based CO<sub>2</sub> emissions. However, *Jatropha* development does have potential to increase provincial revenues, raise rural incomes, and restore environmental services from forests in Southwest China. Whether this potential can be realized will depend on how programs to support *Jatropha* development are structured. This would require a reasonable quality of available marginal land, relatively high oil content and high yielding plants, and institutions that coordinate *Jatropha* markets and explicitly integrate environmental considerations into *Jatropha* planning. None of these conditions are certain to be met. The present, preliminary stage of *Jatropha* development in Southwest China suggests the need for further, intensive research to better understand potential costs and benefits before rapidly scaling up *Jatropha* acreage. This seems to be also the current view of the Yunnan Provincial government.

## 2.3 Forest based bioenergy in China

China is the second largest energy consumer in the world with 1.7 billion tons of oil equivalent in 2006 or 15.6 % of the World consumption [5]. Despite the fact that 96% of the population is connected to the grid, 700 million people in rural areas are still using forest biomass and agricultural residues to meet nearly 90% of their energy needs; particularly in Southwestern China. The vast majority of China's bioenergy is used for cooking and heating in rural areas, where it is the dominant source of energy and is often burned in low efficiency stoves in what is commonly referred to as "traditional" biomass use. As the world's largest bioenergy consumer, China is in a long transitional phase between "traditional" and modern bioenergy use. Reducing the impacts of traditional bioenergy use, while setting the organizational, market, and technological grounds for modern bioenergy, is an important policy priority.

Bioenergy in China is not completely synonymous with rural fuelwood use. Instead, agricultural residues (e.g., corn stover, rice husks) are the dominant source of

bioenergy for many rural households in China. However, in Yunnan, wood is the larger source of rural bioenergy consumption. A transition from traditional bioenergy requires fuel switching to alternative fuel sources; upgrading to more efficient equipment; and reducing energy-using tasks, or the energy needed per task. The problem is that energy substitution in rural China is extremely complex and task specific. Although many of the changes that will shape rural China over the next 20 years will be driven by larger socioeconomic forces, effective interventions focused around bioenergy could help to improve rural livelihoods, further agricultural and forest productivity, enhance energy and timber security, and meet environmental goals. Research undertaken by this project suggest that sound policy making will require improving the base of information on which rural energy- and land-use related interventions are grounded; building a decision-making framework to evaluate trade-offs among different policy goals; and designing and developing rural markets for energy and energy-related technologies.

One critical question from the biomass perspective is the role that forest could play in future policies. China has implemented an incredible forest transition [6] based on national policies such as the Sloping Land Conversion Program (SLCP) which provided grain, seed, and cash subsidies to farmers in 20 provinces to convert farmland to forest on hillsides above 25 degrees (although in a very recent development China has halted a program of letting marginal farmland return to woodland in order to maintain arable land, showing the strain of land use competition). Millions of hectares of new forest have been planted; but these young plantations are typically overstocked and unmanaged. Rural energy and climate change policy are expected to be a strong drivers of a forest and energy transition in rural China within the next 10 years and will determine whether this forest could provide the basis for Sustainable Forest Management with changes in fuelwood use or even Forest Based Biopower with rotation forests used as a feedstock to generate electricity. Research in this project has shown that modern forest based bioenergy is currently financially not competitive in China with bio-based material use. Replacing traditional fuel-wood is a precondition to introduce modern forest based bioenergy or Sustainable Forest Management for timber production but both require policy drivers, forest tenure and capable institutions. Small-scale off-grid modern bioenergy is not cost competitive in China, mainly because 98 % of all households are linked to the power grid. Any viable bioenergy forest policy will require research on forest growth, forest management and rural energy interactions.

### 3 INDIA

#### 3.1 Re-Impact in India

Winrock International India and the Indian Institute of Technology Delhi are the Re-Impact partners in India. Here the project has focused its efforts on the sustainability assessment of the production of *Jatropha curcas* taking the State of Chhatisgarh as the main case study. An initial review of the Indian Biofuels Programme [7] provided the base line for a systematic scoping study involving interactions with key stakeholder at Centre, State and local levels including public and

private interest. The project is currently developing a sustainability assessment methodology for Indian conditions; analyzing the emerging modes of production of *Jatropha curcas* [8] [9]; and building a GIS-based system to model water and other impacts of biofuel plantations at state level [10].

#### 3.2 National Biofuels Policy

Ministry of New and Renewable Energy (MNRE) at Federal level with the mission of developing and implementing policies in this field. However, bioenergy policy is a contested area due to the overlaps of interest from several ministries (eg Ministry of Petroleum and Natural Gas, Ministry of Rural Development and Ministry of Agriculture), leading to frequent deadlocks in policy development. The initial driver for biofuels from the Center has arguably been energy security and the need to save foreign exchange. India has larger reserves of coal, which contribute to more than half of its energy requirements, but it is not endowed with crude oil reserves. The country has to import approximately 70% of its oil. With an expanding economy, the number of vehicles is growing at an exponential rate. It has been estimated by the Planning Commission that by 2020, the oil demand of India will increase to 263 million tones out of which approximately 90% may have to be imported. Furthermore, with rising global oil prices, the total costs of imports would increase rapidly in order to meet the demand, which may have a negative impact on the development and GDP growth of the Indian Economy.

Use of biofuels in India started already during the World War II when ethanol was blended with petrol to meet shortages but, in spite of several isolated R&D projects, has gained significant momentum only in the past decade. Initially the main focus was in ethanol. In 2003 blending of 5% of ethanol with petrol was made mandatory in several States but the program was abandoned due to disagreements in the price of ethanol. The program was then revised and the 5% ethanol target was introduced for most of the country from November 2006. However, with an 80% of diesel driven vehicles there was a need to tackle biodiesel production leading to the launching in 2003 of the National Biodiesel Mission by the Planning Commission. The Mission identified *Jatropha curcas* as the most suitable tree-borne oilseed for the production of biodiesel and expected the program to substitute fossil diesel up to 20% by 2011-12 as well as help rehabilitate degraded land. This is a key point to understand Indian policies. The central thrust of the policy is based on the premise that the very vast land area (approx. 30 mill ha) in India classified as marginal/degraded/waste land can be used for the successful production of non-edible vegetable oil. This means that an energy policy measure becomes de facto a rural development measure when implemented on the ground.

The Ministry of New and Renewable Energy produced a draft National Biofuel Policy which after many discussions has yet to be approved by the National Cabinet. This delay is causing serious problems to the whole sector but is also viewed by some as a chance to improve a flawed policy. One of the consequences of the delay is that private producers have to diversify business to survive. The current approved document has an indicative target of blending of 20% biofuels (both

bioethanol and biodiesel) by 2017. Key features are that bio-diesel production will be taken up from non-edible oil seeds in waste / degraded / marginal lands encouraging plantations on community / Government / forest waste land while avoiding plantation in fertile irrigated lands. Imports of edible oil would be banned, causing trouble to current biodiesel producers which use imported palm oil and used oils. The policy calls for yearly targets of plantations and biofuels use, assuming that Government funds will be used to support plantations. From a cost perspective, the policy offers fiscal incentives and continues the already established policy of fixing a Minimum Support Price (MSP) for bio-diesel oil seeds and a Minimum Purchase Price (MPP) for the purchase of bio-ethanol by the Oil Marketing Companies (OMCs) based (theoretically) on the actual cost of production and import price of bio-ethanol and the prevailing retail diesel price, but without providing a sound analysis of the economic viability of the proposals. Moreover, the draft policy lacks an in depth analysis of the sustainability of *Jatropha* plantations as an option for rural development. There is a lack of evidence behind productivity assumptions which are critical for the technical viability of the policy. Moreover, there is no definition of the supply chains for producers to markets, which will invariably require the participation of the oil marketing companies, in particular the public sector oil companies which control most of the market: Indian Oil Corporation, Bharat Petroleum Corporation and Hindustan Petroleum Corporation. Private biodiesel producers either sell to these oil marketing companies or have to export.

The National Biofuels Policy draft is not the final version and therefore may yet include other important aspects through the consultative process. Meanwhile, at the State level different States have already adopted different approaches, albeit within the spirit of the current draft. Several States have taken the lead to promote plantation of tree-borne oil bearing plants, meanwhile other States have abandoned this policy. Chhattisgarh is one of the leading States with a nodal agency and an initial ambitious target of planting *Jatropha* over one million hectares of land. Uttarakhand has also launched the Uttarakhand Biofuel Board and set a target of 0.2 million hectares by the year 2012. Similarly, other States such as Karnataka, Andhra Pradesh, Tamil Nadu, Gujarat and Haryana have also launched a biodiesel programs.

### 3.3 Chhattisgarh

As per Government of Chhattisgarh (GoCh) estimations, the State has significant land resources that could be applied towards the cultivation of *Jatropha* plantations (around 2 million ha, or 14 percent of its geographical area, is categorized as wastelands). Already around 90,000 ha of barren lands have been brought under *Jatropha* plantations and originally the State aimed to achieve the million mark. This effectively meant that on an average 150,000 ha of *Jatropha* plantations would have to be established per annum. The GoCh has adopted a multi-agency approach that seeks to align cross sectoral objectives and interests. Besides the Chhattisgarh Biofuel Development Authority (CBDA), the Department of Rural Development, the Forest Department and individual farmers are involved in developing *Jatropha* plantations. Further, corporate agencies are increasingly interested in participating in the program on a

commercial scale.



**Figure 2:** State of Chhattisgarh in India

The Department of Rural Development is capitalizing on the biofuels program by clubbing plantation activities with the National Rural Employment Guarantee Program. This is a clear example of how on implementation biofuels policy becomes a rural development measure taking as priority rural employment. As per GoCh estimates, one hectare of *Jatropha* plantation can provide employment to one person for one year. Correlating this to the target of one million hectares, it can be estimated that the GoCh would be capable of providing employment opportunities to 910,000 rural households for a period of at least one year each. Therefore, through the biofuels program the GoCh would be able to reach out to 59 percent of the below poverty line (BPL) households and 24 percent of the rural households in the state, which would appear to be a significant achievement in a much undeveloped State. This policy was only concentrating of the planting of *Jatropha*. Although there were initial plans for trans-esterification units in rural area, the policy assumes that the planted *Jatropha curcas* will find a natural market. Thus progress so far has been limited to the identification of government waste land, formation of task forces in each District, raising of samplings and planting in more than 150.000 ha, and the building of an experimental biodiesel plant in the capital, Raipur. Paradoxically, although there is no clear pathway for the production of biodiesel *Jatropha* seeds from Chhattisgarh are considered to be of high quality and are in great demand in the market outstripping supply.

Aware of the limitations of the initial policy and the need to link seed production to oil marketing companies able to distribute and sell the final produce, the State has introduced a radical change of approach. It is now pursuing the establishment of Joint Ventures with public sector oil companies for new enterprises able to cover the whole supply chain from production to feedstock of distribution. For example, the State is taking a 26% participation as sleeping partner in a joint venture with

the Indian Oil Corporation (IOC) to which it will lease 30,000ha of plantations in 8 Districts of the State. IOC will exploit these plantations without direct subsidies and direct investment of \$8.5 mill. Similar ventures are being discussed with other companies. Independently a number of private operators are still pursuing different models of commercial production.

### 3.4 Future Developments

National level elections at the beginning of this year have hampered any substantial development of the National Biofuels Policy. However, the emergence of strong government would suggest that the potential for a strong mandate exists. There are some signs of a more rational approach that takes into account real yields of *Jatropha* in the fields. There is also an emerging acknowledgment that this is not a zero management crop and requires inputs and management practices, especially in the first year. Also, as the IOC example show, that there is a clear need to sort out economically viable, whole supply chain models. However, these models will open new questions regarding sustainability and rural development objectives that should be carefully examined. As a conclusion, there is still a future for biofuels in India with the potential to spearhead rural development in much needed areas but it will require a more realistic and evidence-based approach to policy making and implementation.

## 4 AFRICA

### 4.1 Re-impact in South Africa and Uganda

Re-Impact has two teams in Africa. In South Africa the Council for Scientific and Industrial Research (CSIR) is focusing on biofuels policies in South Africa while researching also developments in the wider Southern Africa Development Community (SADC) region with an emphasis on *Jatropha* plantations. The South African team is working on sustainability assessment, water, carbon and biodiversity impact and on the rural development potential of biofuels in the region. An initial country review [11] is being followed up by several ad hoc studies on the above topics [12]. Re-Impact research was used to support a CSIR report on biofuels in the region for Oxfam GB [13].

In Uganda, the Re-Impact team includes Unique forestry consultants East Africa Ltd and the Centre for Research in Energy and Energy Conservation (CREEC) of Makerere University. The focus in Uganda is the modern forest bioenergy based on feedstock plantations or agroforestry production systems. The team in Uganda undertook a base line policy review [13] and later more detailed studies on short rotation energy plantations [14] and [15]. It is currently working on an integrated assessment of a proposed site for development in Northern Uganda and a general evaluation of short rotation forestry as a policy alternative for the region.

### 4.2 Biofuels in South Africa and SADC

Bioenergy in the form of fuelwood is an important energy resource throughout rural South Africa. However, bioenergy as either bioethanol or biodiesel has been until recently relatively unknown. As a region, Southern Africa has been identified as a place with high potential to meet global biofuel demands due to large land endowments of currently under utilized land with good

climatic conditions. Developing countries in the area see the biofuel industry as a potential catalyst to economic growth, poverty alleviation and security of energy supply. Biofuel production represents an opportunity to boost rural economies by creating international markets for fuel crop products and in turn opening markets for agricultural surpluses.

This is less applicable to the Republic of South Africa, which is the only country in the region with an established biofuels policy. In 2002, the White Paper on Renewable Energy was published with the vision of an 'energy economy in which modern renewable energy increases its share of energy consumed and provides affordable access to energy throughout South Africa'. The replacement of fossil-derived petroleum with sustainable alternatives was emphasized and as such The Petroleum Products Amendment Act and Bill provided the platform for biofuel development within the country with regards to the ability to acquire licenses for petroleum fuel products derived from biomass. In 2006, this Act was again amended and included specific standards for biodiesel and bioethanol. In late 2006, the Draft Biofuels Industrial Strategy compiled by a biofuels task team was released for public comment. This document emphasized that the main focus of the biofuel industry within South Africa is not only to contribute to the renewable energy goals but to address poverty and economic development. The biofuel industry would be the catalyst for the promotion of farming in rural areas bridging large scale and small scale farming. In December 2007, the strategy was revised to propose a short term focus (5 years) in which to achieve a 2 % penetration level of biofuels in the national liquid fuel supply (bioethanol at 8% blending and biodiesel at 2 % blending). This target was revised from the 4.5 % target initially proposed in the draft strategy. The food fuel debate led South Africa to propose feedstock from sugar cane and sugar beet for bioethanol production and sunflower, canola and soya beans for biodiesel. Two very important developments were introduced in the strategy: maize was excluded to eliminate competition with food and, critically for biodiesel, the National Department of Agriculture rejected *Jatropha* as a feedstock due to its foreseen invasive potential within the country. The policy recognizes the need for creating a favorable investment climate to support biofuels and provide guidelines on how support should be phased in or out dependent on global oil pricing. The strategy fails to address the logistics of refineries, transportation, blending and how these will work within the proposed small scale farming network. All in all, the strategy does not provide a strong support for a buoyant biofuels industry in the country. Although South Africa can meet its 2% blend requirement with minimum food conflict, it can never be a major biofuels producer due to land constraints. South Africa may be better off importing biofuel from surrounding countries rather than attempting to be significant producer in the region using first generation biofuel technologies. Second generation technologies may allow South Africa to be a larger player in the future.

The picture for the rest of the region is different. Although none of the other countries has a proper biofuels policy, some initiatives are already in place. The potential of southern African countries to supply local



(and possibly internationally) biofuel source could potentially lead to significant economic development within each of countries investigated. Biofuels may not be the most profitable, sustainable or best suited land use, but the enthusiasm for biofuels may drive development which may not happen through other sectors. Regarding potential, research highlights that Mozambique and Zambia have sufficient arable land available to meet both their food and total fuel requirements with surplus land to meet fuel or food export requirements. Being an inland country, Zambia needs to import their petroleum product and petroleum prices significantly influences food prices due to transportation cost and agricultural input costs. The biofuel industry is extremely appealing to Mozambique as their ports make it easy to export surplus biofuel products to international markets. Malawi is a small country with a high population density, as this country has limited land available it should not try to become an important biofuel producer. Malawi does, however, have a ready established bioethanol production system which contributes approximately an 8% blend to the country's petroleum. In spite of the potential for productions of biofuels in the region, before any biofuel project or program is initiated both a strategic and bottom up investigation is needed to ensure that the specific projects is sustainable. In particular site specific investigations are needed to consider sustainability of the land use against other land use options.

#### 4.3 Bioenergy and forest resources in Uganda

Uganda is one of the few African countries with a clearly focussed renewable energy policy, which was published by the Ministry for Energy, Minerals and Development (MEMD) in 2007. The policy established the goal to increase the use of modern renewable energy, from the current 4% to 61% of the total energy consumption by the year 2017. Its objectives include increasing access to modern, affordable and reliable energy services as a contribution to poverty eradication. This comprises general public access to electricity and enhancing the modernisation of biomass conversion technologies.

Uganda's current energy demand is largely met by biomass which now accounts for about 93% of the total primary energy supply. The per capita consumption of biomass in Uganda is 680 kg/year and 240 kg/year for firewood and 4 kg and 120 kg for charcoal for rural and urban areas respectively. Total biomass (firewood and wood for charcoal) demand for households was 22.2 million tons in 2006. Small scale industries account for about 20% of total biomass use, adding a further 5.5 million tons and bringing the total biomass demand to about 27.7 million tons countrywide. Trading in biomass energy, especially charcoal, contributes to the economy in terms of rural incomes, tax revenue and employment. It saves foreign exchange, employs 20,000 people and generates €15 Million per year in rural incomes, but the environmental costs and the long term sustainability of the energy source are unclear.

Currently, only 5%-10% of the population in Uganda has access to electricity; in rural areas the number is as low as 1%. Total installed capacity in Uganda is max. 400 MW, mainly from hydropower installations, but production is significantly lower because of the low water levels in Lake Victoria. Daily electricity shortages

are estimated to be in the range of 100-130 MW. To address the predicted shortfall in energy, two major hydropower projects are currently being planned in Bujagali and Karuma, which, when completed, will increase the installed capacity by 470 MW. Some smaller hydro electric schemes, sugar bagasse burning, and thermal schemes are also under construction. Nevertheless, all these projects combined will not meet the anticipated future energy demand and are all exposed to a considerable climate change risks, i.e. they depend on regional rainfall patterns, and therefore alternative renewable energy sources have to be explored. With further increasing demand, Uganda is in need of additional renewable energy systems. Thermal power generation from fossil fuels, which is currently widely installed, is not a sustainable solution considering fossil fuel costs, air pollution and greenhouse gas emissions. Thus, the expansion of bioenergy has emerged onto the political agenda, although its implementation is still not fully anticipated.



Figure 3 Re-Impact research area in Northern Uganda.

Use of forest biomass for modern bioenergy production is in principle difficult due to the unsustainable use of forest resources by traditional biomass use and the rapid increase in population. However, the option of contributing to widely available electricity at affordable prices through expansion of the grid with biomass fuelled power plants should be considered by the Government and donors as a potential land use alternative in rural areas. Unfortunately, the Ugandan Electricity Regulatory Authority has not recognized yet sustainable biomass power project (beside bagasse fired projects) for their feed-in tariffs. Re-Impact is developing a sustainability assessment of the potential use of new short rotation plantations in Northern Uganda.

## 5 CONCLUSIONS

The 4 Re-Impact case studies provide a mixed picture of the future of bioenergy. In general there has been a tendency to develop policies without substantial evidence. The case study of Jatropha in China illustrates how even an in depth scoping study can help to improve policy design. According to the findings of this project, there is currently not much future for Jatropha in China until some basic questions are answered. Similarly, the draft National Biofuels Policy in India would benefit from a more solid experimental approach able to fill in the existing gaps in knowledge. The case study in Chhattisgarh shows how this State is already addressing

some of the flaws of a policy which has not yet worked out a viable business model. However, there is still a chance of using biodiesel as instrument of both rural development and energy policies for the benefit of the extensive rural populations if their needs are also taken into account. In the SADC region there are reasons for moderate optimism for biofuels. In spite of the current drop in interest, several countries in the region have available land and optimal climatic conditions with the potential to use biofuels as a driver for rural development. This doesn't apply to South Africa where there is more pressure on land and the government has adopted a very cautious approach banning the planting of *Jatropha* for its invasive potential.

Modern forest based bioenergy in our case studies is hampered by the current extensive traditional biomass use. This use exerts a strong pressure on forest resources and does not leave space for new activities. In China, in spite of extensive reforestation modern biomass would not be currently economically viable. And there is even an open question on whether sustainable forest management with changes in fuelwood use is possible. Changes in rural energy and climate change policy may determine the future use of these forests. Similarly, in Uganda forest degradation due to traditional use leaves scant space for modern biomass. However, with few development options in rural areas largely bereft of energy, it should still be considered.

One clear conclusion of these case studies is that any policy option needs to address land use and equity issues in order to be acceptable. The rural development implications of bioenergy cannot be understood with a superficial impact assessment. Also, bioenergy projects need to be based on sound management models with technical and economic viability, not on wishful thinking.

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## 7 ACKNOWLEDGEMENTS

This paper has been produced under the RE-Impact project ENV/2007/114431, funded by the European Union Aid Cooperation Office Programmes on Environment in Developing Countries and Tropical Forests and other Forests in Developing Countries. The views of the authors do not represent those of the European Commission or its subsidiaries. RE-Impact is a 40 month project undertaken by a consortium of 7 partners led by the Centre for Land Use and Water Resources Research at Newcastle University, which started in May 2007

