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Working Paper

Biofuels and Economic Welfare: A cost-benefit analysis of Jatropha schemes in Zimbabwe

IEE Working Papers, No. 186

Provided in Cooperation with:

Institute of Development Research and Development Policy (IEE), Ruhr University Bochum

Suggested Citation: Mawire, Banarbas (2008) : Biofuels and Economic Welfare: A cost-benefit analysis of Jatropha schemes in Zimbabwe, IEE Working Papers, No. 186, ISBN 978-3-927276-72-7, Ruhr-Universität Bochum, Institut für Entwicklungsforschung und Entwicklungspolitik (IEE), Bochum

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RUHR UNIVERSITY BOCHUM

**IEE
Working Papers**

Banarbas Mawire

Biofuels and Economic Welfare

A Cost-Benefit Analysis of Jatropha Schemes in Zimbabwe



Volume 186

**Institute of
Development Research
and Development Policy**

Bochum 2008

IEE Working Papers

186

Banarbas Mawire

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ISSN 0934-6058
ISBN 978-3-927276-72-7

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Acknowledgements

Firstly, I would like to give my sincere gratitude to the Institute of Development Research and Development Policy of Ruhr University Bochum for affording me an opportunity to study in this unique programme. I would also like to thank EED for granting me a scholarship without which, my studies would not have been possible. I am very thankful to Environment Africa for giving me a study leave to pursue my studies. Of utmost importance, my gratitude goes to my supervisor, Prof. Dr. Wilhelm Löwenstein for his guidance which enabled me to come up with this work. Lastly I would like to thank my wife Letwin Mawire for support and taking care of our kids during very difficult times in Zimbabwe whilst I was away on studies.

List of Abbreviations

ADB	African Development Bank
CBA	Cost-benefit analysis
CEA	Cost Effectiveness Analysis
CSO	Central Statistics Office
ESAP	Economic Structural Adjustment Programme
GDP	Gross Domestic Product
IMF	International Monetary Fund
MERP	Millennium Economic Recovery Programme
MCA	Multi-Criteria Analysis
NGO	Non Governmental Organisation
NOCZIM	National Oil Company of Zimbabwe
NERP	National Economic Revival Programme
PETS	Public Expenditure Tracking System
RBZ	Reserve Bank of Zimbabwe
ZIMPREST	Zimbabwe Programme for Economic and Social Transformation

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1 Introduction

In contrast to the development achievements of the first 10 years of independence, the decade of the 1990s witnessed a turnaround of Zimbabwe's economic fortunes, as economic decline set in and structural problems of high poverty and inequality persisted. Some of the explanations behind this turnaround include recurring droughts and as well as, the non-realisation of the objectives of the Economic Structural Adjustment Programme (ESAP 1991-1995). During the ESAP period, real GDP growth averaged about 1.5% per annum far below the targeted 6%.¹ Considering population growth, this economic growth rate was insufficient for poverty reduction and employment creation. The period 1996 to 2005 was marked by accelerated deterioration in the socioeconomic situation. The proportion of households living below the food poverty line (very poor) increased from 20% in 1995 to 48% in 2003, representing an increase of 148%.² The government replaced ESAP with a "home-grown" reform package the Zimbabwe Programme for Economic and Social Transformation (ZIMPREST) in April 1998³. However, the lack of resources to implement this reform package undermined its effective implementation. In yet another attempt to address the declining economic performance, the Millennium Economic Recovery Programme (MERP) was launched in August 2001 as a short term 18-month economic recovery program⁴. Its objective was to restore economic vibrancy and address the underlying macroeconomic fundamentals. Unfortunately, MERP was also rendered ineffective largely due to the withdrawal of the international donor community following the implementation of a controversial land reform programme. In February 2003, the government launched yet another 12-month stabilisation programme the National Economic Revival Programme (NERP)⁵. Just like its predecessor programmes, NERP failed to generate the much needed foreign currency to support economic recovery. The Macroeconomic Policy Framework of 2005-2006 called *Towards Sustained growth*, replaced NERP and it too has come to an end without achieving its primary objectives.

Despite all these economic policy making efforts, the country has continued to experience severe macroeconomic instability characterised by hyper-inflation. Although the annual rate of inflation had declined progressively from 622.8% in January 2004 to 123.7% in March 2005, the downward trend has been reversed since April 2005, with inflation resurging to 254.8% and 585.8% by end of July and December 2005 respectively. An official figure of inflation as at August 2007 puts the figure at 8000% whilst others argue that the figure has already surpassed 15000%⁶. The Central Statistics Office has not been able to produce inflation figures since August 2007 because most of the basic goods

1 Zimbabwe Poverty Assessment Study Survey (2006) p3.

2 Ibid p20.

3 Ibid p3.

4 Ibid.

5 Ibid.

6 The Zimbabwe Independent, 2007-11-23 <http://www.theindependent.co.zw>.

(mainly food stuffs) whose prices are needed in calculations of the inflation figures are nowhere to be found since most shops are empty.

Other key challenges on the macroeconomic front include low foreign exchange reserves, an overvalued exchange rate fuelling the emergence of a wide foreign currency parallel market, a build up in external arrears and a decline in savings and investment. Zimbabwe is currently ineligible for financial assistance from the International Monetary Fund (IMF), the World Bank and the African Development Bank (ADB) because of her arrears situation. The cumulative outcome of all this has been a deepening economic recession, in which real GDP growth registered a negative of -7.9% starting from 2000 down to -11.1% in 2002, -5.2% in 2004 and an estimated decline of real GDP growth (-2.5 to -3.5%) in 2005.⁷ This represents a cumulative decline in real GDP growth of above 40% since 2000.⁸ Shortages in basic food items such as mealie-meal, cooking oil, bread and non-food commodities such as fuel persist.

1.1 Justification and Problem Statement

Zimbabwe is an agricultural based economy, with about 70% of its population residing in rural areas and earning a living largely from subsistence agriculture.⁹ 60% of the economically active population in Zimbabwe depends on agriculture for food and employment.¹⁰ Women play an important role in agriculture and it is estimated that 70% of small scale farmers are women.¹¹ The agricultural sector accounts for about 17% of the country's Gross Domestic Product (GDP) and 60% of the raw materials required by the manufacturing industry come from agriculture.¹² The average annual growth in agriculture GDP was estimated at 3.5% during 1981 to 1991, rising to 4.35 in 1999, before recording a steep decline of -17.6% in 2001¹³. Maize is the staple food in Zimbabwe and its production has been erratic since 1990, mainly due to the recurring droughts and also due to the impact of the country's radical land reform programme which have virtually destroyed a once thriving white commercial farming sector¹⁴. The success rate of rain fed agriculture in most rural areas has been in the order of one good harvest in every four to five years¹⁵. Decline in agricultural yields in communal areas has been a cause of concern and it has been blamed among other reasons on declining land productivity as a result of deforestation, soil erosion and loss of soil fertility and also on crop losses due to livestock invasion of fields. Land degradation has

7 Zimbabwe Poverty Assessment Study Survey (2006) p4.

8 Ibid.

9 Zimbabwe Millennium Development Goals Progress Report (2004), p15.

10 AQUASTAT survey (2005) p2. <http://www.fao.org/ag/ag1/aglw/aquastat/countries/Zimbabwe>

11 Ibid.

12 Zimbabwe Millennium Development Goals Progress Report (2004), p15.

13 Ibid.

14 Ibid.

15 AQUASTAT survey (2005) p2.

also been attributed to the energy situation of most rural areas where availability of commercial sources of energy remains very limited.

1.1.1 Energy Situation in Zimbabwe

The energy sector in Zimbabwe accounts for between 8 and 9 percent of the country's GDP, but it contributes only 1 percent to formal employment¹⁶. The country currently requires 900 million litres of diesel and 730 million litres of petrol per annum to operate at full capacity¹⁷. Using 1996 as the base year when the economy was operating at close to full capacity, the sectoral breakdown of annual diesel requirements were 413 million litres (46 percent) in the transport sector; 236 million litres (26 percent) for commerce and services; 122 million litres (14 percent) for agriculture; 89 million litres (10 percent) for manufacturing; and 40 million litres (4 percent) for the mining sector.¹⁸ Petroleum supplies have been as low as 40% of national requirements¹⁹. The government allocates 25% of available convertible currency to the energy sector for importing liquid fuels but this represents only a quarter of the national requirements. It is against this background that the country is making concerted efforts to reduce its fuel import bill by mobilising rural farmers to grow and produce *Jatropha* nuts, one of the feed stocks required in the production of biodiesel.

1.1.2 Biodiesel – A Viable Option?

Since 2005, the government through the Ministry of Energy and Power Development and the National Oil Company of Zimbabwe has stepped up efforts to promote local production of biodiesel from *Jatropha* nuts. According to the Reserve Bank of Zimbabwe (RBZ), biodiesel produced from *Jatropha* would save the country US\$35-80 million per annum in foreign currency²⁰. By 2010, the government is targeting to have substituted 10 percent of the country's diesel consumption with bio-diesel coming from *Jatropha* seed²¹. In order to produce the targeted 10%, the country has to put 80000 hectares of land under *Jatropha* cultivation so as to produce at least 500 tonnes of seed oil required annually²². Whilst it is now widely accepted that more sustainable energy sources need to be identified and developed, the development of biofuels has generated vigorous debate on economic and environmental grounds. Sweeping claims have been made about the role of biofuels in development and poverty reduction.²³ For example it has been argued that

16 The Herald, 2007-03-27 (<http://www.herald.co.zw>)

17 Ibid.

18 The Herald, 2007-03-05 (<http://www.herald.co.zw>)

19 The Herald, 2007-03-21 (<http://www.herald.co.zw>)

20 The Zimbabwe Independent, 2007-11-23 (<http://www.theindependent.co.zw>)

21 The Herald , 2007-03-05 (<http://www.herald.co.zw>)

22 The Zimbabwe Independent, 2007-11-23 (<http://www.theindependent.co.zw>)

23 Peskett et al,(2007), cited in Overseas Development Institute (2007) p2.

energy crops are beginning a green revolution that can offer a new development paradigm. Biofuels, it is further argued, can provide a solution to the twin problems of poverty and climate change. Proponents of biofuels have even postulated that countries in the tropics have comparative advantage in biofuels production which can play a role in job creation and food security. Whilst de Keyser and Hongo (2005) argue that biofuels production presents a win-win situation for developing countries by creating rural jobs, increasing income and thereby improving food security, there is also scepticism on biofuels as some people opposed to the idea also make counter claims that biofuels will result in increased hunger as maize is diverted away from household food utilisation in developing countries to feed cars²⁴. Researchers have recently questioned whether the net energy benefits of biofuels production may be negative for many crops because their energy outputs are less than the fossil energy inputs required to produce them²⁵. Others suggest that biofuels will be a "pandora's box" and question whether large-scale biofuel production can be environmentally, socially and economically sustainable and efficient²⁶. Therefore the rationale of this empirical study does not consider the broader questions about biofuels and energy policy, or their environmental implications, but it is concerned mainly with their impact on welfare of farmers who grow *Jatropha*, an important feedstock needed in producing biodiesel. The research findings will contribute to the current debate on the differing views of the impact of energy crops. It will further shed some light on whether biofuels can play a role in job creation and improving food security.

1.2 Research Objective and General Research Questions

Despite all these efforts already being made in Zimbabwe towards promotion of *Jatropha* schemes to provide feedstock for biodiesel production, no formal evaluation has been done on the impacts of the schemes on the welfare of farmers who are mobilized to grow *Jatropha*. There has been growing concerns on the impact of energy crops such as *Jatropha* on production of food crops. There are fears that such energy crops will take up land that is supposed to be used to produce food crops and this can result in rising food prices and starvation of the poor. Thus, the primary objective of this study is to assess the impact of *Jatropha* schemes on the welfare of rural farmers in Zimbabwe. The specific objectives are:

1. To assess empirically the rentability of *Jatropha* oil milling schemes.
2. To assess the impact of *Jatropha* schemes on the welfare of rural farmers.

24 Overseas Development Institute (2007), p4.

25 Ibid.

26 Overseas Development Institute (2007), p4

The main research questions then are: 1. Are Jatropha oil milling schemes viable? 2. Does a Jatropha scheme lead to an increase in the economic welfare of rural farmers?

1.3 Thesis Organisation

For a better understanding of this research, the scope and structure of this thesis has been organised as follows: Chapter 1, which was already presented, showed the context of the study, defined the problem statement, study objectives and research questions to be answered by the study. Chapter two gives an overview covering evaluation tools, methods and approaches used in evaluation of development initiatives which could also be used in a study of this nature. The chapter highlights what the tools entail, circumstances in which they are applied, their strengths and deficiencies. The chapter is concluded by selection of cost benefit analysis as the approach better equipped to achieve objectives of this study. Chapter three outlines the concepts and theoretical framework of cost benefit analysis as a technique used for evaluating policies and investments. Chapter four list and describes the main items of costs and benefits that would appear in financial and economic appraisal of a project. Chapter five gives an outline of the research methodology used for collecting and analysing empirical data. This chapter starts by introducing the hypothesis of the study and then operationalises the theoretical framework described in chapters three and four by detailing the methodology followed in assessing the impact of Jatropha schemes on the welfare of rural farmers. The methodology described in this chapter proposes use of the income method so as to overcome limitations inherent in cost benefit analysis presented in chapter two. Chapter six presents' research findings and analyses the results from the field study and lastly chapter seven covers the conclusion and recommendations. The hypothesis of the study was assessed in the conclusion so as to check whether it holds true or not in light of study limitations encountered and the findings presented in chapter six.

2 Literature Review and Conceptual Framework

The need for evaluation: The United Nations has defined evaluation as a process of determining systematically and objectively the relevance, efficiency, effectiveness and impact of activities in the light of their objectives²⁷. Evaluation of projects in general and public investment projects in particular is receiving a lot of attention within the development community and there is a strong focus on results and this explains the growing interest in monitoring and evaluation²⁸. Evaluation of development activities provides government officials, development managers, and civil society with better means for learning from past experience, improving service delivery, planning and allocating resources, and demonstrating results as part of accountability to stakeholders²⁹.

2.1 Practice Oriented Approaches

There is quite a number of monitoring and evaluation tools, methods and approaches in use and these include performance indicators, the logical framework approach, rapid appraisal methods, public expenditure tracking surveys, and many others³⁰. Some of these tools and approaches are complimentary; some are substitute, some have broad applicability while others are quite narrow in their use³¹. The choice of which is appropriate for any given context will depend on a range of considerations. These include the uses for which the evaluation is intended, the main stakeholders who have an interest in the evaluation findings, the urgency with which the information is required and the cost involved³². An overview of some of the tools which is given below only indicates methods in use on how to gather information and this is not exhaustive and is largely based on those given by the World Bank³³.

Performance Indicators: These are measures of inputs, processes, outcomes and impacts of development projects, programmes or strategies. Performance indicators enable project managers to track progress, demonstrate results, and take corrective action to improve service delivery. The advantages of using performance indicators are that they are an effective means to measure progress towards objectives of a programme and they facilitate benchmarking comparisons between different organisational units over time. The disadvantage of using performance indicators is that if poorly defined, indicators are not good measures of success.

27 United Nations (1984), Guiding principles for design and use of monitoring and evaluation in rural development projects and programmes. Rome: Report of the United Nations ACC Task Force on Rural Development. Cited by Huylenbroeck, G.; Van and Martens, (1990), p273.

28 The World Bank, (2004) p5.

29 Ibid.

30 Ibid.

31 Ibid.

32 Ibid.

33 Ibid.

The logical Framework Approach: It is also known as the LogFrame and it helps to clarify objectives of any project, program, or policy. It aids in the identification of causal links i.e. the “program logic” in the following results chain: inputs, processes, outputs, outcomes and impact. It leads to the identification of performance indicators at each stage in this chain, as well as risks which might impede the attainment of the objectives, The LogFrame is also a vehicle for engaging partners in clarifying the objectives and designing activities. During implementation, the LogFrame serves as a useful tool to review progress and take corrective action. The approach is very useful in improving the quality of a project and program designs thereby providing objective basis for activity review, monitoring and evaluation. However this approach cannot tell the analyst about welfare changes brought about by a project or program.

Formal surveys: These can be used to collect standardised information from a carefully selected sample of people or households. Survey often collect comparable information for a relatively large number of people in particular target groups. Surveys are useful in that they can provide baseline data against which the performance of a strategy, program, or project can be compared and therefore they provide a key input to a formal evaluation of the impact of a program or project. Some types of survey include multi-topic household surveys, single topic household surveys, core welfare indicators questionnaire, and client satisfaction survey and citizen report cards.

Rapid Appraisal Methods: These are quick, low cost ways to gather views and feedback of beneficiaries and other stakeholders, in order to respond to decision-makers’ needs for information. They can be used to provide rapid information for management decision-making, especially at the project or program level. They can provide qualitative understanding of complex socioeconomic changes, highly interactive social situations, people’s norms, motivations and reactions. Findings usually relate to specific communities or localities and hence this makes it difficult to generalise from the findings. Rapid appraisal methods include key informant interview, focus group discussions, community group interviews, direct observation and mini-surveys.

Participatory Methods: These provide active involvement in decision making for those with a stake in a project, program or strategy and generate a sense of ownership in the monitoring and evaluation of results and recommendations. Participatory approaches are normally used to learn about local conditions and local peoples’ perspectives and priorities to design more responsive and sustainable interventions. Commonly used participatory tools include stakeholder analysis, participatory rural appraisal, beneficiary assessment and participatory monitoring and evaluation.

Public Expenditure Tracking Surveys (PETS): The approach tracks the flow of public funds and determines the extent to which resources actually reach the target groups. The surveys examine the manner, quantity and timing of releases of resources to different level of government, particularly the units responsible for the delivery of social services. PETS are often implemented as

part of larger service delivery and facility surveys which focus on the quality of service, characteristics of the facilities, their management, incentives structures, etc.

Comment on practice based tools: Most of these tools lack a solid theoretical base and hence result in informal judgements being made on the impacts and success of a programme or project. It is also clear from the description of the methods given above that most of the approaches are relevant and useful data collection tools in identification or planning, implementation and monitoring of projects or programmes so that they stay on track.

2.3 Economic Evaluation tools

“Economic analysis helps to design and select projects that contribute to the welfare of a country. Economic analysis is most useful when used early in the project cycle (ex ante) to identify poor projects and poor project components. If used at the end of the cycle (ex post), economic analysis can help determine whether to proceed with a project or not.”³⁴ Tools of economic analysis can help answer various questions about the project’s impact on the entity undertaking the project, on society, and on various stakeholders. In particular, these tools can help to:³⁵ 1. Determine whether the private or public sector should undertake the project, 2. Estimate its fiscal impact, 3. Determine whether the arrangements for cost recovery are efficient and equitable and 4. Assess its potential environmental impact and contribution to poverty reduction. Economic analysis tools such as cost effectiveness analysis, multi-criteria analysis and cost benefit analysis purpose are outlined below.

2.3.1 Cost-Effective Analysis (CEA) Tool

Cost-effective analysis (CEA) refers to the consideration of decision alternatives in which both their costs and consequences are taken into account in a systematic way³⁶. It is a decision tool, in that it is designed to ascertain which means of attaining particular goals are most efficient³⁷. Cost effective analysis is done from the society’s or financier’s perspective. “The purpose of cost-effectiveness analysis is to ascertain which programme, project or alternative can achieve particular objectives at the lowest cost. The underlying assumption is that different alternatives are associated with different costs and different results and therefore by choosing those alternatives with the least cost for a given outcome, the society can use its resources more effectively. Those

34 Belli, P. et al. (2001) p1.

35 Ibid.

36 Carnoy, M. (1995) p381.

37 Ibid, p382.

resources that are saved through using more cost-effective approaches can be devoted to expanding programmes or could be invested elsewhere³⁸.

The main steps involved in CEA: A cost effectiveness analysis normally involves four stages.³⁹ Firstly, the programme objectives are determined. The expected result of the project must be identified and quantified in physical terms (e.g. number of road accidents avoided, number of farmers trained after a course). The following questions should be answered: What are the goals to be achieved? What are the project outputs? What are the expected impacts? Which one of these may be considered predominant? The second step in CEA involves the definition of total costs of the programme. Here the total cost of the intervention must be calculated. At this stage the cost of all the public resources of the programme are added up to obtain a total cost. The cost of a programme is sometimes measured in relation to the benefits that could have been obtained by allocating public monies to other ends (opportunity costs). Generally speaking, only direct resources that have a well-defined monetary value are included. The third step in CEA is measuring the impact and this is the trickiest one. Numerous studies use empirical approaches based on the collection of primary data in order to gather information on the positive effects of a programme under evaluation. It is also possible to estimate impacts on the basis of secondary data or through modelling of the implementation of the programme. This should be the case for different alternatives with the same time horizons with different investment and recurrent costs and different level of the same benefit achieved during the entire life cycle of the project. Whatever method is used to measure the impacts, it is important to have an exact picture not only of the positive effects, but also negative effects such as employment displacement effects, investment crowding out effects etc. Certain evaluators have suggested that indications should be given about output multiplier and indirect or secondary effects. In practice it is very difficult to accurately evaluate these secondary effects. The fourth and last step in CEA involves the calculation of the cost-effectiveness ratio. The costs per unit output and outcome are assessed through simple division of costs by outputs or outcomes. This step ends with the creation of the cost-effectiveness matrix which will show objectives, costs per project and effectiveness.

Circumstances in which CEA is applicable: CEA is mainly used as a tool for the selection of projects within a well defined programme.⁴⁰ It has been most commonly used in the evaluation of projects in the health sector by the World Health Organisation (WHO) to evaluate the costs and health effects of specific interventions⁴¹. CEA has been successfully applied and used in

38 Ibid.

39 Evaluating Socio Economic Development, SOURCEBOOK 2: Methods and Techniques Cost effectiveness analysis, Final Materials (December 2003) p3-4, www.evaled.info/downloads/sb2_cost_effectiveness_analysis.doc

40 Evaluating Socio Economic Development, SOURCEBOOK 2: Methods and Techniques Cost effectiveness analysis, Final Materials (December 2003), p2, www.evaled.info/downloads/sb2_cost_effectiveness_analysis.doc

41 Tan-Torres Edeger, T. et al (2003): Making choices in Health- WHO guide to cost-effectiveness analysis, World Health Organization, Geneva.

examining the cost effectiveness of strategies used to combat malaria in developing countries⁴². It is used to make the comparisons between alternatives that have the same scope⁴³. It cannot be used for projects with different objectives or for a project with multiple objectives⁴⁴.

Strengths of CEA as a tool for evaluation: It is a very useful tool where project or program outputs are not easy to monetise but can be quantified on a physical unit of account⁴⁵. CEA is some times useful for evaluating the expected impacts in the ex-ante appraisal and for calculating the achieved impacts in the ex-post evaluation⁴⁶. Since CEA is based on an estimation of the programme impact in relation to its main objective, it presents the advantage of producing findings that are easily understood by decision makers including politicians⁴⁷. If the analysis is based on specific links between inputs and outputs that are relatively well established, the tool can facilitate the description of the actual functioning of programmes⁴⁸. This can be useful for refining existing policies or improving the effectiveness of future projects.

Limitations of CEA: The main limitation of cost effectiveness analysis is recommendations are less easily related to questions of aggregate social welfare⁴⁹. It cannot be used for projects with different objectives or for a project with multiple objectives. However, such a situation is rare since many programmes in reality have many objectives⁵⁰. CEA can not tell us something on the absolute desirability of a project as it does not compare benefits and costs but only concentrate on costs alone⁵¹. Assessing the cost effectiveness of a project will not by itself provide a clear assessment of the project's social net benefits and hence it cannot measure welfare⁵². The next section looks at Multi- criteria analysis (MCA), another tool closely related to CEA also used in project evaluation.

42 Morel, Chantal M.; Lauer, Jeremy A. and Evans, David B. (2005): Achieving the millennium development goals for health - Cost-effectiveness analysis of strategies to combat malaria in developing countries. *BMJ*;10.1136/bmj.38639.702384.AE.

43 Evaluating Socio Economic Development, SOURCEBOOK 2 (December 2003) p2, www.evaled.info/downloads/sb2_cost_effectiveness_analysis.doc

44 Ibid.

45 Ibid.

46 Ibid.

47 Evaluating Socio Economic Development, SOURCEBOOK 2 (December 2003) p2, www.evaled.info/downloads/sb2_cost_effectiveness_analysis.doc

48 Ibid.

49 Dunn, 2003 cited by Bruinsma, Frank and Vreeker, Ron. (Undated) p83, <http://ecomana.dcea.fct.unl.pt/projects/advisor/publications/ADVISOR%20Final%20report%20Chapter%206.pdf>.

50 Evaluating Socio Economic Development, SOURCEBOOK 2: (December 2003) p6, www.evaled.info/downloads/sb2_cost_effectiveness_analysis.doc

51 Ibid.

52 Ibid.

2.3.2 Multi Criteria Analysis (MCA) Tool

Multi-criteria analysis (MCA) is an instrument for policy advice and it is done from an expert's perspective⁵³. A key feature of MCA is its emphasis on the judgement of the decision making team, in establishing objectives and criteria, estimating relative importance weights and to some extent, in judging the contribution of each option to each performance criterion⁵⁴. The subjectivity that pervades this can be a matter of concern since the outcomes can be expert driven and easily manipulated⁵⁵. The foundation of MCA in principle is the decision makers' own choice of objectives, criteria, weights and assessments of achieving the objectives. One limitation of MCA is that it cannot show that a project or intervention adds more to welfare than it detracts.⁵⁶ A standard feature of MCA is a performance matrix in which each row describes an option and each column describes the performance of the options against each criterion⁵⁷. The individual performance assessments are often numerical, but may also be expressed as scores or by colour coding⁵⁸. In a basic form of MCA the performance matrix may be the final product of analysis from which the decision makers will be left with the task of assessing (sometimes assisted by some supplementary advice from those who constructed the matrix) the extent to which their objectives are met by the entries in the matrix.⁵⁹ Such intuitive analysis of data can be speedy and effective, but it can lead to the use of unjustified assumptions causing incorrect ranking of options.⁶⁰

Main steps in MCA: A full application of MCA involves eight steps and the steps are;⁶¹ 1).The first step is to establish the decision context and this involves clarifying the aims of the MCA and identification of decision makers and other key stakeholders; 2).The second step involves identification of options and this involves listing the set of options available; 3).The third step involves identification of the objectives and criteria that reflects the value associated with the consequences of each option; 4).Step four involves description of the performance of each option against the set criteria; 5).The fifth step involves assigning of weights for each of the criteria to reflect their relative importance to the decision; 6).The sixth step involves combining the weights and scores for each of the options to derive an overall value; 7).The seventh step involves examining of the results and ; 8). The eighth and last step in MCA involves construction of a sensitivity analysis of the results to changes in scores or weights. Although MCA is described here as a cut and

53 ETR (1999): Review of Technical Guidance on Environmental Appraisal - A Report by Economics for the Environment Consultancy,

<http://www.defra.gov.uk/environment/economics/rtgea/8.htm>

54 DTRL Multi criteria analysis manual (Chapter 4.3),

http://www.communities.gov.uk/pub/252/MulticriteriaanalysismanualPDF1380Kb_id1142252.pdf

55 Ibid.

56 Ibid.

57 Ibid.

58 Ibid.

59 Ibid.

60 Ibid.

61 Ibid, Chapter 5.1.

dried step by step process, some of the steps will require detailed thought about issues surrounding the decision⁶². It can be necessary to move forth and backwards so as to revisit and revise earlier steps as one proceed with the analysis⁶³.

Advantages of MCA over informal judgement: MCA has the following advantages over informal judgement⁶⁴: Firstly, it provides an explicit method of taking into account of project impacts that are not easily given monetary values often called intangibles. Secondly, the choice of objectives and criteria that any decision making group may make are open to analysis and to change if they are felt to be inappropriate. Thirdly, the scores and weights, when used, are also explicit and are developed according to established techniques. They can also be cross-referenced to other sources of information on relative values and amended if necessary. Fourth, performance measurement can be sub-contracted to experts; hence it may not necessarily be left in the hands of decision making body itself. Fifth, it can provide an important means of communication, within the decision making body and sometimes, later, between that body and the wider community and lastly, scores and weights used can provide an audit trail.

Limitations of MCA as an evaluation tool: The ability of MCA to take account of a wider range of project impacts is a product of its much looser theoretical structure⁶⁵. MCA has no built-in standard of value and treats the definition of project objectives as the first stage of appraisal, in which stakeholders should be involved⁶⁶. It might seem that this feature gives MCA greater flexibility but meaningful comparisons can be made between appraisals only if they use a common standard value⁶⁷. Evaluating MCA proposes a standard of value that is specific to a project, in two senses⁶⁸. Firstly, the relative weights given to different impact categories are defined separately for project, to reflect the particular concerns of stakeholders at the project level. Secondly, the system of scoring impacts uses project-specific scales, e.g. giving a score of 100 to the option that is best on the relevant dimension and 0 to the one that is worst. Thus, scores are not comparable across projects, only across alternative options for a given project (e.g. different levels of flood protection at a given site)⁶⁹. This prevents the scores from being used in choosing between projects which is one of the main functions of appraisal⁷⁰. For the same reason, cross-project inconsistencies in decision making are harder to detect which results in a serious loss of transparency.⁷¹.

62 Ibid.

63 Ibid.

64 Ibid, Chapter 4.3.1.

65 Ibid.

66 Ibid.

67 Ibid.

68 Ibid.

69 Sugden, R. (2005) p5. www.defra.gov.uk/enviro/fcd

70 Ibid.

71 Ibid.

2.3.3 The Cost-Benefit Analysis (CBA) Tool

The standard framework for evaluating policies and investments from an economic perspective is cost-benefit analysis (CBA)⁷². The French engineer Dupuit laid the theoretical foundation for CBA in 1844⁷³. CBA is an approach to policy recommendation that permits analysts to compare and advocate policies by quantifying their total monetary costs and monetary benefits⁷⁴. The social cost benefit analysis model is based on the theory of welfare economics, according to which the welfare of a society depend on the aggregate individual utility levels of all members of that society⁷⁵. The aim of CBA is to locate and include all effects of a project and to express the unobservable change in welfare in observable monetary units⁷⁶. A project increases the welfare of a society if the winners can hypothetically compensate the losers, while still attaining a higher utility level than was the case prior to the project (Hicks-Kaldor compensation or potential Pareto improvement).⁷⁷

CBA typically uses consumer surpluses as the operational measure for benefit. A consumer surplus is the maximum sum of money a consumer would be willing to pay for a given amount of the good, less the amount he actually pays.⁷⁸ The advantage of consumer surplus is that it is based on directly observable market demand functions by taking individuals' willingness to pay as the basis for the determination of benefits.⁷⁹

The main steps in CBA: In carrying out CBA various steps are undertaken. In the first step, the project and its alternatives are defined, along with the relevant population (i.e. those individuals whose welfare is considered relevant and affected)⁸⁰. In the second step, the relevant impacts of the project and its alternatives are identified, using the criterion of whether they constitute a cost or a benefit⁸¹. Furthermore, all stakeholders should be identified that will be positively and negatively affected by the adoption and implementation of the

72 ADVISOR (Undated) p78

<http://ecomana.dcea.fct.unl.pt/projects/advisor/publications/ADVISOR%20Final%20report%20Chapter%206.pdf>

73 Ibid.

74 Dunn, 2003 cited in ADVISOR (Undated) p78.

75 Brucker et al., 1998 cited in ADVISOR (Undated pp. 78) Final report on: Combined Cost Benefit Analysis and Cost Effectiveness Analysis Framework for Flood Protection – Case study of the Rhine and Meuse river basins, Frank Bruinsma and Ron Vreeker. Department of Spatial Economics, Free University of Amsterdam, the Netherlands.

76 Johansson, P. O. (1991), p112.

77 The Kaldor-Hicks compensation criterion, which stated that the gainers in project should be able to compensate the losers and still have some left over, but actual compensation was not required. Brent, R. J. (1998) p16.

78 Mishan, E.J. (1982) p 23.

79 Dunn, 2003 cited by Bruinsma, Frank and Vreeker, Ron. (Undated pp. 83): Combined Cost Benefit Analysis and Cost Effectiveness Analysis Framework for Flood Protection – Case study of the Rhine and Meuse river basins, Department of Spatial Economics, Free University of Amsterdam, The Netherlands, <http://ecomana.dcea.fct.unl.pt/projects/advisor/publications/ADVISOR%20Final%20report%20Chapter%206.pdf>.

80 Ibid, p79.

81 Ibid.

project or policy. In the third step, relevant cost and benefits are valued in monetary units. Where price changes are involved, this necessitates calculation of changes in consumers' and producers' surplus⁸². Producer surplus is the difference between the total amount earned from a good and the production costs⁸³. When no market prices exist to value costs and benefit, non-market valuation techniques are used⁸⁴. Costs are measured as social opportunity costs. Opportunity costs refer to the value of the best alternative to a given choice or the value of the resources in their next best use⁸⁵. Where market imperfections or market interventions create differences between market prices and marginal social costs or benefits, shadow prices are calculated⁸⁶. In the fourth step, benefits and costs are aggregated over time by means of discounting⁸⁷. Discounting expresses future costs and benefits in terms of their present value. The correct discount rate to use in CBA is a matter of great dispute, as capital market imperfections drive a gap between the social time and the social opportunity cost of capital⁸⁸. The fifth step of a CBA involves the comparison of total discounted benefits with total discounted costs, to produce a net present value (NPV)⁸⁹. "If the net present value is positive, then the project has passed the CBA test. Alternatively, information may be presented in terms of benefit cost ratios or as an internal rate of return, which is the discount rate that yields a zero NPV"⁹⁰. The final step in a CBA consists of conducting a sensitivity analysis on important parameters such as the discount rate, the project life, cost and benefit estimates⁹¹.

Limitations of CBA: However, the application of CBA encounters several problems which can be summarised as: 1) distorted markets; 2) valuation of environmental effects; 3) determining the discount rate; 4) spatial scope of CBA; 5) risk and uncertainty; and 6) equity concerns⁹². A number of tools have been developed to try and improve on these limitations. The methods include; 1) the market price method; 2) Productivity methods; 3) Hedonic pricing method; 4) the travel cost method; 5) Damage cost avoided, replacement cost

82 Ibid.

83 King, D.M.; Mazzotta, M. (Unknown) : http://www.ecosystemvaluation.org/supply_curve1.gif

84 Bruinsma, Frank and Vreeker, Ron. (Un dated pp.79): Combined Cost Benefit Analysis and Cost Effectiveness Analysis Framework for Flood Protection – Case study of the Rhine and Meuse river basins, Department of Spatial Economics, Free University of Amsterdam, The Netherlands
<http://ecoman.dcea.fct.unl.pt/projects/advisor/publications/ADVISOR%20Final%20report%20Chapter%206.pdf>.

85 King, D.M.; Mazzotta, M. (Unknown): <http://www.ecosystemvaluation.org/>

86 Bruinsma, Frank and Vreeker, Ron. (Un dated pp.79): Combined Cost Benefit Analysis and Cost Effectiveness Analysis Framework for Flood Protection – Case study of the Rhine and Meuse river basins, Department of Spatial Economics, Free University of Amsterdam, The Netherlands,
<http://ecoman.dcea.fct.unl.pt/projects/advisor/publications/ADVISOR%20Final%20report%20Chapter%206.pdf>

87 Ibid.

88 Ibid.

89 Ibid.

90 Ibid.

91 Ibid.

92 Ibid.

or substitute cost methods; 6) the contingent valuation method; and 7) the benefit transfer method⁹³. These valuation methods aim to estimate the individuals' marginal 'willingness-to-pay' (WTP) in monetary terms for an improvement in the quantity or quality of the environmental good concerned, and therefore the methods are consistent with the general philosophy of CBA.⁹⁴ These valuation techniques show that despite the lack of a market price for certain products and services, tools exist to value environmental effects⁹⁵.

CBA compared with MCA and CEA: In the judgement of many economists, it is a major merit of CBA that it is based on well-understood theoretical foundations, derived from more than a century of research in welfare economics.⁹⁶ This gives CBA a high degree of internal consistency because all CBA studies share a common methodology, lessons learned in one study (or, indeed, in microeconomics more generally) can be transferred to other studies, allowing the accumulation of expertise⁹⁷.

It is particularly significant that CBA has a built-in standard value whereby benefits are measured by the maximum amount of money that recipients would pay for them, and costs by the minimum amount of money that recipients would accept as compensation for them⁹⁸. Thus (provided that the assumptions for economic theory hold) the CBA valuation of any given benefit or disbenefits is an absolute amount of money, which the analyst discovers or elicits; it is not defined relative to any particular view about the objectives of the project that created those benefits or costs⁹⁹. In this sense, CBA (unlike MCA which has no clear criteria for selecting impacts) does not allow project objectives to be chosen by the government or influenced by stakeholders.¹⁰⁰ The standard of value used in CBA plays an important part in preventing double counting of benefits and in screening out special pleading. Because benefits are measured by the amount of money recipients would pay for them, there can be no benefits that are not benefits to specific individuals¹⁰¹. This imposes the discipline that a supposedly beneficial project impact cannot be registered in the CBA accounts unless a corresponding class of beneficiaries can be identified, and unless it can be shown that those beneficiaries actually value the impact, i.e. would be willing to give up other valuable things in order to have it. It is not open to the government, a project

93 King, D.M.; Mazzotta, M. (Unknown): <http://www.ecosystemvaluation.org/>

94 ADVISOR (Un dated pp. 79) Final report on: Combined Cost Benefit Analysis and Cost Effectiveness Analysis Framework for Flood Protection – Case study of the Rhine and Meuse river basins, Frank Bruinsma and Ron Vreeker. Department of Spatial Economics, Free University of Amsterdam, The Netherlands, <http://ecoman.dcea.fct.unl.pt/projects/advisor/publications/ADVISOR%20Final%20report%20Chapter%206.pdf>

95 Ibid.

96 Sugden, R. (2005) p4: www.defra.gov.uk/environ/fcd

97 Ibid, p5.

98 Ibid.

99 Ibid.

100 Ibid.

101 Ibid.

sponsor or stakeholders merely to stipulate that some type of impact is desirable or valuable¹⁰².

There is loss of consistency when MCA is used even if it takes its objectives and weighting system from the government of the day and applies it consistently to all projects; there still is a loss of consistency and transparency relative to CBA¹⁰³. Because cost benefit studies of different governments and different countries use a common standard values (money), a much larger set of studies can be used to test the credibility of the findings of any particular one¹⁰⁴. As experience of CBA accumulates, it becomes possible to use "benefit transfer" methods (i.e. to estimate benefits in one situation by extrapolation or interpolation from previous studies of similar situations)¹⁰⁵.

CEA is closely related to Cost benefit analysis (CBA) in that both methods try to quantify the pros and cons of the proposed project alternatives¹⁰⁶. In contrast to CBA, that attempts to measure all relevant factors in a common measurement unit (monetary values), CEA uses two different measurements¹⁰⁷. Costs are measured in monetary units, while effectiveness is typically measured in units of goods, services, or some other valued effect.¹⁰⁸ In the absence of a common unit of value, CEA does not permit measurement of net effectiveness or net benefits since it makes no sense to subtract the total costs from the total units of goods or services¹⁰⁹. It is however possible to produce cost effectiveness ratios¹¹⁰. These ratios have a different interpretation than cost benefit ratios. Whereas effectiveness cost and cost effectiveness ratios tell us how much of a good or service is produced per dollar or Euro expended, benefit cost ratios tell us how many times more benefits than costs are produced in a given instance.¹¹¹

Given the merits of CBA as a tool which can overcome limitations of practice based approaches and other economic tools discussed earlier, it has been considered as the tool used in this study for evaluating the impact of Jatropha schemes on the welfare of rural farmers in Zimbabwe. As highlighted earlier

102 Ibid.

103 Ibid.

104 Ibid.

105 Ibid, p6.

106 Bruinsma, Frank and Vreeker, Ron. (Un dated pp. 83): Combined Cost Benefit Analysis and Cost Effectiveness Analysis Framework for Flood Protection – Case study of the Rhine and Meuse river basins, Department of Spatial Economics, Free University of Amsterdam, The Netherlands,
<http://ecomana.dcea.fct.unl.pt/projects/advisor/publications/ADVISOR%20Final%20report%20Chapter%206.pdf>

107 Dunn, 2003 cited by Bruinsma, Frank and Vreeker, Ron. (Un dated pp. 83): Combined Cost Benefit Analysis and Cost Effectiveness Analysis Framework for Flood Protection – Case study of the Rhine and Meuse river basins, Department of Spatial Economics, Free University of Amsterdam, The Netherlands,
<http://ecomana.dcea.fct.unl.pt/projects/advisor/publications/ADVISOR%20Final%20report%20Chapter%206.pdf>

108 Ibid.

109 Ibid.

110 Ibid.

111 Ibid.

on, an analyst using CBA is able to locate and include all effects of a project and to express the unobservable change in welfare in observable monetary units¹¹².

112 Johansson, P. O. (1991) p112.

3 Rationale of Financial Analysis and Economic Analysis

All countries, but particularly the developing countries, are faced with the basic economic problem of allocating limited resources such as labour, capital and land to many different uses such as production of consumer goods or investment in infrastructure, industry, agriculture, education and other sectors.¹¹³ At any point of time, the amount of resources can be considered as fixed.¹¹⁴ This means, the amount of resources and goods that is necessary to satisfy the unlimited human needs is smaller than the amount of resources and goods that is available. In order to cope with the problem of scarcity, individuals and society need to be efficient so that available goods and resources are not wasted. In order to achieve efficiency in use of resources informed choices must be made among the competing uses and cost benefit analysis is a tool for weeding out potentially poor investments and selecting potentially worthwhile ones.¹¹⁵ Cost benefit analysis is strictly anthropogenic as it only records those project effects which have an effect on people and to which the affected people attribute importance. Using CBA, the evaluation is done from the perspective of the affected people only. There is no room for politicians' or experts evaluations in CBA. All projects effects are monetarised and for this purpose the affected people's monetary evaluation of the quantitative project effects is investigated. Monetarised project effects which the affected people judge to be positive are called (social) benefits, and those judged to be negative are called (social) costs. The difference between social benefits and social costs is equal to the change in social welfare brought about by the project.

Most real world policy changes or projects create conflicts of interest among different parties, in other words, have gainers and losers. Then the best way to evaluate a project would be to assess how it affects social welfare from the aggregate effects of individual utilities, but because that is not possible¹¹⁶, CBA represent the best practical way to capture and express in a single dimension (monetary terms) many, but not all, of the project's effects (utility changes), therefore, it is used instead. The basic idea behind CBA is then, to measure in monetary units how social welfare is affected by a particular project, hence, it is applied welfare economics.¹¹⁷ The aim of a social cost-benefit analysis is to locate and include all effects, regardless of who in society is affected. The ultimate goal is to translate or express the unobservable change in social welfare to observable monetary units.¹¹⁸ A project increases the welfare of a society if the winners can hypothetically compensate the losers, while still attaining a higher utility level than was the case prior to the project (Hicks-

113 Squire, L, Herman G. and van der Tak (1995) p8.

114 Johansson, Per-Olov (1991) p1.

115 Squire, L, Herman G. and van der Tak (1995) p8.

116 That is not possible because of the difficult to assess how an economic change (project) affects the utility level of each household in society in order to aggregate them into a social welfare function (Johansson, 1991 p40).

117 Ibid, p9.

118 Ibid, p112.

Kaldor compensation or potential Pareto improvement).¹¹⁹ CBA typically uses consumer surpluses as the operational measure for benefit. A consumer surplus is the maximum sum of money a consumer would be willing to pay for a given amount of the good, less the amount he actually pays.¹²⁰ The advantage of consumer surplus is that it is based on directly observable market demand functions by taking individuals' willingness to pay as the basis for the determination of benefits.¹²¹

3.1 Financial Analysis

At its simplest level, a financial analysis may be undertaken by an individual or a business, and is only concerned with costs and benefits to that person or business, and not to the society as a whole.¹²² Financial analysis gives us an answer to the question whether a private investment is rentable or not and what the associated liquidity effects are from the perspective of a private investor. It identifies the project's net money flows to the implementing entity and assesses the entity's ability to meet its financial obligations and to finance future investments. Financial analysis is based on the actual prices (market prices) that the project entity pays for inputs and receives for outputs¹²³. Market prices are used as the unit of valuation since the benefits are given by the revenue receipts from the sale of a project's outputs while costs are derived from expenditure receipts. Projects are financially rentable if their net benefits are positive throughout the project's life span.

3.2 Economic Analysis

Economic analysis in contrast (to financial analysis) gives us an answer to the question whether an intervention of the state is economically desirable or not from the perspective of the affected population. Economic analysis looks at a project from the perspective of the entire society and measures the effects of the project on the economy as a whole¹²⁴. It assesses the opportunity cost for the whole society. "If a project diverts resources from other activities that produce goods and services, the value of what is given up represents an

119 The Kaldor-Hicks compensation criterion, which stated that the gainers in project should be able to compensate the losers and still have some left over, but actual compensation was not required. Brent, R. J. (1998) p16.

120 Mishan, E.J. (1982) p23.

121 Dunn, 2003 cited by Bruinsma, Frank and Vreeker, Ron. (Un dated pp. 83): Combined Cost Benefit Analysis and Cost Effectiveness Analysis Framework for Flood Protection – Case study of the Rhine and Meuse river basins, Department of Spatial Economics, Free University of Amsterdam, The Netherlands, <http://ecomman.dcea.fct.unl.pt/projects/advisor/publications/ADVISOR%20Final%20report%20Chapter%206.pdf>.

122 Thompson, Paul and Handmer, John, (1996) p19.

123 Belli, P. et al. (2001) p26.

124 Ibid. p25.

opportunity cost of the project to the society¹²⁵. The prices used for economic analysis are based on the opportunity cost to that country. The economic values of both inputs and outputs differ from their financial values because of market distortions created either by the government or by the private sector. The divergence between financial and economic prices and flows shows the extent to which someone in society, other than the project entity, enjoys a benefit or pays a cost of the project¹²⁶. By identifying the groups benefiting from the project and the groups paying for its costs, valuable information can be extracted about the incentives for these groups to implement the project as designed, or support it or oppose it¹²⁷. The point here is that financial and economic analysis answer different questions to different audiences and the two are complimentary. A thorough evaluation should summarize all the relevant information about the project. To look at the project from society's and the implementing entity's viewpoint, to identify gainers and losers, and ultimately to decide whether the project can be implemented and sustained, it is necessary to integrate the financial and economic analyses.¹²⁸When the result of an economic analysis show that a project is worthwhile for a society, but the financial analysis indicates that the project is not rentable, it may make sense to provide subsidies for the project so as to attract investors by cushioning them from the risk. On the other hand, if a project is financially viable, but its economic costs are judged too high, then it should never be promoted.¹²⁹

125 Ibid. p26.

126 Ibid.

127 Ibid.

128 Belli, P. et al.(2001) p27.

129 Thompson, Paul and Handmer, John, (1996) p20.

4 Capturing a Project's Effects in Financial Analysis and Economic Analysis

This chapter describes the context of project analysis. As mentioned earlier in chapter 3, all countries are faced with the basic problem of allocating limited resources to many different uses such as current production of consumer goods and public services or investment in infrastructure. These different uses of resources, however, are not the final aim of the allocative process; rather, they are the means by which an economy can marshal its resources in pursuit of more fundamental objectives such as the removal of poverty, the promotion of growth, and the reduction of inequalities in income¹³⁰. Using limited resources in one direction (for example, investment in industry) reduces the resources available for use in another direction (investment in agriculture)¹³¹. Pursuit of one objective (better income distribution) may involve a sacrifice in other objectives (rapid growth). Thus, there are clearly tradeoffs that have to be made and hence a country can have more of some things and less of others, but not more of everything at once¹³². A choice therefore has to be made among competing uses of resources based on the extent to which they help the country achieve its fundamental objectives. If a country consistently chooses allocation of resources that achieve most in terms of these objectives, it ensures that its limited resources are put to their best possible use¹³³.

Project analysis is the method of presenting this choice between competing uses of resources in a convenient and comprehensible fashion¹³⁴. In essence, project analysis assesses the benefits and costs of a project and reduces them to a common denominator. If benefits exceed costs, both expressed in terms of this common denominator then the project is acceptable and if not, the project should be rejected¹³⁵. As such, project analysis may appear divorced from both the fundamental objectives of the economy and the possible alternative uses of resources in other projects. The definition of benefits and costs, however, is such that these factors play an integral part in the decision to accept or reject. Benefits are defined relative to their effect on the fundamental objectives whilst costs are defined relative to their opportunity cost, which is the benefit forgone by not using these resources in the best of the available alternative investments that cannot be undertaken if the resources are used in the project¹³⁶. The forgone benefits are in turn defined relative to their effect on the fundamental objectives. By defining costs and benefits in this fashion we try to ensure that acceptance of a project implies that no alternative use of the resources consumed by this project would secure a better result from the perspective of the country's objectives¹³⁷.

130 Squire, L.; Herman G. and van der Tak (1995), p14.

131 Ibid.

132 Ibid.

133 Ibid.

134 Ibid.

135 Ibid.

136 Squire, L.; Herman G. and van der Tak (1995), p15.

137 Ibid.

Economic analysis of projects is similar in form to financial analysis in that both assess the profit of an investment¹³⁸. The concept of financial profit, however, is not the same as the social profit of economic analysis. The financial analysis of a project identifies the money profit accruing to the project (which is the operating entity), whereas social profit measures the effect of the project on the fundamental objectives of the whole economy¹³⁹. These different concepts of profit are reflected in the different items considered to be costs and benefits and in their valuation. Thus, a money payment made by the project (i.e. the operating entity) for, say, wages is by definition a financial cost. But it will be an economic cost only to the extent that the use of labour in this project implies some sacrifice elsewhere in the economy with respect to output and other objectives of the country. Conversely, if the project has an economic cost in this sense that does not involve a corresponding money outflow from the project entity, for example, because of environmental effects or subsidies, this cost is not a financial cost¹⁴⁰. The two types of cost need not coincide¹⁴¹. Economic cost may be larger or smaller than financial costs and similar comments apply to economic and financial benefits.

4.1 Assessing a Project's Negative and Positive Effects in Financial Analysis

In financial analysis, the task of identifying and valuing the project's benefits and cost collapse into one, since the benefits are given by revenue receipts from the sale of the project outputs and the inputs are given by the costs (expenditures) of production.¹⁴² Market prices are therefore used as the unit of valuation.¹⁴³

The first step in the financial appraisal is to calculate the project's cash flow¹⁴⁴. This is done by recording on an annual basis the revenues and expenditure for the entire life of the project. The difference between the yearly receipts and expenditures is the net cash flow. Costs are divided into capital and operational costs¹⁴⁵. Capital costs are those costs incurred in establishing the project, and will include costs of equipment, buildings and land. Operating costs are those incurred in running and maintaining the project, and will include raw materials, labour, utilities and repair and maintenance. The financial benefits to be included in the cash flow are identified and valued as the project's output which is sold at the market price¹⁴⁶. In all cases, the cost and benefit item is entered into the cash flow at the time it occurs.

138 Ibid.

139 Ibid

140 Ibid.

141 Ibid.

142 Chowdhury, A and Kirkpatrick, C (1994) p110.

143 Ibid.

144 Ibid.

145 Ibid.

146 Ibid.

The net cash flows consist of forecasted revenues and expenditures over the life of the project. It is necessary to take note of the fact that cash received in the future is less valuable than cash received immediately. The reason for this is simply that money received in the future rather than the present represents an opportunity cost, in terms of the income that could have been earned by investing the funds in an interest-bearing account or revenue-earning productive activity.¹⁴⁷ This is why borrowers have to compensate lenders for the income they are forgoing, by paying a rate of interest. The rate of interest therefore reflects peoples' preference for money in the future, i.e. it represents individuals' "rate of time preference".¹⁴⁸ In order to combine each year's net cash flow into a single aggregate figure, we need to convert them into equivalent terms. This is done by the process of discounting, which converts future values into an equivalent present period value. The technique of discounting allows the analyst to take into account the differences in the timing of cash flow and thus to assess the viability of projects with different streams of benefit and costs¹⁴⁹. Two methods are commonly used in making this assessment and these are the net present value (NPV) criterion and the internal rate of return (IRR) criterion. The NPV of a project is the value of the benefits net of the costs, both discounted at the opportunity cost of capital¹⁵⁰. A general expression for calculating the NPV is given below:¹⁵¹

$$NPV = \sum_{t=1}^n \frac{B_t - C_t}{(1 + r)^t}$$

Where **B_t** and **C_t** are the benefits (revenues) and costs (expenditures) in each year **t**, **r** is the discount rate (rate of interest) and **n** is the life of the project. Two conditions must be satisfied if a project is to be accepted on economic grounds.¹⁵² First, the present value of the net benefits of the project must be positive (a positive NPV shows gains in welfare while a negative one show a decline in welfare); second, the NPV of the project must be higher than the NPV of mutually exclusive project alternatives¹⁵³. Some projects are mutually exclusive in the sense that they are alternative ways of producing the same output and if one is chosen, the others cannot be undertaken.

The internal rate of return criterion is less obvious, but in most cases will give the same decision as the NPV rule. By investing in the project, the owner of the capital has given up other investment opportunities. The project must therefore yield a rate of return which is at least equal to the opportunity cost of the investment funds¹⁵⁴. The IRR is the discount rate at which the NPV is equal to zero. The decision rule for the IRR is that one accepts projects that have an

147 Chowdhury, A and Kirkpatrick, C (1994) p111.

148 Ibid.

149 Chowdhury, A and Kirkpatrick, C (1994) p112.

150 Baum, Warren C and Tolbert, Stokes M, (1985) p430.

151 Chowdhury, A and Kirkpatrick, C (1994) p112.

152 Baum, Warren C and Tolbert, Stokes M, (1985) p430.

153 Ibid.

154 Chowdhury, A and Kirkpatrick, C (1994) p112.

IRR greater than the interest rate¹⁵⁵. In other words, if the discount rate equals or exceeds the opportunity cost of capital, it can be concluded that the projects is justified¹⁵⁶.

4.2 Assessing a Project's Negative and Positive Effects in Economic Analysis

4.2.1 Economic Cost or a Project's Negative Effects.

The economic cost is the cost of establishing a Jatropha scheme to a society. To come up with this cost, the boundary of the society for which the analysis is to be carried out must be defined because the economic cost varies with the boundary of the community. For example there could be underemployment of agricultural labour in a country or project area (as is the case in most rural areas of Zimbabwe). If the labour for establishing a Jatropha scheme is from within the society (project area), then the cost incurred is not a cost to the society. It only becomes a cost when it is sourced from outside that society or country.

Capital Costs for Jatropha schemes in rural Zimbabwe are financed through grants from NGOs and government. Under the grants rural farmers receive seeds and technical information free of charge so that they establish Jatropha hedges. The grants used in the establishment of Jatropha hedges are not calculated as a capital cost because the money is not a cost to the communities establishing the hedges.

Externalities: are effects of a project that do not impose or confer a benefit within the confines of the project itself and therefore are not included in the project's financial accounts¹⁵⁷. In general, an externality is said to exist when the production or consumption of a good or service by an economic agent has a direct effect on the welfare of other producers or consumers. Externalities may be positive or negative. A positive externality may reduce the costs of a production process of an unrelated economic agent, as when the bees of a bee keeper pollinate a neighbour's apple orchard. They may also increase the enjoyment of another economic agent. A negative externality increases the production costs or reduces enjoyment for another economic agent. Environmental pollution from Jatropha oil milling is an example of negative externalities.

4.2.2 Economic Benefit or a Project's Positive Effects

Changes in risk of crop losses are counted as benefits. Crop losses avoided due to use of Jatropha hedges as live fence around crop fields is one

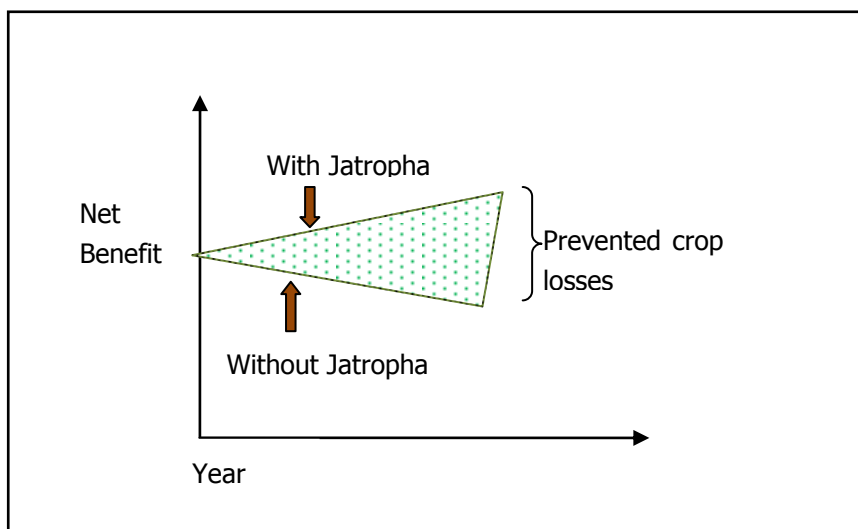
155 Ibid.

156 Ibid.

157 Baum, Warren C and Tolbert, Stokes M,(1985) p436.

of the benefits that may arise. This kind of benefit stream is one in which the “with” and “without” test tend to point out clearly. In rural Zimbabwe land is communally owned and this means that livestock normally roam around and end up straying in fields causing crop losses. An investment in live fences being promoted through Jatropha schemes enable farmers to put a barrier around their fields, gardens and homesteads so as to avoid livestock damage to crops. The benefit from Jatropha hedges is not increased crop production but avoiding the loss of agricultural crop output. A simple “before” and “after” comparison would fail to identify this type of benefit. Total crop production may change very little as a result of protection offered by Jatropha hedges yet farmers and the economy will realize a real benefit because of the loss of income which is avoided through adoption of Jatropha hedges promoted under Jatropha schemes. Figure1 below illustrates benefits that could be realised due to prevented crop losses.

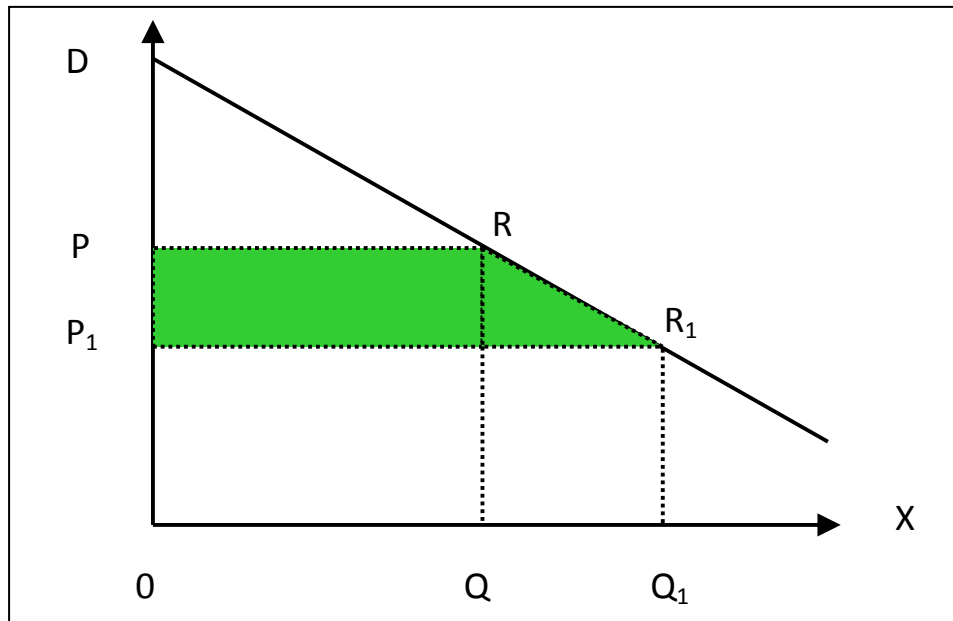
Figure 1: An Illustration of Benefits that could be derived from a Jatropha Project



Savings on Household expenditure for Lighting are counted as benefits: Any investment having the object of reducing the cost of a product or service is deemed to confer a benefit on the community, which benefit is often referred to as a “cost-difference”, or “cost-saving”.¹⁵⁸ The concept of cost saving is derived directly from the concept of consumers’ surplus, as can be shown by reference to figure 2, which makes an illustration of how a household may enjoy lighting at a lower price through substitution of paraffin with Jatropha oil for use in wick lamps.

158 Mishan, E.J. (1982) p. 25.

Figure 2: An Illustration of Possible Household Savings on Lighting



Thus, prior to the introduction of, say, Jatropha oil for lighting, the consumers' surplus from using paraffin (being the maximum sum households are willing to pay above the amount they currently spend on paraffin say an average price of **OP** per litre) is the triangle **PDR**. If Jatropha oil reduces the cost of lighting to households, from **OP** to **OP₁**, at which lower cost the quantity of Jatropha oil used increases from **OQ** to **OQ₁**, the consumers' surplus increases from **PDR** to **P₁DR₁**, an increase equal to the shaded strip **PP₁R₁R**. This increase of consumers' surplus can be split up into two parts. There is, first, the cost saving component, the rectangle **PP₁SR**, which is calculated as the saving per litre, **PP₁**, multiplied by the original quantity purchased, **OQ**. The other component, represented by the triangle **SRR₁**, is the consumers' surplus made on additional quantities of Jatropha oil purchased, **QQ₁**, either by the same households or by additional households. The cost-saving item that enters a cost-benefit calculation is, as indicated, no more than a portion of the increment of consumers' surplus from a fall in the cost of the good or service. Since it takes no account of the additional goods that will be bought in response to the fall in cost, the cost-saving rectangle alone can be accepted as a minimum estimate of the benefit.¹⁵⁹

Savings on household expenditure on fertilizers are counted as benefits: Seed cake, a residue from Jatropha oil pressing can be used as a valuable fertilizer, whose mineral composition is comparable to poultry manure.¹⁶⁰ Farmers who sell their Jatropha seed to oil milling schemes are allowed to collect free of charge Jatropha press cake which they can use in

¹⁵⁹ Mishan, E.J. (1982) p26.

¹⁶⁰ Being rich in nitrogen, the seed cake is an excellent source of plant nutrients whose mineral composition is comparable to poultry manure. Henning, R. K, (1989) cited in Leihner, D. E. and Mitschein, T. A. (1996) p369.

crop production as fertilizer. This can have the same effect of cost-saving explained earlier above.

Household income from sale of Jatropha seed is counted as benefits: Households that grow Jatropha hedges are able to sale Jatropha seed to millers for income and this adds to the household income.

4.2.3 Aggregation of Cost and Benefit

In the discussion on financial analyses given above, net cash flows need to be discounted to give the project's net present value. To do this requires a choice as to the rate of discounting and in financial analysis the market rate of interest is used on the ground that it reflects the notion of time value for money. The same discounting procedure is applied to the stream of shadow net benefits over the life of the project, using a shadow rate of discount which is usually referred to as the social discount rate¹⁶¹. The argument for using a shadow rate of discount, rather than using the market rate of interest, is the same as for the project's benefits and costs, namely that there are market imperfections or distortions which cause the market interest rate to deviate from its efficiency or shadow value¹⁶². Unfortunately, the aggregation of shadow cost and benefits of Jatropha hedges to farmers in Zimbabwe will not involve discounting since the costs and benefits assessed were captured from the same year.

161 Chowdhury, A and Kirkpatrick, C (1994) p118.

162 Ibid.

5 Hypothesis of Study and Research Methodology

Hypothesis of the study: The theoretical framework outlined above in chapters 3 and 4 can be applied to evaluate Jatropha schemes in Zimbabwe. The schemes comprise of fields and gardens which are fenced in by Jatropha shrubs planted in the form of hedges so as to keep out livestock. Jatropha shrubs produce seed which contain oil that can be extracted using simple devices such as hand and motor driven presses¹⁶³. After being extracted and filtered, Jatropha oil can be directly used as a substitute to diesel in suitable engines and it can also be used as a paraffin substitute for cooking and lighting. Jatropha oil can also be used as a raw material in soap making. Seed cake, a residue from oil pressing mills is given back free of charge to farmers to use as organic fertilizer.¹⁶⁴ Given this background the following hypothesis can be formulated and tested.

- 1) Jatropha schemes increase the economic welfare of rural people by preventing crop losses from livestock.
- 2) Jatropha schemes increase Economic Welfare of people in rural areas by reducing costs incurred on fertilisers and energy.
- 3) Jatropha schemes increase Economic Welfare of people in rural areas by increasing their income from sale of seed.

Given the theoretical framework outlined earlier in chapters 3 and 4, a CBA of Jatropha schemes would require data on costs and benefits involved in the growing of Jatropha shrubs and setting up of oil milling plants. Such information could only be obtained by asking farmers and owners of oil mills. Given this background, a field research was carried out in Zimbabwe from August to October 2007 so as to collect data.

5.1 Secondary and Primary Data

The empirical research was divided into two phases. The first phase comprised of collection of secondary data regarding the development of Jatropha schemes in Zimbabwe. This was done through a desk study of various documentations supported by interviews conducted with representatives of organisations involved in the development of Jatropha schemes. In the second phase, primary data was collected from an existing Jatropha oil mill and from farmers who are growing Jatropha shrubs through a household survey.

Secondary data: This kind of data was obtained from a desk study of Jatropha schemes documentation, publications and literature. The data was sourced from government departments, NGOs, from the internet and from private organisations involved in the promotion of Jatropha in Zimbabwe. Past studies and project reports of the organisations involved in Jatropha schemes

163 Leihner, D. E. and Mitschein, T. A. (1996) p369.

164 Being rich in nitrogen, the seed cake is an excellent source of plant nutrients whose mineral composition is comparable to poultry manure. Henning, R. K, (1989).

provided secondary data which was verified during field work through interviews, meetings and focus group discussions. The secondary data collected acted as pointers for the collection of primary data

Primary data: The inclusion of environmental effects in a CBA requires the economic valuation of environmental goods such as the protective value of *Jatropha* hedges on reducing crop losses from livestock. Since no markets for such environmental goods exist, it is difficult to observe market prices that reflect marginal costs or benefits¹⁶⁵. To deal with this problem a valuation technique called the “net income method” has been employed in this study to identify shadow prices for *Jatropha* hedges and *Jatropha* cake. The net income method also referred to as the productivity method or derived value method is a CBA derivative used to estimate the economic value of environmental products or services that contribute to the production of commercially marketed goods¹⁶⁶. It is applied in cases where products or services of an ecosystem are used along with other inputs to produce a marketed good¹⁶⁷. The income or productivity method was selected because soil fertility (a natural resource) is a production factor in the production of crops which are marketed goods¹⁶⁸. Changes in soil fertility quality may result in changes in production costs and productivity of other inputs. This in turn may affect the yield realised and this may also affect the economic returns to the other inputs. Thus the economic benefits of using *Jatropha* cake to improve soil fertility, can be measured by increased revenues from greater agricultural productivity, or from decreased costs of producing crops¹⁶⁹. Two types of benefits or costs may be important¹⁷⁰. First, if the quality or price to consumers of the final good (e.g. crops) changes, there will be changes in consumer surplus. Second, if the productivity or the production cost changes, there will be changes in producer surplus. Thus, the economic benefits from improvements in the resource can be estimated using changes in observable market data¹⁷¹. To apply the method, data must be collected regarding how changes in the quantity or quality of the natural resource affect;¹⁷² 1) the costs of production for the final good, 2) the supply and demand curves for the final good and 3) the supply and demand for other factors of production. This information is used to link the effects of changes in the quantity or quality of the resource to changes in the consumer surplus and/or producer surplus, and thus to estimate the economic benefits¹⁷³. This method is most easily applied in two specific instances¹⁷⁴. The first instance is in cases where the resource in question is a perfect substitute for other inputs. For example, increased soil fertility quality resulting from an

165 Ibid.

166 King, D.M.; Mazzotta, M. (Unknown): <http://www.ecosystemvaluation.org/>

167 Ibid.

168 Ibid.

169 Ibid.

170 Ibid.

171 Ibid.

172 King, D.M.; Mazzotta, M. (Unknown): <http://www.ecosystemvaluation.org/>

173 Ibid.

174 Ibid.

agro-forestry initiative by farmers' means less chemical fertilizers may be needed to supply crop nutrients. Thus, in this example, the benefits of increased soil fertility can be directly measured by the decreased fertilizing costs. The second instance is in situations where only producers of the final good benefit from changes in the quantity or quality of the resource and consumers are not affected. For example, improved soil fertility may lead to greater agricultural productivity (more crops are produced on the same amount of land). If the market price to consumers does not change, benefits can be estimated from changes in producer surplus resulting from increased income from other inputs. Thus, in this example, the profits per acre will increase, and this increase can be used to estimate the benefits of improved soil fertility.

5.2 Expert Interviews and Household Survey in Mutoko District

Prior to going out to the field to gather primary data from selected sample sites, some interviews were carried out with officials of relevant government departments, NGOs, banks and other support agencies. Such interviews were done concurrently with desk studies and the focus was on generating background information concerning project areas and initiatives of respective organizations.

A household questionnaire was administered in three wards of Mutoko district within the site of Makosa Jatropha milling scheme so as to come up with a random sample of households growing Jatropha hedges. A total of 158 questionnaires were administered in the enumeration area and data was collected using face-to-face interviews with a member of households growing Jatropha hedges. Visits were also made to some of the hedges in order to make observations on the location, design and effectiveness of Jatropha hedges against livestock invasion, use of Jatropha products for energy and to measure the area occupied by the hedges.

5.3 Rentability of Jatropha Oil Milling Schemes

Primary data is essential for performing a financial analysis of the Jatropha oil milling schemes so as to provide answers to the research question on whether or not Jatropha schemes are rentable and what the associated liquidity effects are from the perspective of those investing in the oil milling schemes. Data on cash inflows and out flows of the milling schemes was collected by interviewing owners of a Jatropha oil milling scheme using a structured interview guide provided in annex 1b. The information collected include name of the scheme, its location, ownership of the scheme, type of equipment used (whether manual pressing machines or power driven oil pressing machine), capacity of the scheme in terms of amount of seed expelled per hour, day, month, year and amount of oil produced. The information also included the year the scheme was established and the total capital costs in year zero, sources of financing (grants, loans and equity) and conditions on the finances e.g. interest

rates on loans, repayment periods and other lending conditions. Information collected on annual cash inflows and out flows together with investment information made in year zero was used to compute the financial net present value (fNPV) and the financial internal rate of return (fIRR) for the scheme. All the various financial costs (cash out flows) and benefits (cash inflows) accruing during different periods were discounted and aggregated. The fNPV reveals to us whether or not Jatropha schemes are worthwhile ventures onto which scarce financial resources can be expended on.

5.4 Welfare Effects of Jatropha Schemes on Rural Farmers

This analysis should give us an answer to the question of whether Jatropha schemes are economically desirable or not from the perspective of farmers involved in growing of the Jatropha hedges. Primary data for economic analysis was collected from farmers through a researcher administered questionnaire which is given at the end of this document as annex 1a. The questionnaire was translated into local Shona language and a test run of the questionnaire was done in the field prior to launching of the household survey. This resulted in revision, reviewing and adjusting of certain problematic parts of the questionnaire and omissions which were not anticipated during designing of the questionnaire.

Information collected in section A of the questionnaire includes back ground information of the respondents. The first question is a filter question and this has been included as a selection criterion to select farmers involved in growing Jatropha from those not participating. Section A of the questionnaire also collected information on the names of villages and wards, gender, year of birth, marital status, size of family, level of education and income category of the respondents. Section B of the questionnaire collected mainly quantitative data used to assess whether Jatropha schemes increase or decrease the welfare of rural farmers who embark on such a venture.

5.5 Site Selection

Jatropha growing is found in many parts of Zimbabwe, with known concentrations in the north-eastern districts of Mutoko, Rushinga, Mudzi, Guruve and Binga. These districts fall under geo-ecological regions four and five where rainfall is erratic and unreliable, making dry land cultivation a risky venture. The success rate of rain fed agriculture in regions four and five has been in the order of one good harvest in every four to five years¹⁷⁵. Evaluation of Jatropha schemes require an analysis of information from each of these districts (shown in figure 3) since the costs and benefits realized at each of the schemes are affected by location specific circumstances. Such a thorough analysis would have required a lot of time and resources, which unfortunately, were quite limited for this study and thus collection of primary

175 FAOSTAT:<http://www.fao.org/documents/showcdr.asp?urlfile=/docrep/X5594E>.

data necessary for undertaking financial and economic analyses was done using only two sampling sites in Binga and Mutoko districts respectively. The map given below in figure 3 shows the main *Jatropha* growing districts (in green) of Zimbabwe and these are mainly in the Zambezi valley

Figure 3: Map of Zimbabwe Showing *Jatropha* Growing Districts



Source: Adapted and modified from Surveyor General (2005)

The selection of the actual sites enumerated also depended on the accessibility of the areas since some rural areas became very difficult to visit due to political violence emanating from campaigns for the country's parliamentary and presidential elections due to be held in March 2008. The other consideration for selection of sites was on the willingness of mill owners to freely avail their information as regards cash flows and other records essential for financial analysis.

5.6 Study Limitations

It is important to note that the field survey was carried out in August 2007 shortly after the government had launched a blitz on businesses so as to enforce price controls. This resulted in many business owners being arrested

and prosecuted for overpricing. Such an environment created an atmosphere of suspicion and some businesses closed shop. Initially, this research had targeted to collect data from three oil milling schemes but in the end, data for financial analysis was collected only from one scheme in Binga district as the other schemes had suspended their operations because they were caught up in the price blitz. Secondly, the survey was conducted under very difficult conditions due to stringent conditions put forward by the government. One such condition is that the researcher had to obtain written permission from local authorities to carry out the field survey and this took up to a month to obtain such permission. The researcher had also to comply with the Public Order and Security Act (POSA) which requires anyone organising a public meeting to first seek police clearance prior to holding any such meeting. This impacted negatively on some of the research instruments the researcher had planned to use such as focus group discussions. All this required a lot of time which was not available as the research had to be conducted and completed from the end of August 2007 to the first week of November 2007. The third limitation to this study is that many households do not normally keep farming records as the majority of them is subsistence farmers. This was a very big challenge since quantitative data is required on crop yields with and without *Jatropha* hedges. To overcome this problem, the researcher had to move around with a weighing scale so as to measure some of the yields for example of *Jatropha* seed, maize and other crops harvested per year. The fourth limitation to this study was the prevailing macroeconomic environment in Zimbabwe characterised by hyperinflation at the time of the study. In such an environment all banks were no longer offering loans and hence it was very difficult to arrive at an appropriate discount rate necessary for computing the net present value. This was however, overcome by using information from a neighbouring country (Zambia). The other challenge related to hyperinflation was that prices of goods under investigation could change three or more times a week as the local currency tumbled against other currencies. This challenge was overcome by shadow pricing of the commodities and again the shadow prices adopted are not without problems due to some speculative behaviour in the market.

5.7 Data Processing and Analysis

Data processing started during designing of the questionnaire and a pre-coded questionnaire was used. This coding enabled statistical analysis of both quantitative and qualitative data using a computer. Data capturing was done concurrently with field work using Statistical Package for Social Science (SPSS) software for windows version 13.0 and a total of 158 completed household questionnaires were entered into SPSS. Data verification and cleaning was also done to identify outliers, mismatches and omissions. Simple statistical methods such as frequency count, aggregates, averages and percentages were used to analyze the information generated. In that respect, both qualitative and quantitative data analysis was performed to assess the welfare impacts of

Jatropha schemes to farmers making up the sample based on the farmers' crop losses (with and without Jatropha), savings on fertilizer and energy (with and without Jatropha) and income from sale of Jatropha seed. Analyzed data are presented in the form of tables and graphs and these outputs have been used for interpretations and drawing of conclusions.

6 Research Findings and Discussion

This section presents and discusses the findings of the study by carrying out a financial analysis of an oil milling scheme from which data was collected and also carrying out an economic analysis of *Jatropha* hedges. Furthermore some findings of financial analysis were subjected to the net present value (NPV) and the internal rate of return (IRR) tests. The NPV of the oil milling scheme was also subjected to some sensitivity analysis so as to determine how it is affected by changes in major inputs and outputs of the scheme.

For economic analysis a study was conducted with a sample size of 158 households. The entire sample was randomly selected and consideration was made to certain similar characteristics such as age, gender, level of education and marital status. Respondents were asked a variety of questions about their farming activities with and without *Jatropha* so as to assess the impact of *Jatropha* schemes on their welfare. In particular, study respondents were asked to report on their farming activities in the 2006/7 farming season and to estimate changes in specific aspects of their welfare over the same one year period. The data collected was then analyzed, comparing welfare changes with and without *Jatropha* hedges in order to come up with the results presented below under economic analysis.

6.1 Financial Analysis of a *Jatropha* Oil Milling Scheme

A Case Study of Binga Trees Scheme: Binga Trees Scheme was set up as a development trust to teach rural farmers how to profitably make use of natural resources, especially oil seed producing trees to improve their low standard of living. By growing *Jatropha*, Moringa, Neem trees, and selling the harvested seed to Binga Trees Scheme, rural households in Binga district earn money. The organization started its work in 1996 and started to promote growing of oil producing trees among peasant farmers. Willing farmers were issued with *Jatropha* seed to plant as hedge around homes, fields and gardens. The farmers also received training on planting and managing *Jatropha* hedges. Households in Manjolo, Sikalenge and Lusulu wards of Binga district are now supplying an oil milling Scheme established by Binga Trees with five tones of *Jatropha* seed per year. The households are now earning an annual income from sale of *Jatropha* seed. Most of the households growing *Jatropha* have low input costs as no fertilizer is required and what is required is their labour to prune the trees and pick the seed. These operations are usually undertaken shortly after peak labour periods during the agricultural season. Harvesting of seed normally takes place during the months of July and August and pruning of the trees normally takes place in September shortly after harvesting of the seed. Most materials from pruned branches are used as firewood. Crop failure is common in Binga district since the district is located in the Zambezi valley which is prone to droughts as rainfall is erratic and unreliable. The success rate of rain fed agriculture in most rural area has been in the order of one good

harvest in every four to five years¹⁷⁶. Binga Trees received a grant of 20000 Euros from the Netherlands Embassy in 2006 for establishing and running an oil milling scheme. As explained earlier in chapter 4, a financial analysis is done from the view point of a private investor so as to assess the financial rentability of a *Jatropha* oil milling scheme on the basis of its costs and revenues. Data on all the expenditures incurred for the establishment and operation of a scheme and the associated revenues are taken into consideration.

6.1.1 Financial Cost of a *Jatropha* Oil Milling Scheme

Capital cost of Binga Trees Scheme: The grant received from the Netherlands Embassy was used for establishment of an oil milling scheme through acquisition of the following capital equipment summarized in table 1, below:

Table 1: Capital Expenditure in 2006

Capital Items	Cost in Euro (€)
1 Sundara oil Press	8 000
1 Project vehicle	8 000
Construction of a store	3 000
1 motor cycle	500
1 Grinding mill	500
Total capital expenditure	20 000

Operating and maintenance costs: The annual operating costs are summarized in table 2 below. The annual operating and maintenance costs of Binga Trees oil milling scheme are based on annual staff salaries, rent (which include electricity, water and telephone), vehicle costs, feedstock costs and inputs for soap making.

Table 2: Annual Operating Expenses in 2006

Expenditure item	Cost in Euro (€)
Staff salaries	1 795
Rent, electricity, water and telephone costs	1 572
Vehicle and expenditure (fuel & repairs)	1 173
Costs for <i>Jatropha</i> seed feed stock	692
Extension work (field operations)	629
Inputs for soap making (Caustic soda)	297
Total operating costs	6 150

176 FAOSTAT:http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/X5594E.

6.1.2 Revenue of a Jatropha Oil Milling Scheme

The annual financial returns of Binga Trees Scheme are summarized below in table 3.

Table 3: Revenue in 2006

Source of Income	Amount in Euro (€)
Soap sales	3532
Jatropha oil sales	75
Moringa leaf powder	801
Nursery (Tree seedlings)	312
Expelling of sunflower seed	123
Photocopying fees	290
Total	5133

The revenue of a Jatropha oil milling scheme is the total amount of money received through sale of products of the scheme such as Jatropha soap, Jatropha oil, tree seedlings and service charges for expelling of sunflower oil and photocopying services.

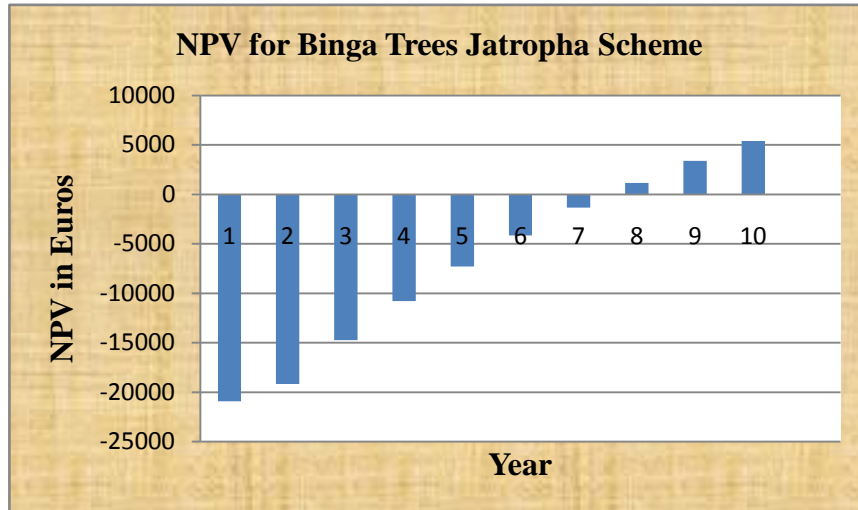
6.1.3 Aggregation of Financial Costs and Revenue of a Jatropha Oil Milling Scheme

Given the prevailing macroeconomic environment conditions in Zimbabwe outlined earlier characterized by hyperinflation of more than 15 000% resulting in most banks suspending lending money out to clients, it would make sense to use a discount rate used by the central planning authority in one of the neighbouring countries (Zambia) in computing the financial net present value. Most banks in Zambia were charging an annual interest rate of 20% and the country's annual inflation rate was 8%. So the real discount rate corrected for inflation is 12% per year and this has been adopted as the discount rate for computation of the financial net present value presented below.

6.1.3.1 The Financial Net Present Value (fNPV) of Binga Trees Scheme

The financial net present value of the Binga Trees scheme has been computed using the NPV formula outlined earlier in chapter 4.1. The costs and revenues of each year presented earlier (in tables 1, 2 and 3) are discounted at a rate of 12% per annum and the discounted costs are subtracted from the discounted revenue so as to arrive at the financial net present value (fNPV). Refer to annex 1.c for more information as regards assumptions made and calculations of the NPV for the scheme. Figure 4, given below makes an illustration of the investment made at Binga trees scheme.

Figure 4: Net Present Value

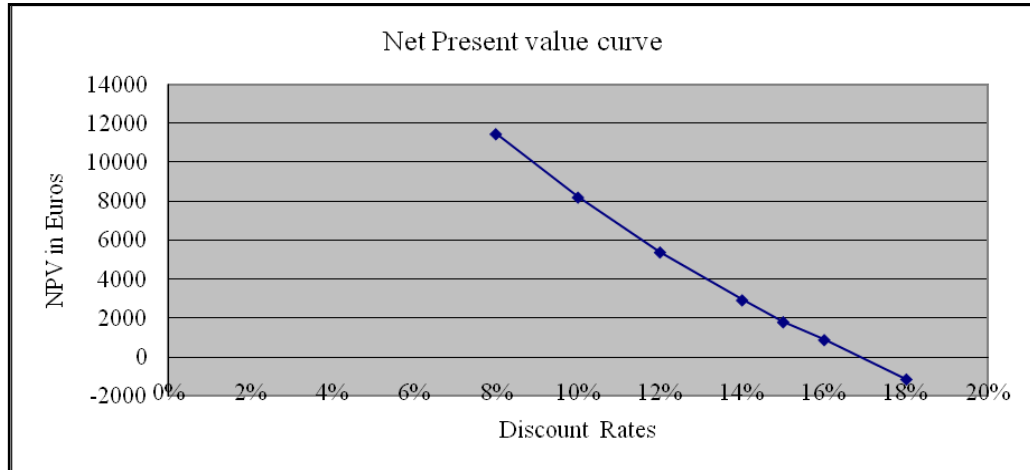


As can be seen from the chart above, the scheme will lead to a stream of net benefits throughout its ten year life span. Each year's net benefits will have a value today. The NPV of the scheme given above is simply a summation of the annual future net benefits in today's value terms. As can be seen from figure 4 above, the oil milling scheme will experience negative net cash flows for the first seven years and the net cash flow will only turn positive during the eighth year and thereafter. The financial NPV for the scheme is positive and is €5 396. Following the NPV decision rule explained earlier which states that a project is worth proceeding with if its NPV is positive, it is quite evident that Binga Trees oil milling scheme is a worthwhile investment.

6.1.3.2 The Internal Rate of Return for Binga Trees Scheme

As already explained earlier in chapter 4.1, the IRR is the discount rate at which the discounted streams of costs and benefits are equal. The IRR indicates the earning rate of money invested in the project. It also tells the maximum interest rate a project will be able to pay for the resources used, or in other words it is the rate of return to capital internal to the project. All projects that show an IRR above the market rate of interest are acceptable in financial analysis. The decision rule for the IRR is that one accepts projects that have an IRR greater than the market rate of interest. That is, a project passes the test if $R > r$. One can invest in the project, or one can use the funds elsewhere. If one invests in the project, one receives an average return of R . If one uses the funds elsewhere, one would have earned a return of r . Thus, if $R > r$, one is obtaining the highest return possible for those funds assuming that r is the next best alternative return. Figure 5 gives an overview of Binga Trees scheme's NPR-curve.

Figure 5: The Internal Rate of Return for Binga Trees Scheme.



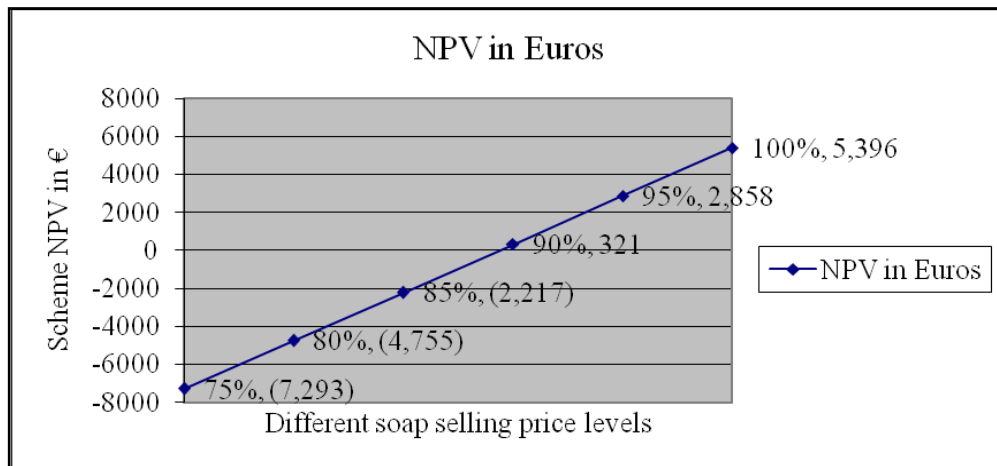
The NPV-curve above shows information about the NPVs' of the scheme at different discount rates, including the IRR of the oil milling scheme (NPV=0). On the Y-axis the NPV value is stated, while the X-axis presents the discount rate. As stated before, the scheme is acceptable as long as the NPV is positive, provided that the discount rate reflects the costs of capital. This is anywhere in the figure where the curve is above the X-axis. The point where the curve exactly cuts the X-axis tells the IRR of the scheme because at this point the NPV is zero. As can be seen from the NPV curve, the IRR for the scheme is 16.84%. This is the interest rate at which the NPV of the scheme becomes zero. This also means that at a discount rate of 16.84% the scheme's returns are just sufficient to repay the principal invested in the scheme and the interest payments made to lenders. If the rate of interest is less than 16.84% the mill should go ahead with the investment as the benefits will be larger than the opportunity cost of capital. However, if the interest rate is more than 16.84%, the investment should not go ahead because the benefits from the scheme will be less than the opportunity cost of capital and hence the scheme will not be rentable.

Sensitivity Analysis: As pointed out earlier in chapter 4.1, a sensitivity analysis is a customary step in project appraisal to analyse how sensitive a measure of project worth (the NPV) is to increased costs, reduced benefits and other changes. The analysis makes an assessment of the influence of changes in important items on the NPV. This has been done by varying each item whilst holding other items constant and then recalculating the NPV. The items selected for sensitivity analysis for a Jatropha oil milling scheme are the soap selling price, staff salary increases and costs for procuring Jatropha seed from farmers. The results of a sensitivity analysis on these items are presented and discussed below.

The revenue cash flow presented earlier in table 3 shows that Jatropha soap brings in much more revenue than other products of the scheme and hence it is a very important output of the scheme. However, the NPV of the scheme is very sensitive to any reductions in the selling price of soap. Figure 6 shows the

NPV on the Y-axis and different soap selling price levels on the X-axis. As can be seen from figure 6, a reduction in the selling price level of soap from the current selling price by a 5% margin will drastically reduce the NPV by 47 % from € 5396 to €2858. If the soap selling price level is reduced by a 10% margin, this will seriously diminish the NPV by 94% as it reduces from €5396 to a mere €320.51 and any further price reductions in the price levels will render the scheme unviable as the NPV eventually becomes negative.

Figure 6: Sensitivity Analysis of the NPV to the Selling Price of Soap



Given the context of this study presented in chapter one, (characterised by hyperinflation, price controls by the state and closing down of traditional soap producers such as Unilever) the good sales being enjoyed by the scheme now could be as a result of the vacuum left after moving out of major soap producers. This could be short-lived because if the macroeconomic environment improves in Zimbabwe, the major soap producers are likely to come back and this could create more competition for the soap market thereby causing a reduction in the price of soap.

Staff costs include salaries for employees who work at Binga Trees oil milling scheme. The scheme employees include one mill manager, one mill operator, and one field officer for procurement of feedstock from farmers, one Office assistant and one general hand. As can be seen in figure 7, a 10% increase in staff costs will reduce the NPV by about 23% as the NPV reduces from €5396 to €4172. If staff cost rise by 15% the NPV will be reduced by about 42% as it reduces from €5396 to €3156. If staff costs rise by 20%, the NPV is eroded by about 45% and further increases in staff costs by 25% will eventually make the scheme unviable as the NPV turns negative. Staff prices may increase perhaps up to 20% and it is very unlikely that a 25% salary increment will be experienced by the scheme because the scheme is located in a very remote area where the cost of living is not as high as that experienced in other urban areas in Zimbabwe. The other reason for not anticipating a salary increase of 25% is that most of the employees of the scheme are high school leavers save

for the manager of the scheme who has a diploma in forestry and with a high unemployment rate in the country employees are unlikely to demand such unsustainable salary levels.

Figure 7: Sensitivity Analysis of the NPV to Staff Costs

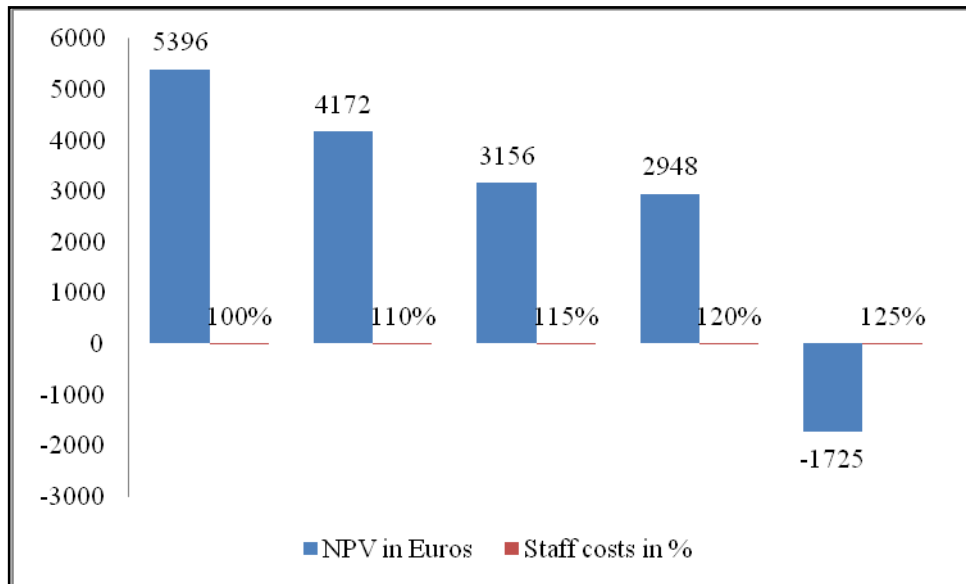


Figure 8: Sensitivity Analysis of the NPV to Seed Costs

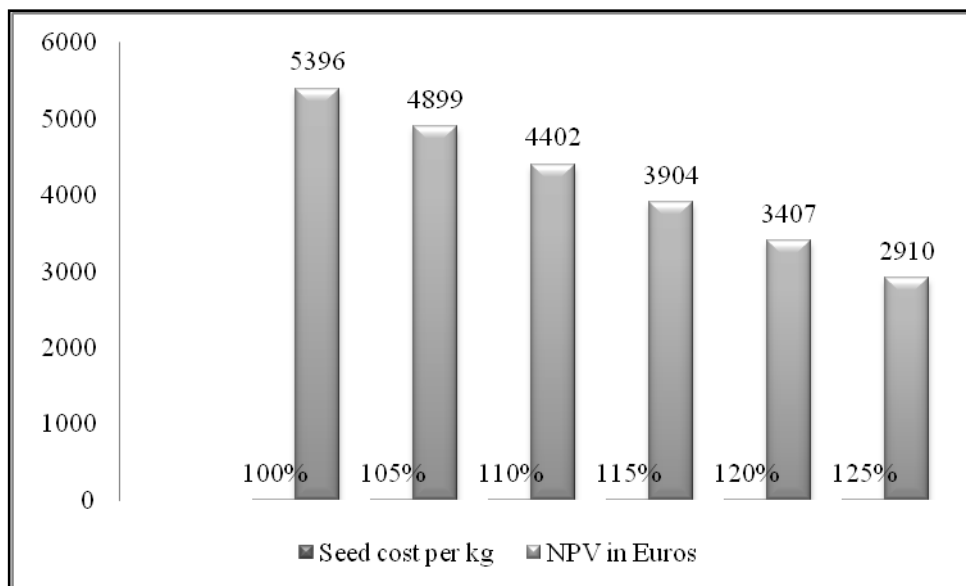


Figure 8 above makes an illustration of how sensitive the scheme NPV is to changes in the price of Jatropha seed. Jatropha seed is the main raw material required for the scheme and it is purchased from households who grow Jatropha hedges. The price of seed per kg at the time of the study was 21 Euro cents. If the price of seed increases by 5%, the NPV is reduced from €5396 to €4899. If the price of the seed is increased by 10%, the NPV is reduced from

€5396 to €4402. A further rise in seed price by 15% will reduce the NPV from €5396 to €3904 and even if the price of seed were to increase by 25% the scheme's NPV will remain positive. This implies that it will require very huge changes upwards in the price of seed for the scheme to be rendered unviable and this is very unlikely as the scheme enjoys a monopoly since it's located more than 500km from the nearest scheme in Victoria Falls.

Figure 9: Sensitivity Analysis of NPV to Major Inputs/Outputs Compared

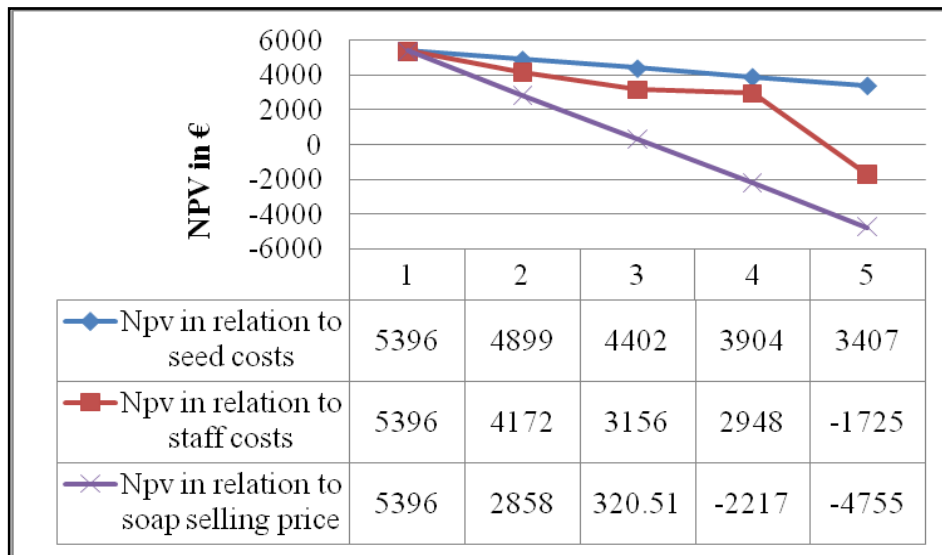


Figure 9 above shows a comparison of how sensitive the scheme NPV is to major inputs and outputs of the scheme which were separately presented earlier. As can be seen from the chart, the scheme NPV is most sensitive to the selling price of soap followed by staff costs and lastly the cost of seed. What this means is that the selling price of soap is a very critical item requiring more attention from management of the scheme. The management could introduce new products such as mosquito repellents and market raw Jatropha oil in urban areas so as to deal with the threat posed by returning of established soap manufacturers should the macroeconomic environment improves.

6.2 Economic Analysis of Jatropha Hedges in Mutoko District.

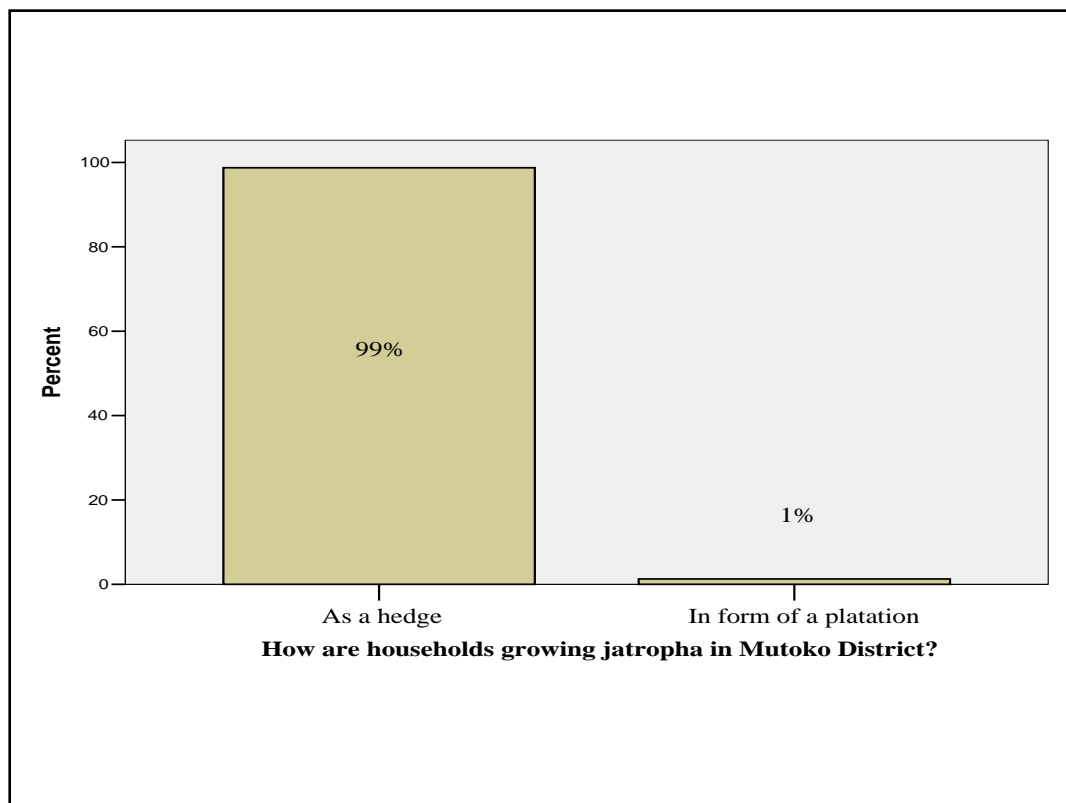
Since economic analysis covers the welfare effect to all members of a society, the costs and benefits used during evaluation of a scheme are not the same as those used when one is carrying out a financial analysis. The evaluation of the impact of Jatropha schemes are assessed through changes in the welfare of households in the whole community. A household survey was conducted covering a total of 158 households involved in cultivation of Jatropha hedges.

6.2.1 Economic Cost of Jatropha Hedges to Farmers in Mutoko.

The economic cost is the sum of the costs brought about by a Jatropha scheme to each individual member in the community. The costs include those incurred on inputs such as labour, seed and cuttings required to establish Jatropha hedges and the opportunity cost of diverting land to individual farmers who forgo production of other crops they used to grow so as to grow Jatropha hedges. The costs of inputs such as labour and seed are minimal and local and hence they have been ignored in this analysis. The opportunity cost of having Jatropha hedges to the farmers is assessed below.

As can be seen from figure 10, 99% of the households reported that they are growing Jatropha in form of hedges at the periphery of fields, gardens and homesteads whilst only 1% reported that Jatropha is being grown in form of a plantation. The plantations reported are actually communally owned and where planted when households came together to commemorate national tree planting day in 2006. The following table makes an analysis of land ownership and utilisation per household in the area covered by the study.

Figure 10: How are the Households Growing Jatropha in Mutoko District?



Source: Questionnaire, Question No.10

Table 4: Land Ownership and Utilisation per Household in Mutoko

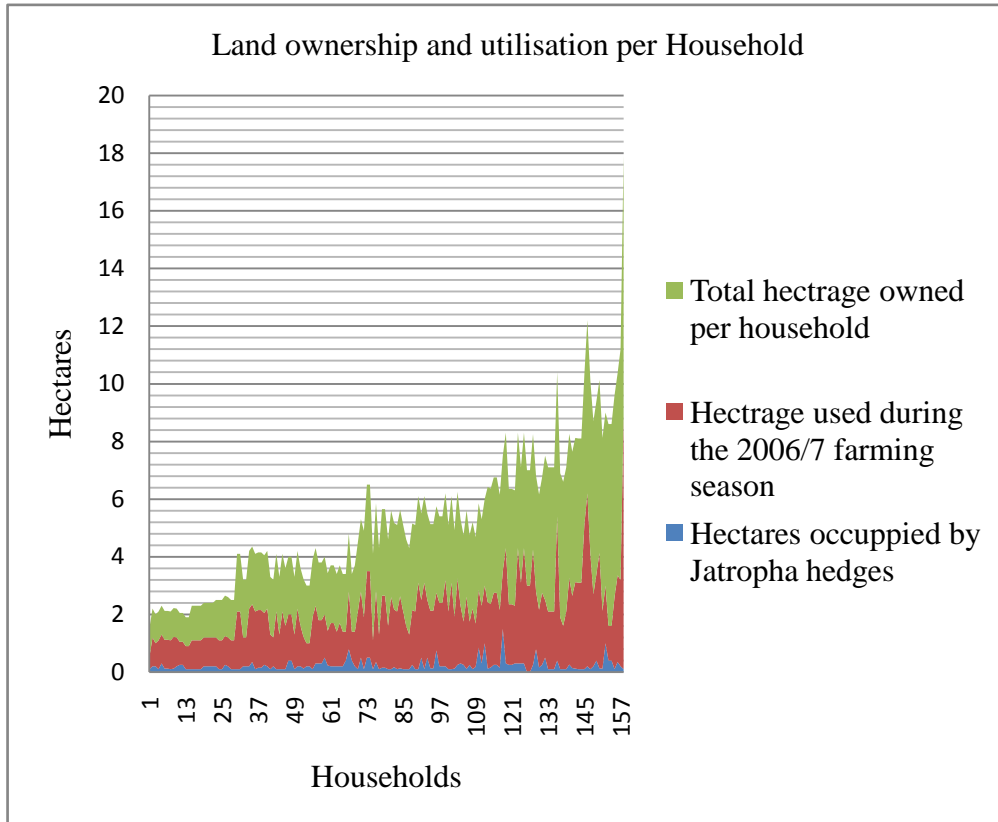
Statistic	Land owned per HH in hectares	Land utilised per HH last season in hectares	Land occupied by hedges per HH in hectares
Mean	2.85	2	0.2
Mode	3	2	0.1
Minimum	1	0.45	0.1
Maximum	9	8.8	1.5
Range	8	8	1.4
Standard Dev.	1.6	1	0.197

Source: Questionnaire, Question Nos. 11g, 13a & 13b.

Households were asked about the hectares of cropping land they own and their usage. As can be seen from table 4 above, most households reported that they own 3 hectares of cropping land. The minimum size of land ownership per household is 1 hectare whilst the maximum size of land owned per household is 9 hectares giving a range of 8 hectares. On average land ownership per household is 2.85 hectares and average land utilization per household during the 2006/7 farming season was 2 hectares which is about 72% of the total land owned by a household. Jatropha hedges occupy on average an area of 0.2 hectares per household which is 7.59% of the total land owned by a household. The minimum portion of land occupied by Jatropha hedges per household is 0.1 hectares whilst the maximum portion of land occupied by hedges is 1.5 hectares giving a range of 1.4 hectares.

Figure 11 makes an illustration of land ownership, land utilisation during the 2006/7 farming season and the portion of land taken up per household by Jatropha hedges. For detailed information used in coming up with the chart refer to annex 2 given at the end of this document. As can be seen from the chart, hedges take up a very small portion of land owned and utilised per household. The chart also shows that all the households did not fully utilize all their cropping land during the 2006/7 farming season. The reason given by some of the farmers for not fully utilizing their cropping land is the shortage of farming inputs such as fertilizers and certified seed.

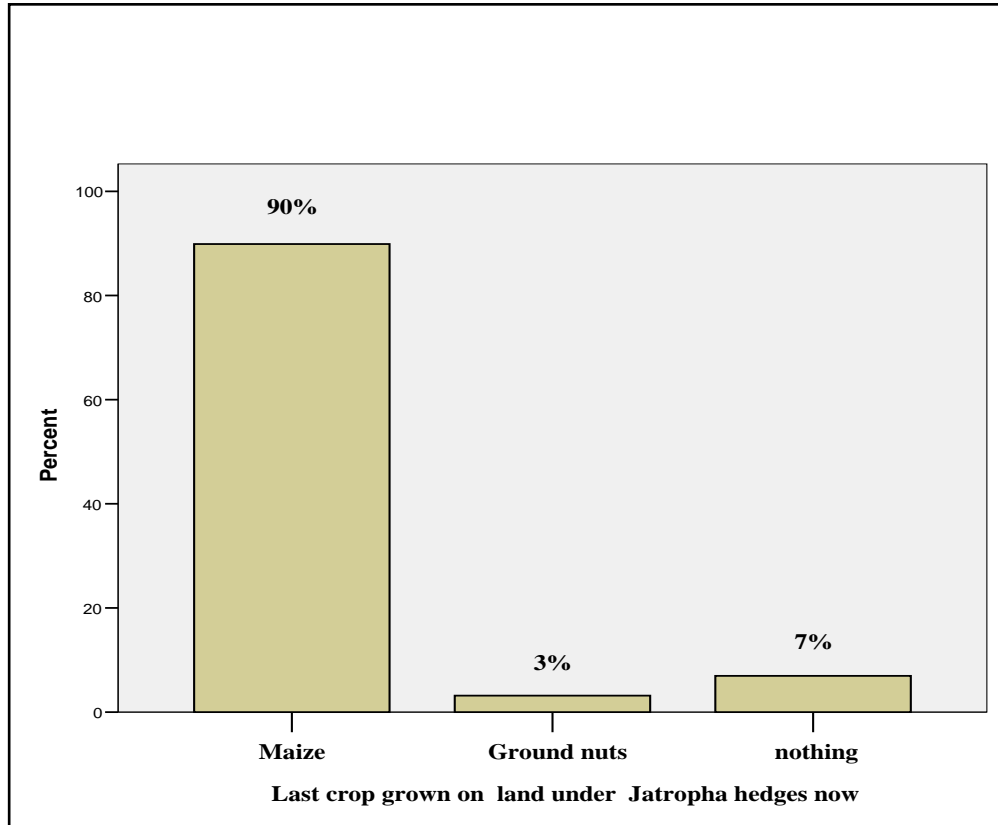
Figure 11: Land Ownership and Utilisation in Mutoko



Source: Questionnaire

Crops normally produced on land occupied by Jatropha hedges: The households were asked to report on crops they used to grow on the portion of their cropping land now occupied by hedges. As can be seen from figure 12, 90% of the households reported that they grew maize on the portion of their cropping land now occupied by Jatropha hedges whilst 3% grew ground nuts and 7% of the household just left the land to lay fallow. From this information an analysis was done to find out what the households had forgone (opportunity cost) by planting Jatropha hedges. Since 90% of the households had reported that they produced maize which is the main staple food crop on the portions of their land now occupied by hedges, their opportunity cost is the forgone maize yield they used to get every season.

Figure 12: Crops Normally Produced on Land Occupied by Jatropha Hedges



Source: Questionnaire, Question No. 12c

The Opportunity Cost of Jatropha hedges to households: The opportunity cost of using land for growing Jatropha hedges is shown in table 5 below. As can be seen from the table, households on average can now forgo production of 85 Kgs of maize per year on a portion of land which is now occupied by hedges. The 85 Kgs of maize forgone is enough to sustain an average family of four members for a period two months. The opportunity cost translates to 21.25 USD per year per household in monetary terms as maize sells for 25 US cents per Kg.

Table 5: Opportunity Cost of Jatropha Hedges to Rural Farmers in Mutoko

Statistic	Last Mean maize yield per household in Kgs per year.	Forgone Income in USD. (Current price per Kg is 25 US-cents).
Mean per household.	85kgs	21.25

Source: Questionnaire, Question No.12d

Maintenance Cost For Jatropha hedges: These costs are local costs and mainly include labour cost for pruning of the hedges, harvesting of Jatropha

seed and repairing of sections of the hedges which are destroyed by livestock during the dry season. As already mentioned earlier in section 4.2, most of these activities are undertaken by households during off-peak labour periods and hence they are not regarded as opportunity costs to the households' labour.

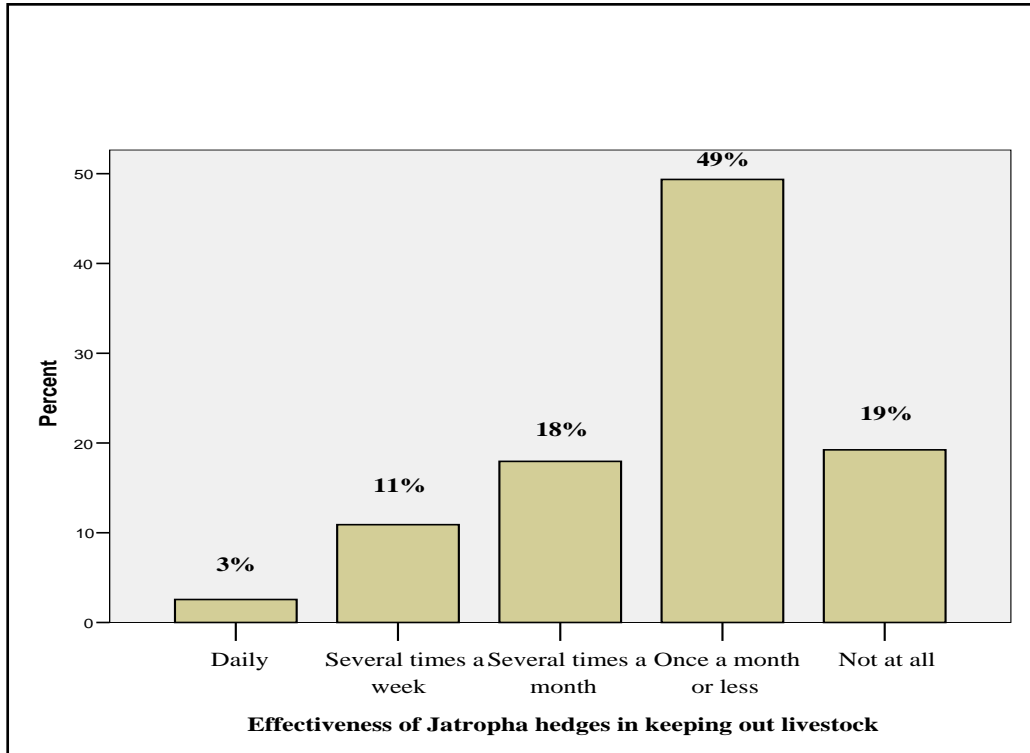
External costs: These occur when a project have negative impacts on specific groups in the society without the project entity incurring a corresponding monetary cost. These may include altering of the natural vegetation as *Jatropha* shrubs replace natural vegetation thereby reducing availability of traditional medicinal plants. The loss of medicinal plants would represent a cost to the society and yet the monetary flows of a *Jatropha* scheme would not necessarily reflect this cost. Such external effects should be considered when adjusting financial flows to reflect the economic cost. However, in the case of *Jatropha* hedges, such costs are assumed to be negligible and hence they have been ignored.

6.2.2 Economic Benefit of Jatropha Hedges to Farmers in Mutoko.

The benefits of *Jatropha* hedges to farmers in Mutoko as captured under economic analysis include prevented crop losses, savings on fertilizers, savings on energy for lighting and cooking and income generated from sale of seed produced from the hedges. The benefits are explained in detail below.

Figure 13 shows responses from households on the effectiveness of the hedges in keeping out livestock from invading crops. 19% of the households reported that their crops were not invaded at all during the 2006/7 farming season whilst 49% of the households reported that their crops were invaded at least once or less a month. 18% of the households reported that their fields were invaded several times a month whilst 11% of the households reported an invasion of several times a week and 3% of the households reported a daily invasion of their crops. The effectiveness of the hedges against livestock invasion depended on how the hedge had been planted.

Figure 13: Effectiveness of Hedges in Preventing Crop Losses from Livestock



Source: Questionnaire, Question No. 11a2

A visit to some of the households who reported that their crops were not invaded at all showed that most of the trees in the hedges were closely planted as can be seen in Plate 1 showing a garden fenced in by Jatropha hedges. Plate 2 show a Jatropha hedge of one of the households who reported that their crops are invaded at least once a month or less whilst plate 3 show a hedge of one of the households that reported that their crops are invaded several times a week. Plate 4 shows a Jatropha hedge of a household that reported that crops are invaded on a daily basis. The effectiveness of Jatropha hedges in keeping out livestock as reported by farmers in Mutoko district is further illustrated below in plates 1, 2, 3 and 4.



Plate 1: No invasion at all



Plate 2: Invasion once a month or less



Plate 3: Invasion several times a week



Plate 4: Daily invasion

Source: Field Observations

Table 6: Prevented Crop Losses per Household

Crops Grown by each Household	Mean crop loss per year per household without hedges	Mean crop Loss per year per household With hedges	Unit price in US\$	Mean crop loss in US\$ Without hedges	Mean crop loss in US\$ With hedges	Prevented mean crop loss in US\$ per Year per household.
Maize	114 Kgs	51Kgs	\$0.25/kg	28.50	12.75	15.75
Beans	23Kgs	9Kgs	\$0.56/kg	12.88	5.04	7.84
Tomatoes	30 boxes	11 boxes	\$0.75/kg	22.50	8.25	14.25
Vegetables	36 bundles	15 bundles	\$0.12 per bundle	4.32	1.80	2.52
			Total	68.20	27.84	40.36

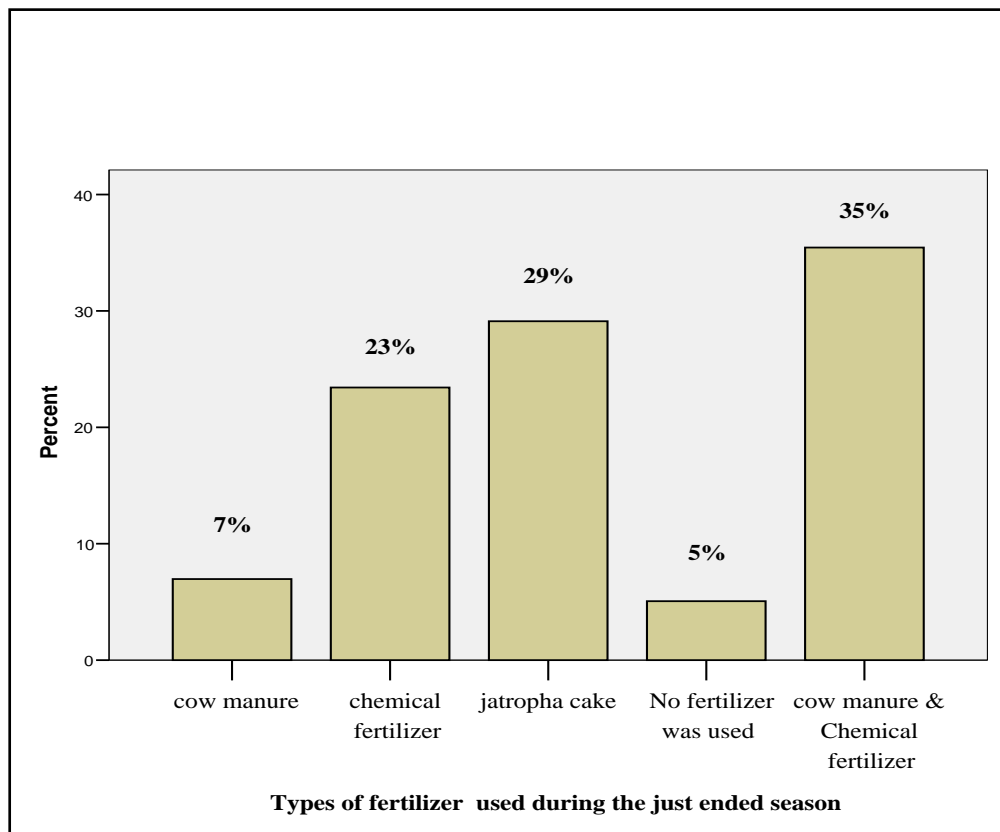
Source: Questionnaire, Question No.11b

Table 6 above, shows that without Jatropha hedges a household incurs a loss of 114 Kgs of maize due to livestock invasion and with Jatropha hedges the

loss is reduced to 51kgs of maize per season. This means that Jatropha hedges are able to prevent a loss of 63Kgs per household per year which translates to 15.75 US dollars worth of avoided losses. The hedges are also able to reduce losses of beans from 23kgs to 9kgs per season per household giving a mean prevented loss of 14kgs of beans per season. This translates to 7.84 US dollars worth of prevented bean losses. The hedges are also reducing tomato losses from 30 boxes per year per household to 11 boxes resulting in prevented losses of 19 boxes worth 14.25 US dollars per year. The households are also able to reduce vegetable losses from 36 bundles per year to 15 bundles per year preventing a loss of about 21 bundles worth 2.52 US dollars per year. In total a household growing Jatropha hedges as live fence is able to prevent crop losses worth 40.36 US dollars per year.

Household Savings on fertilizers: The households were asked to state the type of fertilizer they used during the 2006/7 farming season and the result of their responses is presented below

Figure 14: Types of Fertilizers Used by Households during the 2006/7 Farming Season

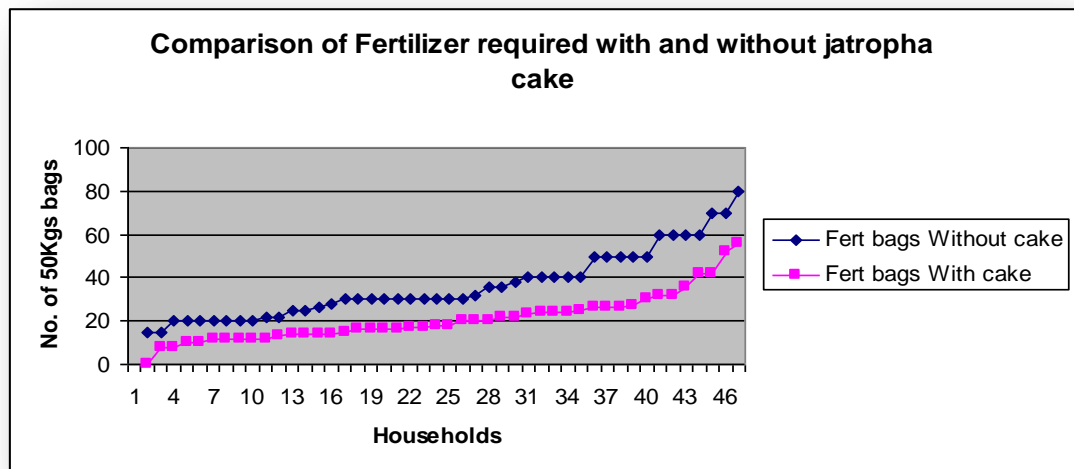


Source: Questionnaire, Question No.14

As can be seen from figure 14 above, 35% of the households reported that they used cow manure and chemical fertiliser whilst 29% of the households used Jatropha cake, 23 % used chemical fertilizer, 7% used cow manure and

5% did not use any fertilizer. All the farmers who used Jatropa cake as fertilizer are from ward 15 which is within a radius of 5km from an oil milling expeller at Makosa business centre. The cake is collected free of charge by those farmers who will have sold their seed to the mill. This is done as an incentive for farmers to continue bringing seed to the mill. The farmers who use Jatropa cake as fertilizer were asked to state their fertilizer requirements with and without Jatropa cake. The comparison of chemical fertilizer requirements of the households with and without Jatropa cake is given below in figure 15.

Figure 15: Fertilizers Required With and Without Jatropa Cake



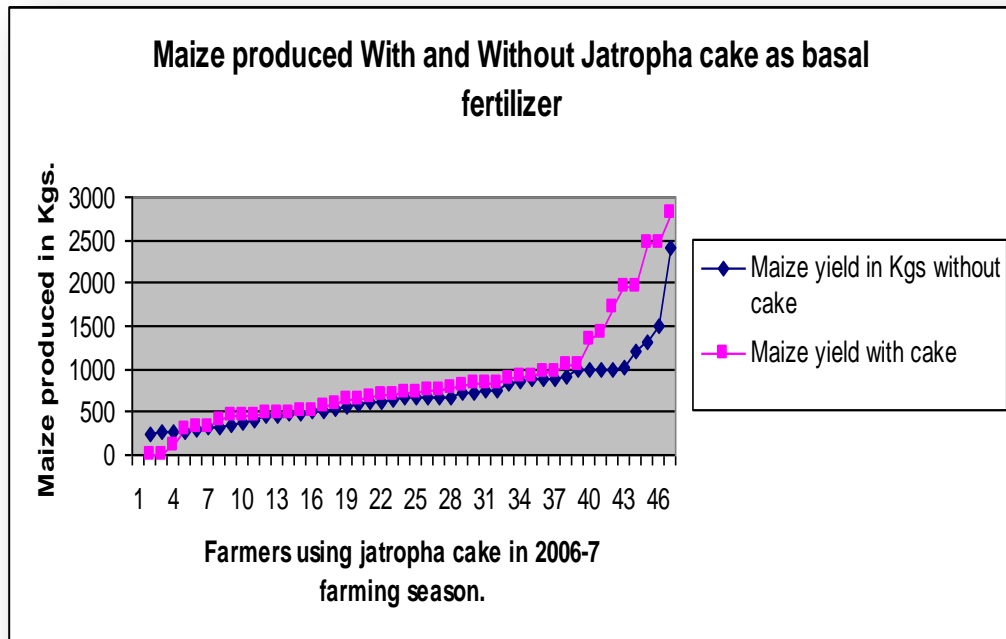
Source: Questionnaire, Question No.15

Figure 15 above shows on the horizontal axis respondents and on the vertical axis the number of fertilizer bags. As can be seen from the graph, a household will require an average of 36 bags of fertilizer per year without use of Jatropa cake and when the households are using Jatropa cake; their annual basal fertilizer requirement reduces to 21 bags. In monetary terms without usage of Jatropa cake a household would spend on average US\$45.38 for the 36 bags and with use of Jatropa cake the households would spend US\$26.22 for the 21 bags. This means that a household using Jatropa cake as basal fertilizer would be able to save an amount of US\$19.16 on average per year. This saving is counted as a benefit to households coming from Jatropa schemes.

Maize production with and without Jatropa cake: A yield analysis of 46 households who are using only Jatropa press cake as basal fertilizer for maize production revealed that an average maize yield per household per season without Jatropa cake is 707kgs whilst if the farmers use Jatropa cake the average maize yields per household increases to 861Kgs per season. This translates to 154 Kgs more per household on average as compared to a situation without use of the cake. Use of Jatropa cake for maize production

indicates a 22% increase in maize production per household per season. For further information on how these figures were arrived at refer to Annex 3. Figure 16 below gives an illustration of maize yields with and without use of Jatropha cake for the 46 households. The Y-axis shows maize yield in kilograms whilst the X-axis shows farmers respondents.

Figure 16: Maize Production With and Without Jatropha Cake¹⁷⁷



Source: Questionnaire, Question No.15

Figure 17 makes an illustration of net benefits realized per household per year emanating from use of Jatropha cake as basal fertilizer. The Y-axis show benefits in US dollars and the X-axis show the respondents. As can be seen from figure 17, 3 households experienced negative benefits whilst 8 household did not see much change in their maize benefits and 25 households recorded meaningful maize benefits after using Jatropha cake as basal fertilizer.

177 This chart is constructed from annex 3 showing annual crop yields per household with and without Jatropha cake as basal fertilizer.

Figure 17: Benefits Realized Attributable to Use of Cake¹⁷⁸.

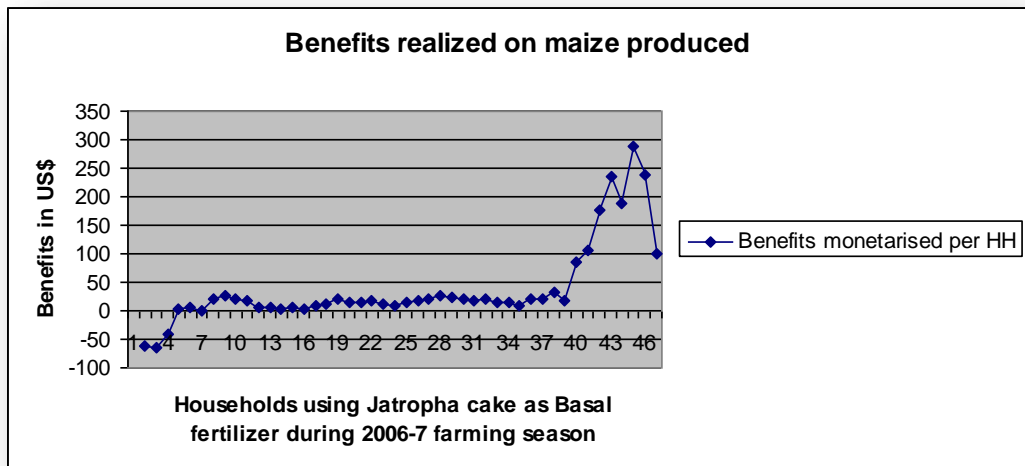
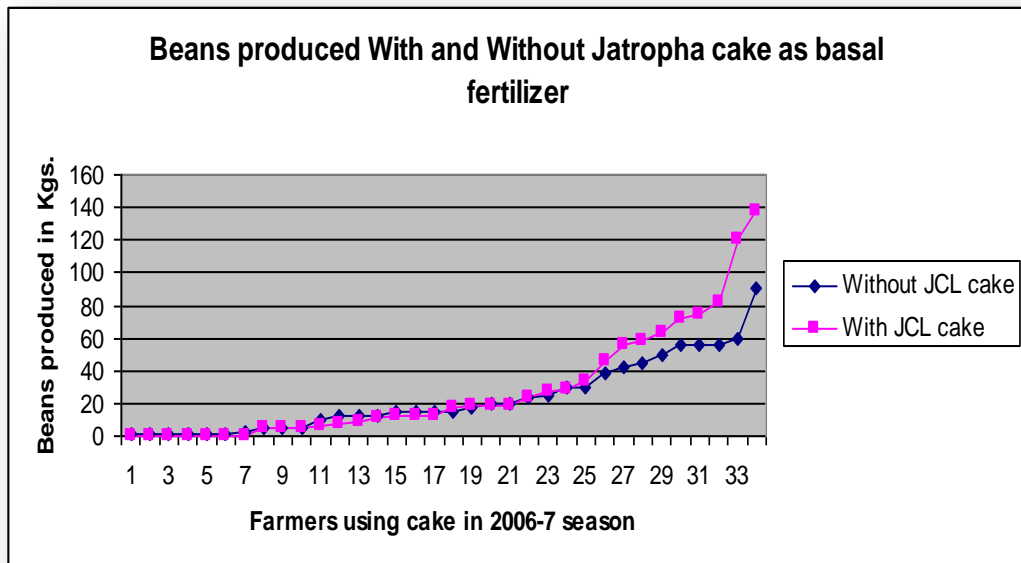


Plate 4: Adapted from Biomass Users Network (1998)

The picture above was taken on one of the trials conducted in Makosa village by Biomass Users Network in their research area. As can be seen in the picture, maize on the left part of the trial plot which received Jatropha cake as basal fertilizer appears to be better than maize on the right that did not receive anything.

178 This chart is constructed from annex 4 showing household income per year from Maize, vegetables and beans.

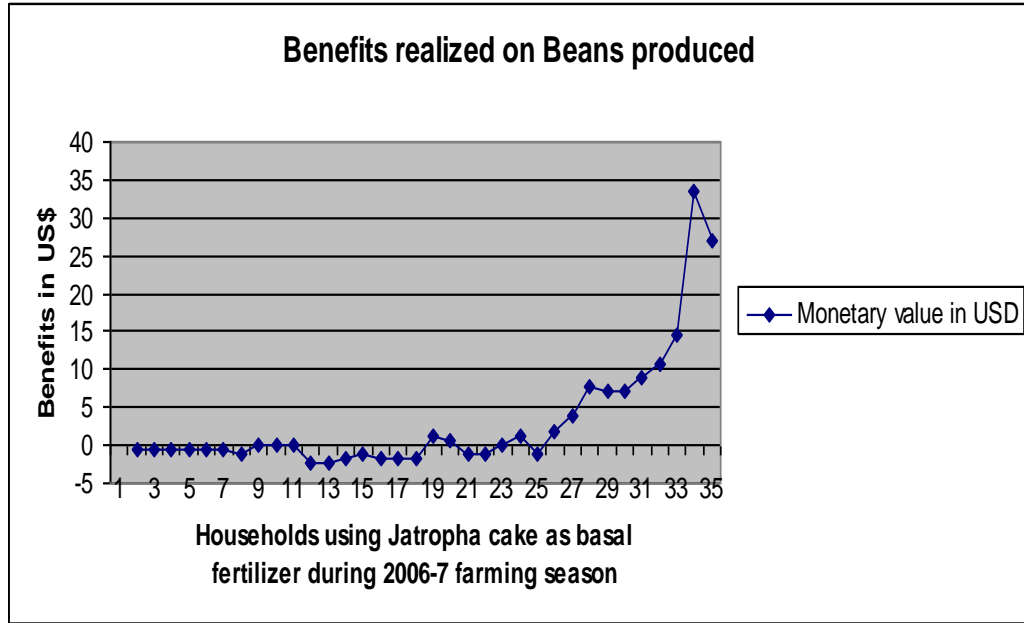
Figure 18: Production of Beans With and Without Jatropa Cake



Source: Questionnaire, Question No.15

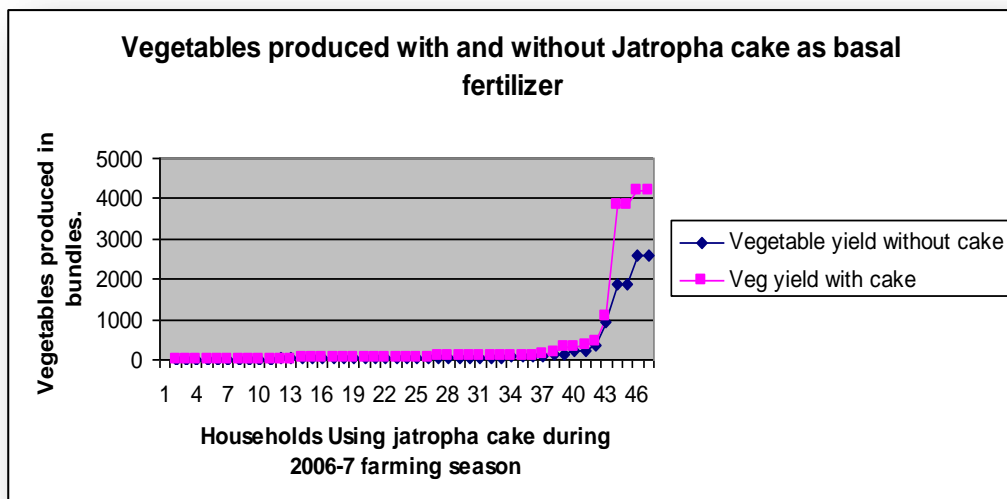
As can be seen from figures 18 and 19 (above and below respectively), use of Jatropa cake as basal fertilizer for bean production results in negative benefits for most households. As can be seen from figure 19 below, of the 34 households who used the cake for their bean crop during the 2006-7 farming season only 13 of them recorded positive benefits whilst 17 realized negative benefits and 4 households' benefits were neither positive nor negative. The average monetary benefit per household resulting from use of the cake for bean production is positive, US\$2.28. This is so because there are outliers making the mean positive, otherwise most households recorded negative benefits on their bean yield.

Figure 19: Benefits Realized on Beans Produced



Vegetable production with and without Jatropa cake: Although a comparison of households benefits on vegetable production with and without Jatropa cake show an aggregate average income of about US\$21 per household per year, most households did not experience much changes in their vegetable yield. Figure 20 below shows that there is not much difference in vegetable yields produced with and without use of the cake. The Y-axis show benefits in bundles whilst the X-axis show respondents.

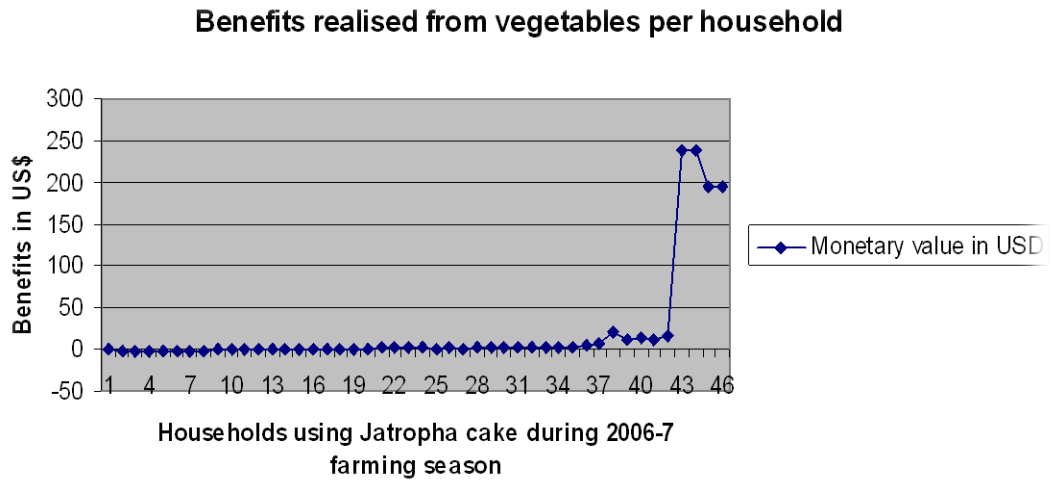
Figure 20: Vegetable Production With and Without Jatropa Cake



Source: Questionnaire, Question No.15

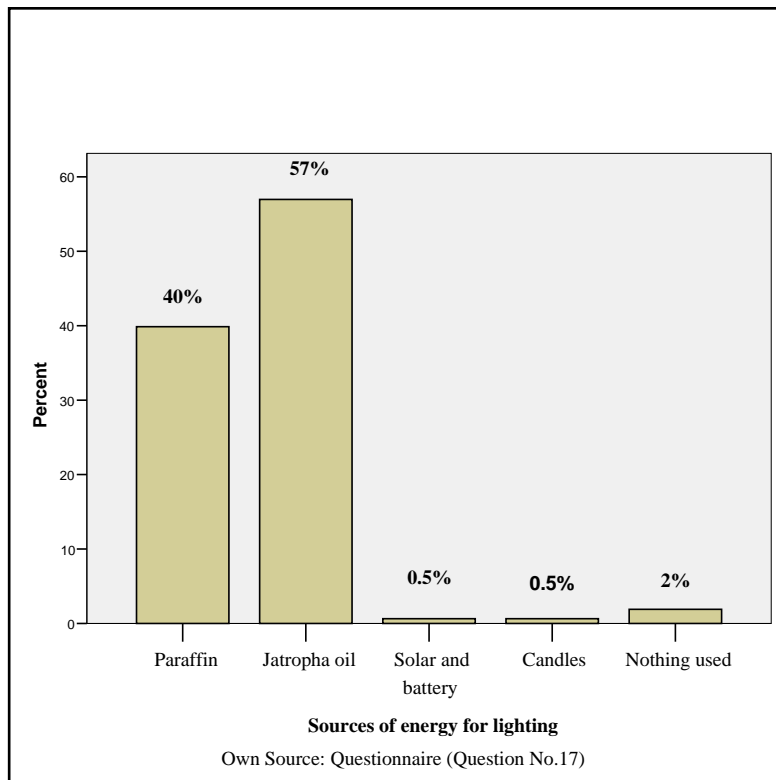
As can be seen from figure 21 below , 35 households using Jatropa cake for vegetable production did not realize much change in their benefits and only 11 households recorded an increase in their benefits due to use of the cake as fertilizer.

Figure 21: Benefits Realized from Vegetable Production



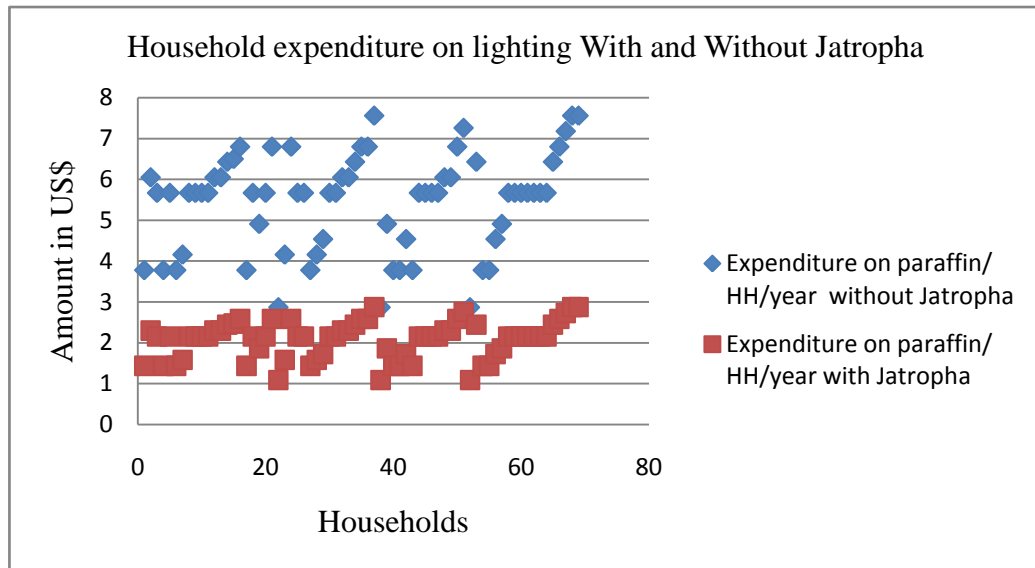
Saving on Household expenditure for Lighting

Figure 22: Sources of Energy for Lighting



As can be seen from figure 22 above 57% of the households are using wick Jatropha oil lamps for lighting at night and 40% are using wick paraffin lamps. 2% of the households do not use anything for lighting and this means that such households are limited as to what they can do at night and they have to rely on daylight to accomplish most of their productive activities. The remaining 1% of the households uses candles, solar and battery for their lighting requirements. Solar and battery are quite expensive and very few households can afford them.

Figure 23: Energy Usage With and Without Jatropha



Source: Questionnaire, Question No.17

Figure 23 above shows the annual bill per household on paraffin with and without Jatropha. As can be seen from the chart, most households are now having a lower annual bill on lighting with Jatropha as compared to their annual bill on paraffin without Jatropha. As can be seen from figure 23, a household would spend an average of US\$5.55 per year on paraffin for its lighting requirements Without Jatropha as compared to an average annual bill of US\$2.11 it would pay on paraffin With Jatropha. This means an average saving of US\$3.44 (62%) on lighting per household per year and this amount can be interpreted to represent a gain in welfare per household brought about by Jatropha.

Most households interviewed reported that they now prefer to use Jatropha oil as a substitute for paraffin for their lighting requirements. The first reason given by households is that Jatropha oil is cheaper (as it costs 38 US cents per litre) than paraffin which costs 63 cents when available.

Jatropha oil wick Lamp



Paraffin wick Lamp



Plate 5. Wick lamps used in Mutoko for lighting at night

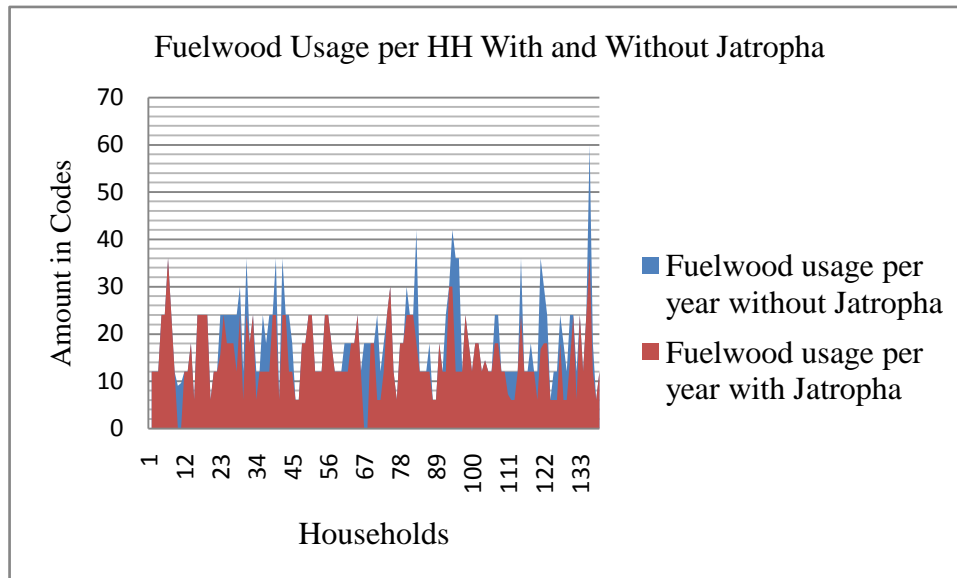
The other reason given by households for preferring Jatropha oil to paraffin is that the Jatropha oil burns with an odourless and a clear smoke-free flame than paraffin which burns with an unpleasant odour and smoke. This is very evident from Plate 5 above, which shows two wick lamps (one that burns on Jatropha oil and the other one burning on paraffin) observed during a household survey in Mutoko. As can be seen the wick lamp using Jatropha has a clean glass because it burns with a clear smoke-free flame whilst the one using paraffin has black soot. The third reason given by households who preferred Jatropha oil to paraffin as a source of energy for lighting is that when Jatropha oil is spilled or splashed from a burning lamp the fire goes off immediately and hence there is no risk of fire spreading in the hut. This is unlike paraffin which if it is splashed or spilled from a burning lamp it continues to burn and spreads.

Fuelwood usage with and without Jatropha

Figure 23 shows the difference between usage of fuelwood with and without Jatropha. On the Y-axis the total amount of fuelwood in codes is stated and the X-axis show respondents. On average a household uses 18.804 codes of fuelwood without Jatropha per year and fuelwood usage per household per year reduces to 15.061 codes with Jatropha. Most households interviewed showed low preference to use of Jatropha as fuelwood because it burns quickly as its wood is very light. A code of wood was costing 75 (US) cents in Mutoko during the time the study was conducted. In monetary terms, a household on average spends US\$14.10 per year on fuelwood without Jatropha and the bill reduces to US\$11.30 with Jatropha. This translates to an average saving of

US\$2.81 per household per year and this money could be used elsewhere to meet other needs of the household. For more details refer to annex 6.

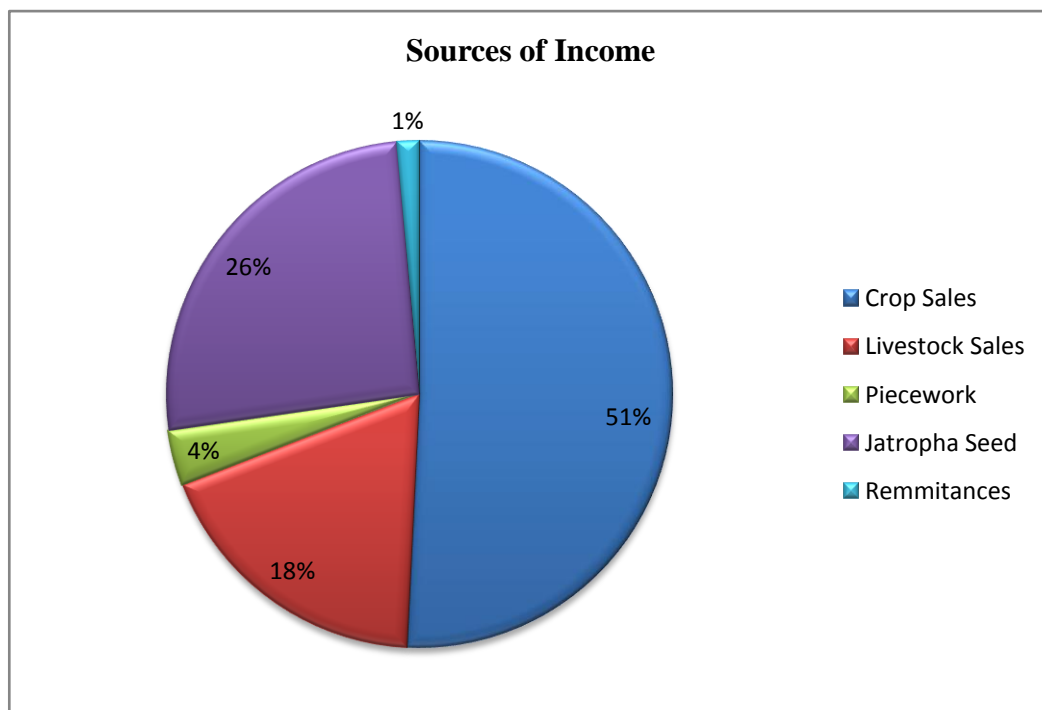
Figure 24: Comparison of Fuelwood Usage With and Without Jatropha



Source: Questionnaire, Question No.17

Sources of income for households in Mutoko district

Figure 25: Sources of Income for Households in Mutoko District



Source: Questionnaire, Question No.19

The households were asked to list and state their sources of income and the result of their answers is given above. As can be seen crop sales makes 51% of their annual income followed by sale of Jatropha seed (26%) and livestock sales makes up 18% whilst piecework makes 4% of their income and 1% of the income comes from remittances. Livestock is normally sold as a last resort especially to raise money for paying school fees or when there is bereavement in the family. As can be seen from the pie chart above remittances contribute only 1% to the annual household income and this is quite low. What this means is that very few people are sending back money to their relatives in rural areas perhaps due to the fact that life is becoming unaffordable in urban areas and hence very people are able to remit.

Income from sale of Jatropha seed: The mean net income from sale of Jatropha seed per year per household is 53.45 USD. This has been arrived at by deducting the forgone income from sale of last maize crop (produced on the portion of land now occupied by Jatropha hedges) from income realized from sale of Jatropha seed produced on the land which previously was used for maize production. As can be seen from table 7 below, the mean last maize yield per household per year from the portion of land now occupied by Jatropha hedges was 85Kgs worth 21.25 USD. Mean Jatropha seed yield per household per year from the same portion of land which previously was used by households to produce maize is 249 Kgs worth 74.70 USD. Therefore, the net average income from Jatropha seed per year per household is 53.45USD.

Table 7: Mean Annual Income per Household from Sale of Jatropha Seed

Statistic	Last Maize yield in Kgs. (Price per Kg is 25 US-cents).	Jatropha seed yield per year in Kgs. (price per kg is 30 US-cents).	Income from maize in USD	Income from sale of Jatropha seed in USD	Net Income from sale of seed less forgone income from maize in USD.
	A	B	C=A*0.25	D=B*0.30	E=D-C
Mean per HH.	85	249	21.25	74.70	53.45
Minimum yield	15	20	3.75	6.00	2.25
Maximum yield	500	850	125.00	255.00	130.00
Range	485	830	121.25	249.00	127.75

6.2.3 Aggregation of Cost and Benefit of Jatropha Hedges to Farmers in Mutoko.

The aggregation of the cost and benefit to the society brought about by Jatropha hedges from findings presented above are summarised in table 8 below.

Table 8: Aggregation of Economic Costs and Benefits of Jatropha Hedges to Farmers

Net Benefit	Value in US\$
1. Mean prevented income loss per household per season	40.36
2. Savings on fertilizer per household per season due use of Jatropha cake	19.16
3. Savings on lighting per household per year from use of Jatropha oil	3.44
4. Savings on fuelwood per household per year	2.81
5. Income per HH per year from sale of Jatropha seed ¹⁷⁹	53.45
Total net benefits per HH per year	119.22

179 This is net Income from sale of Jatropha seed less the opportunity cost of using land to grow hedges.

7 Conclusion and Recommendations

7.1 Conclusion

The basic aim of the study was to verify empirically the rentability and desirability of Jatropha schemes as seen by oil millers and rural farmers involved in the schemes. The study therefore tried to identify welfare changes among rural farmers with and without Jatropha schemes.

From the findings, consistent trends were identified which reveal that Jatropha schemes had positive welfare impacts on some key indicators assessed. Among these is the case of Binga Trees scheme which revealed that an investment in Jatropha oil milling could be a worthwhile venture. The scheme has created a market for Jatropha seed for rural farmers and a small industry has been developed in a rural area creating some employment opportunities. The scheme passed the NPV test as it recorded a positive NPV of €5396. Such a positive NPV shows possible gains in welfare for undertaking an investment in Jatropha oil mills. However, a sensitivity analysis of the NPV which is the main measure of project worth has revealed that the NPV of the scheme is very sensitive to any reductions in selling price of soap which is the main revenue generating output from the scheme. Given the prevailing macroeconomic environment prevailing in Zimbabwe characterised by price controls enforced by the state, viability of such promising ventures become threatened.

The economic analysis on the desirability of Jatropha hedges have demonstrated that the hedges have an opportunity cost to rural farmers. The hedges take up cropping land whose next best use is growing of maize which is the main staple crop. By planting Jatropha hedges rural farmers have to forgo an annual maize yield of about 85kgs worth 21.25 United States of America dollars per household per farming season. In other words, the benefits forgone represent a decline in the welfare of rural farmers brought about by Jatropha hedges. However, the research findings have also shown some potential benefits rural farmers engaged in cultivation of Jatropha hedges could realise. The benefits include reduction of crop losses caused by livestock, savings on fertilizer and energy and income earned from sale of Jatropha seed. A comparison of the costs and benefits indicates that the benefits seem to outweigh the costs. In the area of prevented crop losses, the results showed differences in the losses incurred with and without Jatropha hedges. Without Jatropha hedges farmers' incur on average crop losses worth 68.20 US dollars per household per year and With Jatropha hedges the losses are reduced to 27.84US dollars per household per year. This shows that the hedges were able to prevent crop losses worth 40.36 US dollars per household per year. These prevented losses represent welfare gains made by farmers as a result of having Jatropha hedges.

As regards savings made by farmers on fertilizer, the results of the findings indicated that only farmers from ward 15 which is within the proximity of the oil pressing mill at Makosa are using the cake for crop production. The results shows that without use of Jatropha cake, a household would on average spend

45.38 US dollars on fertilizer per farming season and with use of cake the amount spend on fertilizer would reduce to 26.22 US dollars per household. This indicates an average saving of about 19.16 US dollars on fertiliser per household per season and again this represent a gain in welfare brought about by Jatropha schemes. However, a further analysis of crop yields among 36 farmers using the cake as fertilizer produces mixed results for different crop. For maize production, the average yield without use of Jatropha cake was 707 Kgs per household per season and the yield rose to 861kgs per household per year with use of Jatropha cake as fertiliser. This result show a 22% increase in maize yield and this represent welfare gains brought about by application of the cake. However, the results were quite different for households using the cake for bean production. A total of 34 farmers who used the cake reported that 17 of them recorded negative benefits whilst 4 farmers did not see any change in their bean yield and 13 farmers realised positive yields. For vegetable production, the results do not show much difference between yields with and without use of the cake.

In the area of savings made on energy the results indicate welfare gains on usage of energy for lighting and cooking. The results show that on average a household would spend 5.55 US dollars for lighting per year without Jatropha and with Jatropha the average annual bill on lighting reduces to 2.11 US dollars per household. This indicates a saving of 3.44 US dollars per household per year and again this represents welfare gains. Since paraffin is a commodity that is imported using scarce foreign currency use of Jatropha oil to meet lighting requirements of household will save the country's resources currently being used to import paraffin.

An analysis of fuelwood usage with and without Jatropha shows an interesting scenario. Without Jatropha a household on average uses 18.804 codes of fuelwood (worth 14.10 US\$) per year and with Jatropha the usage of fuelwood drops to about 15.061 codes (worth 11.30 US\$) per household. Although this gives a positive average annual saving of 3.744 codes (worth 2.81US\$) per household, most households showed low preference of Jatropha as a source of fuelwood because the wood is very light and burns very quickly. However, a saving of 3.744 codes of fuelwood per household per year would reduce pressure put on indigenous woodlands and allow them to regenerate.

The results have also shown that farmers are able to derive income from sale of Jatropha seed to oil millers. The results have shown that on average a household can realise an annual income from sale of seed to the tune of 53.45 US\$. This represents 26% of the total annual income per household. The results have also shown that annual income from sale of Jatropha seed is the second largest source of income for the households.

From the aforementioned results, it can be seen that Jatropha schemes can have positive impacts on the welfare of rural farmers who take part in the schemes, and therefore the hypothesis hold true that the schemes can lead to an improvement in the economic welfare of rural farmers. However, it is important to acknowledge that the study experienced limitations due to the

prevailing unstable political and economic challenges facing the country. Firstly, the study had to adopt a discount rate based on information from Zambia since banks in Zimbabwe are not offering loans due to hyper-inflation conditions in the country. Secondly, the study was carried out during the period when the government had launched massive crackdown on businesses and this affected some of the mills the study had targeted to collect information from. The crackdown led to closing down of some mills and hence information for financial analysis was collected from one mill instead of the initial target of three.

Thirdly, the operating environment under which the study was carried out was very tense due to political polarisation and campaigning for the forthcoming harmonised parliamentary and presidential elections to be held in March 2008 in Zimbabwe. Such a tense atmosphere led to some suspicion among respondents to the extent that some of the respondents were not comfortable to be seen talking to strangers. Furthermore, most farmers in the study area do not keep production records since the majority of them are subsistence farmers and hence the author had to rely on estimates given by the farmers interviewed.

7.2 Recommendations

The study of the impacts of Jatropha schemes on the welfare of rural farmers revealed a number of recommendations for both those taking part in the schemes and others planning to participate in Jatropha scheme. The most important recommendations are outlined as follows:

Recommendations to mill owners: Firstly, Jatropha oil mills should be located within easy reach by farmers so that farmers can be able to collect Jatropha cake for use as fertilizer. As has been mentioned under research findings, only farmers who stay within the proximity of the oil milling plant came back to collect the cake. The cake plays a role of motivating farmers to continue bringing seed to the mill.

Secondly, mill owners need to diversify the number of products they produce for sale so as to be able to stay in business. A sensitivity analysis of Binga scheme has shown that the mill is very vulnerable to any price reductions of soap which is the main revenue earner for the mill. The mill may also go on a marketing research so that it can maintain high volumes of sales in the likely event of competition from other soap manufacturers. More sales could also be achieved through certification of products and this could be achieved if the scheme owners could have their products certified by the Standards association of Zimbabwe.

Recommendations to Rural farmers

Farmers should plant Jatropha in form of hedges so that they don't divert their limited cropping lands from production of food crops. The hedges will act as a fence and prevent crop losses from invading livestock. Apart from this benefit

farmers should use Jatropha cake as basal fertilizer as this will reduce their costs on fertilizing their crops. However farmers need to seek technical advice from agricultural experts on application of the cake for different crops. Since crop failure due to unfavourable weather conditions is a common thing in most communal areas in Zimbabwe, planting of Jatropha hedges will also provide the farmers with some form of coping mechanism since Jatropha can tolerate dry conditions. Income from sale of Jatropha seed during years of poor crop harvest could be used by farmers to source food from other areas.

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Appendices

1a: Household Survey – Questionnaire

Section A: Background information

1. Do you grow Jatropha?

Yes (1) → **if yes:** Since when? _____

No (2) → **if no:** Wish a good day and say goodbye

2. What is the name of your village? _____

3. What is the name of your ward? _____

4. Gender (silent!): → Female (1) → Male (2)

5. What is your year of birth? 19____

6. What is your marital status?

Married (1) Single (2) Widow (3) Divorced (4)

7. How many people are there in your family? ____

8. Education

Primary (1) Secondary (2) Tertiary (3) No Education (4)

9. How would you categorize your family earnings per year in Zimbabwe dollars?

Below 50 million (1) 51-100 million (2)
101-300 million (3) above 300 million (4)

Section B:

10. How are you growing Jatropha?

As a hedge (1) In form of a plantation (2)

11. If Jatropha is grown in hedges;

a1. Where are the hedges?

Around fields (1) around gardens (2) around homesteads (3)

a2. During the past farming season how regularly did livestock invade your field? Would you say that it was:

Daily (1) Several times a week (2)
Several times a months (3) Once a month or less (4)
Not at all (5)

b. What is the crop loss from your fields as a result of livestock invasion?

Type of crops grown in fields.	Without Jatropha hedges (in kilograms/year)	With Jatropha hedges (in Kilograms/year)	Prevented loss in kilograms
Maize			
Beans			
Tomatoes			
Vegetables			
Other			

c. How would you rank the effectiveness of Jatropha hedges in preventing soil erosion on a scale from 1 = not effective, 2= slightly effective, 3= effective to 4= very effective?

c1. related to protection of soil from water erosion.	1	2	3	4
c2. related to protection of soil from wind erosion.	1	2	3	4

d. Are the crops growing better than before you had the Jatropha hedges?

Yes (1) No (2) There is no difference (3)

f. How many Kgs of Jatropha seed do you harvest per year?
_____ Kg

g. What portion of your cropping land is occupied by Jatropha hedges? _____ Hectares

12. If Jatropha is grown in form of a plantation:

a. What is the size of your plantation? _____ in Hectares

b. How many kg of Jatropha seed do you harvest per year?
_____ in kg

c. What crops did you use to grow on the land under Jatropha now? _____

d. What was the crop yield per year from the land under Jatropha plantation now? _____ kg

13. a. Do you use Jatropha press-cake as fertilizer?

Yes (1) → **if yes: proceed to Qs 13b.**

No (2) → **if no: proceed to Qs 14.**

b. How would you rank the effectiveness of Jatropha press-cake as a fertilizer on a scale from 1= not effective, 2= slightly effective, 3= effective to 4= very effective?

b1. related to improving maize yields	1	2	3	4	Not sure
b2. related to improving vegetable yields	1	2	3	4	Not sure

14. a. How many hectares of cropping land do you have?
_____ Hectares

b. How many hectares of cropping land do you use?
_____ Hectares

15. Expenditure in agriculture per year.

Input	Without Jatropha	With Jatropha Cake
Seed		
Fertilizer		
Labour		
Other		

16. Agricultural production per year

Crop	Production quantities Without Jatropha/year	Production quantities With Jatropha Cake per year
Maize		
Beans		
Vegetables		
Other		

17. a. What is the main source of lighting fuel for your family?

1 = paraffin 2 = Candles 3 = Electricity
4 = Jatropha oil 5 = no light.

b. What is the main source of cooking fuel for you family?

1 = Collected fire wood 2 = Purchased firewood 3 = Paraffin
4 = Jatropha oil 5 = electricity and 6 = other

18. What are the sources, usage and cost of energy that is required in your house?

Energy Source	Usage without Jatropa/month	Usage with Jatropa/month	Cost per month of usage without Jatropa	Cost per month of usage without Jatropa
Fuel-wood				
Paraffin				
Other				

19. What are the sources of income for your family?

Source of Income	Amount per year
Crop sales	
Livestock sales	
Piecework	
Remittances	
Jatropha seed sales	

1b: Interview Guide for Jatropha Oil Milling Projects

1. Name of the Scheme.
2. Location
3. Ownership: Private CBO Donor assisted cooperative.
4. When was the mill established?
5. What is the capacity and type of the mill?
- 6.1. What was the total capital cost during establishment? \$ _____ in Yr 0.
- 6.2. Sources of financing in year zero.

Sources	Amount in dollars (Zimbabwe).
Loan	
Equity	
Grant	

- 7.1. Operating Costs per year. (Cash out flow)

Personnel

Title of employee.	No. of people employed.	Qualification	Salary per month	Comments

- 7.2. Variable costs per year (Cash outflows)

Seed purchase			
Packaging			
Others			

8. Revenue per year. (Cash inflows)

Jatropha oil		
Press cake		
Other products (soap)		

9. Problems faced in operation and management of the scheme.
10. How many farmers sell their seed to the mill?

1c: The Net Present Value for Binga Trees Scheme

The following NPV formula has been applied to the cash flows of the scheme.

$$NPV = \sum_{t=1}^n \frac{B_t - C_t}{(1 + r)^t}$$

Notes: The following additional assumptions have been made:

1. Sales of soap, Moringa powder and seedlings to increase by 100% in year 2 and by 50% in year 3 thereafter the sales remain constant.
2. Inputs are to increase in proportion to sales.
3. Electricity and water charges are to increase by 10% in year 2 and 5% in year 3
4. Staff costs will increase by 15% in year 2 and 10% in year 3.

Period	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Discount Factors at 12%		0.893	0.797	0.712	0.636	0.567	0.507	0.452	0.404	0.361	0.322
Capital Expenditure (Figures in Euros)											
1 Motor oil presses	(8,000)										
Motor cycle	(500)										
Hammer mill	(500)										
Construction of store	(3,000)										
Motor vehicle	(8,000)										
Total	(20,000)										

Period	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year
	0	1	2	3	4	5	6	7	8	9	10
Discount Factors at 12%		0.893	0.797	0.712	0.636	0.567	0.507	0.452	0.404	0.361	0.322
Income from sales											
Soap sales		3,532	7,064	10,596	10,596	10,596	10,596	10,596	10,596	10,596	10,596
Jatropha oil		75	75	75	75	75	75	75	75	75	75
Moringa leaf powder		801	1,602	2,403	2,403	2,403	2,403	2,403	2,403	2,403	2,403
Tree seeds, nursery		312	624	936	936	936	936	936	936	936	936
Expelling of sunflower seed		123	123	123	123	123	123	123	123	123	123
Photocopies, faxes		290	290	290	290	290	290	290	290	290	290
Total revenue		5,133	9,778	14,423	14,423	14,423	14,423	14,423	14,423	14,423	14,423
Operating expenses											
Rent, electricity, water tele etc		1,572	1,729	1,816	1,816	1,816	1,816	1,816	1,816	1,816	1,816
Field operations		629	629	0	0	0	0	0	0	0	0
Fuel, car maintenance etc		1,173	1,173	1,173	1,173	1,173	1,173	1,173	1,173	1,173	1,173
Staff costs		1,795	2,064	2,271	2,271	2,271	2,271	2,271	2,271	2,271	2,271
Jatropha seed		692	1,384	2,076	2,076	2,076	2,076	2,076	2,076	2,076	2,076
Caustic soda, perfumes etc		297	593	890	890	890	890	890	890	890	890
Total operating costs		6,157	7,572	8,224	8,224	8,224	8,224	8,224	8,224	8,224	8,224
Net inflow/(outflow)		1,024	2,206	6,199	6,199	6,199	6,199	6,199	6,199	6,199	6,199
Discounted Net inflow/(outflow)											
Discounted Cash flows	(20,000)	(915)	1,758	4,413	3,942	3,515	3,143	2,802	2,504	2,238	1,996
Cumulative Cash flows		20,915	19,156	14,743	10,801	7,286	4,144	1,342	1,162	3,400	5,396

The NPV is positive at the end of the project life and is €5,396. Take note that Cash flows from the sale of the store and motor vehicle at the end of the project have not been included.

2: Land Ownership and Utilisation per Household in Mutoko

Land owned per Household in hectares	Land utilised (in hectares) during 2006/7 farming season	Land occupied in hectares by Jatropha hedges	Land utilized as a percentage of the total land owned	Land occupied by hedges as a percentage of total land owned
1	0.45	0.1	45	10
1	0.8	0.1	80	10
1	0.8	0.1	80	10
1	0.8	0.1	80	10
1	0.8	0.1	80	10
1	0.8	0.1	80	10
1	0.8	0.1	80	10
1	0.8	0.1	80	10
1	1	0.1	100	10
1	1	0.1	100	10
1	1	0.1	100	10
1	1	0.1	100	10
1	1	0.1	100	10
1	1	0.1	100	10
1	1	0.1	100	10
1	1	0.1	100	10
1	1	0.1	100	10
1	1	0.1	100	10
1	1	0.1	100	10
1	1	0.1	100	10
1.1	1	0.1	91	9
1.1	1	0.1	91	9
1.2	1	0.1	83	8
1.2	1	0.1	83	8
1.2	1	0.1	83	8
1.2	1	0.1	83	8
1.2	1	0.1	83	8
1.2	1	0.1	83	8
1.2	1	0.1	83	8
1.2	1	0.1	83	8
1.2	1	0.1	83	8
1.2	1	0.1	83	8
1.2	1	0.1	83	8
1.2	1	0.1	83	8
1.2	1	0.1	83	8
2	1.2	0.1	60	5
2	1.2	0.1	60	5
2	1.2	0.1	60	5
2	1.2	0.1	60	5

Land owned per Household in hectares	Land utilised (in hectares) during 2006/7 farming season	Land occupied in hectares by Jatropha hedges	Land utilized as a percentage of the total land owned	Land occupied by hedges as a percentage of total land owned
2	1.2	0.1	60	5
2	1.2	0.1	60	5
2	1.3	0.1	65	5
2	1.4	0.1	70	5
2	1.4	0.1	70	5
2	1.4	0.1	70	5
2	1.4	0.1	70	5
2	1.4	0.1	70	5
2	1.4	0.1	70	5
2	1.4	0.1	70	5
2	1.4	0.1	70	5
2	1.5	0.1	75	5
2	1.5	0.1	75	5
2	1.5	0.11	75	6
2	1.5	0.12	75	6
2	1.5	0.12	75	6
2	1.5	0.12	75	6
2	1.5	0.12	75	6
2	1.5	0.12	75	6
2	1.5	0.12	75	6
2	1.5	0.12	75	6
2	1.5	0.12	75	6
2	1.5	0.12	75	6
2	1.5	0.12	75	6
2	1.5	0.12	75	6
2	1.5	0.12	75	6
2	1.5	0.13	75	7
2	1.5	0.13	75	7
2	1.6	0.13	80	7
2	1.6	0.13	80	7
2	1.8	0.13	90	7
2	1.8	0.14	90	7
2	1.8	0.15	90	8
2	1.8	0.15	90	8
2	1.8	0.15	90	8
2	1.9	0.15	95	8
2	2	0.15	100	8
2	2	0.16	100	8
3	2	0.16	67	5
3	2	0.17	67	6
3	2	0.18	67	6
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7

Land owned per Household in hectares	Land utilised (in hectares) during 2006/7 farming season	Land occupied in hectares by Jatropha hedges	Land utilized as a percentage of the total land owned	Land occupied by hedges as a percentage of total land owned
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.2	67	7
3	2	0.23	67	8
3	2	0.25	67	8
3	2	0.25	67	8
3	2	0.25	67	8
3	2.1	0.25	70	8
3	2.1	0.25	70	8
4	2.1	0.25	53	6
4	2.2	0.25	55	6
4	2.2	0.25	55	6
4	2.2	0.25	55	6
4	2.3	0.25	58	6
4	2.3	0.25	58	6
4	2.4	0.25	60	6
4	2.5	0.25	63	6
4	2.5	0.25	63	6
4	2.5	0.26	63	6
4	2.5	0.3	63	8
4	2.5	0.3	63	8

Land owned per Household in hectares	Land utilised (in hectares) during 2006/7 farming season	Land occupied in hectares by Jatropha hedges	Land utilized as a percentage of the total land owned	Land occupied by hedges as a percentage of total land owned
4	2.5	0.3	63	8
4	2.5	0.3	63	8
4	2.5	0.3	63	8
4	2.5	0.3	63	8
4	2.5	0.3	63	8
4	2.5	0.3	63	8
4	2.5	0.3	63	8
5	2.8	0.3	56	6
5	3	0.3	60	6
5	3	0.35	60	7
5	3	0.35	60	7
5	3	0.35	60	7
5	3	0.4	60	8
5	3	0.4	60	8
5	3	0.4	60	8
5	3	0.4	60	8
5	3	0.4	60	8
5	3	0.4	60	8
5	3	0.4	60	8
5	3	0.4	60	8
5	3	0.4	60	8
5	3	0.4	60	8
5	3	0.5	60	10
6	3	0.5	50	8
6	3	0.5	50	8
6	3	0.5	50	8
6	4	0.5	67	8
6	4	0.5	67	8
6	4	0.5	67	8
6	4	0.75	67	13
7	4	0.8	57	11
7	4	0.8	57	11
7	5	0.85	71	12
7	5.2	1	74	14
8	6	1	75	13
9	8.8	1.5	98	17
2.929114	1.985127	0.229241	72%	7.59%
mean	mean	mean	mean	mean

3: Annual Crop Yields With and Without Jatropha Cake as Basal Fertilizer

Annual Maize yield in Kgs without cake	Annual Maize yield in Kgs with cake	Annual maize Benefits in Kgs per household.	Annual Vegetable yield in bundles without cake per household	Annual Vegetable yield in bundles with cake per household.	Annual Vegetable benefits in bundles per house hold.	Annual Bean yield in Kgs without cake per household	Annual Bean yield in Kgs with cake per household	Annual Benefits from beans in Kgs per household
(A)	(B)	(C=B-A)	(D)	(E)	(F=E-D)	(G)	(H)	(I=H-G)
245	0	-245	3	0	-3	1	0	-1
258	0	-258	7	0	-7	1	0	-1
278	112	-166	10	0	-10	1	0	-1
280	296	16	14	0	-14	1	0	-1
290	314	24	14	0	-14	1	0	-1
320	318	-2	16	5	-11	1	0	-1
320	406	86	18	10	-8	2	0	-2
350	460	110	20	12	-8	5	5	0
380	460	80	20	16	-4	5	5	0
390	464	74	20	20	0	5	5	0
450	478	28	23	20	-3	10	6	-4
460	481	21	25	22	-3	12	8	-4
471	486	15	25	23	-2	12	9	-3
490	513	23	28	26	-2	13	11	-2
510	520	10	28	27	-1	15	12	-3
520	550	30	28	32	4	15	12	-3
540	586	46	30	41	11	15	12	-3
560	638	78	32	43	11	15	17	2
580	640	60	34	45	11	17	18	1
620	680	60	36	48	12	20	18	-2
620	687	67	36	53	17	20	18	-2

(A)	(B)	(C=B-A)	(D)	(E)	(F=E-D)	(G)	(H)	(I=H-G)
670	710	40	42	56	14	25	27	2
670	730	60	45	58	13	30	28	-2
675	750	75	52	63	11	30	33	3
680	760	80	53	67	14	39	46	7
680	786	106	55	67	12	42	56	14
720	815	95	55	72	17	45	58	13
730	817	87	56	73	17	50	63	13
750	820	70	59	78	19	56	72	16
750	830	80	64	86	22	56	75	19
830	890	60	65	93	28	56	82	26
850	903	53	78	97	19	60	120	60
875	913	38	80	103	23	90	138	48
875	960	85	80	106	26			
875	960	85	82	126	44			
920	1046	126	125	189	64			
980	1050	70	126	305	179			
1000	1346	346	225	320	95			
1000	1420	420	240	360	120			
1002	1708	706	340	436	96			
1008	1950	942	920	1060	140			
1200	1950	750	1860	3850	1990			
1300	2455	1155	1860	3850	1990			
1500	2455	955	2580	4205	1625			
2400	2800	400	2580	4205	1625			
707 Average per household	861 Average per household	154 Average per household	265.9 Average per household	444 Average per household	178 Average per household	23 Average per household	29 Average per household	5.5 Average per household

4: Household Income per Year from Maize, Vegetables and Beans

Household Number	Monetary value in US\$ of benefits from maize	Monetary value in US\$ of benefits from vegetables in USD	Monetary benefits in US\$ from beans per Yr. per HH.	Total annual Income per HH from maize, beans and Vegetables in US\$
	A	B	C	D=A+B+C
1	-61.25	-0.36	-0.56	-62.17
2	-64.5	-0.84	-0.56	-65.9
3	-41.5	-1.2	-0.56	-43.26
4	4	-1.68	-0.56	1.76
5	6	-1.68	-0.56	3.76
6	-0.5	-1.32	-0.56	-2.38
7	21.5	-0.96	-1.12	19.42
8	27.5	-0.96	0	26.54
9	20	-0.48	0	19.52
10	18.5	0	0	18.5
11	7	-0.36	-2.24	4.4
12	5.25	-0.36	-2.24	2.65
13	3.75	-0.24	-1.68	1.83
14	5.75	-0.24	-1.12	4.39
15	2.5	-0.12	-1.68	0.7
16	7.5	0.48	-1.68	6.3
17	11.5	1.32	-1.68	11.14
18	19.5	1.32	1.12	21.94
19	15	1.32	0.56	16.88
20	15	1.44	-1.12	15.32
21	16.75	2.04	-1.12	17.67
22	11.25	1.68	0	12.93
23	10	1.68	1.12	12.8
24	15	1.56	-1.12	15.44
25	18.75	1.32	1.68	21.75
26	20	1.68	3.92	25.6
27	26.5	1.44	7.84	35.78
28	23.75	2.04	7.28	33.07
29	21.75	2.04	7.28	31.07
30	17.5	2.28	8.96	28.74
31	20	2.64	10.64	33.28
32	15	3.36	14.56	32.92
33	13.25	2.28	33.6	49.13
34	9.5	2.76	26.88	39.14
35	21.25	3.12		24.37
36	21.25	5.28		26.53
37	31.5	7.68		39.18
38	17.5	21.48		38.98
39	86.5	11.4		97.9
40	105	14.4		119.4
41	176.5	11.52		188.02

Household Number	Monetary value in US\$ of benefits from maize	Monetary value in US\$ of benefits from vegetables in USD	Monetary benefits in US\$ from beans per Yr. per HH.	Total annual Income per HH from maize, beans and Vegetables in US\$
	A	B	C	D=A+B+C
42	235.5	16.8		252.3
43	187.5	238.8		426.3
44	288.75	238.8		527.55
45	238.75	195		433.75
46	100	195		295
Averages per household	38.5109	21.37	2.289	62.173

5: Annual Expenditure on Lighting With and Without Jatropha

Household number	Amount spent in US\$ on paraffin per household per year without Jatropha	Amount spent in US\$ on paraffin per household per year with Jatropha	Savings in US\$ per household per year on paraffin
1	3.78	1.44	2.34
2	6.05	2.30	3.75
3	5.67	2.15	3.52
4	3.78	1.44	2.34
5	5.67	2.15	3.52
6	3.78	1.44	2.34
7	4.16	1.58	2.58
8	5.67	2.15	3.52
9	5.67	2.15	3.52
10	5.67	2.15	3.52
11	5.67	2.15	3.52
12	6.05	2.30	3.75
13	6.05	2.30	3.75
14	6.43	2.44	3.99
15	6.5	2.47	4.03
16	6.8	2.58	4.22
17	3.78	1.44	2.34
18	5.67	2.15	3.52
19	4.91	1.87	3.04
20	5.67	2.15	3.52
21	6.8	2.58	4.22
22	2.87	1.09	1.78
23	4.16	1.58	2.58
24	6.8	2.58	4.22
25	5.67	2.15	3.52
26	5.67	2.15	3.52
27	3.78	1.44	2.34
28	4.16	1.58	2.58
29	4.54	1.73	2.81
30	5.67	2.15	3.52
31	5.67	2.15	3.52
32	6.05	2.30	3.75
33	6.05	2.30	3.75
34	6.43	2.44	3.99
35	6.80	2.58	4.22
36	6.80	2.58	4.22
37	7.56	2.87	4.69
38	2.87	1.09	1.78
39	4.91	1.87	3.04
40	3.78	1.44	2.34
41	3.78	1.44	2.34
42	4.54	1.73	2.81
43	3.78	1.44	2.34
44	5.67	2.15	3.52
45	5.67	2.15	3.52

46	5.67	2.15	3.52
47	5.67	2.15	3.52
48	6.05	2.30	3.75
49	6.05	2.30	3.75
50	6.8	2.58	4.22
51	7.26	2.76	4.50
52	2.87	1.09	1.78
53	6.43	2.44	3.99
54	3.78	1.44	2.34
55	3.78	1.44	2.34
56	4.54	1.73	2.81
57	4.91	1.87	3.04
58	5.67	2.15	3.52
59	5.67	2.15	3.52
60	5.67	2.15	3.52
61	5.67	2.15	3.52
62	5.67	2.15	3.52
63	5.67	2.15	3.52
64	5.67	2.15	3.52
65	6.43	2.44	3.99
66	6.80	2.58	4.22
67	7.18	2.73	4.45
68	7.56	2.87	4.69
69	7.56	2.87	4.69
70	7.56	2.87	4.69
71	7.56	2.87	4.69
72	1.89	0.72	1.17
73	4.54	1.73	2.81
74	5.67	2.15	3.52
75	5.67	2.15	3.52
76	5.67	2.15	3.52
77	6.80	2.58	4.22
78	7.56	2.87	4.69
79	7.56	2.87	4.69
80	4.16	1.58	2.58
81	4.91	1.87	3.04
82	5.29	2.01	3.28
83	5.67	2.15	3.52
84	5.67	2.15	3.52
85	5.67	2.15	3.52
86	5.67	2.15	3.52
87	5.67	2.15	3.52
88	5.67	2.15	3.52
89	5.67	2.15	3.52
90	6.80	2.58	4.22
91	5.67	2.15	3.52
92	7.56	2.87	4.69
93	4.23	1.61	2.62
Averages per household per year	\$5.55	\$2.11	\$3.44

6: Fuelwood Usage With and Without Jatropha in Mutoko

Fuelwood usage in codes per year without Jatropha	Fuelwood usage in codes per year with Jatropha	Benefit (savings) in codes per Yr.	Cost of fuelwood (in US\$) per HH per year without Jatropha	Cost of fuelwood (in US\$) per HH per year with Jatropha	Savings (benefits) in US\$ per HH/Yr.
12	12	0	9	9	0
12	12	0	9	9	0
12	12	0	9	9	0
24	24	0	18	18	0
24	24	0	18	18	0
36	36	0	27	27	0
24	24	0	18	18	0
12	12	0	9	9	0
9	0	9	6.75	0	6.75
9.6	0	9.6	7.2	0	7.2
12	12	0	9	9	0
12	12	0	9	9	0
18	18	0	13.5	13.5	0
6	6	0	4.5	4.5	0
24	24	0	18	18	0
24	24	0	18	18	0
24	24	0	18	18	0
24	24	0	18	18	0
6	6	0	4.5	4.5	0
12	12	0	9	9	0
12	12	0	9	9	0
24	15.6	8.4	18	11.7	6.3
24	24	0	18	18	0
24	18	6	18	13.5	4.5
24	18	6	18	13.5	4.5
24	18	6	18	13.5	4.5
24	12	12	18	9	9
30	24	6	22.5	18	4.5
12	6	6	9	4.5	4.5
36	24	12	27	18	9
18	18	0	13.5	13.5	0
24	24	0	18	18	0
12	6	6	9	4.5	4.5
12	12	0	9	9	0
24	12	12	18	9	9
18	12	6	13.5	9	4.5
24	12	12	18	9	9
24	24	0	18	18	0
36	24	12	27	18	9
6	6	0	4.5	4.5	0
36	24	12	27	18	9
24	24	0	18	18	0
24	12	12	18	9	9

Fuelwood usage in codes per year without Jatropa	Fuelwood usage in codes per year with Jatropa	Benefit (savings) in codes per Yr.	Cost of fuelwood (in US\$) per HH per year without Jatropa	Cost of fuelwood (in US\$) per HH per year with Jatropa	Savings (benefits) in US\$ per HH/Yr.
18	12	6	13.5	9	4.5
6	6	0	4.5	4.5	0
6	6	0	4.5	4.5	0
18	18	0	13.5	13.5	0
18	18	0	13.5	13.5	0
24	24	0	18	18	0
24	24	0	18	18	0
12	12	0	9	9	0
12	12	0	9	9	0
12	12	0	9	9	0
12	12	0	9	9	0
24	24	0	18	18	0
24	24	0	18	18	0
18	18	0	13.5	13.5	0
12	12	0	9	9	0
12	12	0	9	9	0
12	12	0	9	9	0
18	12	6	13.5	9	4.5
18	12	6	13.5	9	4.5
18	18	0	13.5	13.5	0
18	18	0	13.5	13.5	0
24	24	0	18	18	0
12	12	0	9	9	0
18	0	18	13.5	0	13.5
18	0	18	13.5	0	13.5
18	18	0	13.5	13.5	0
18	18	0	13.5	13.5	0
24	6	18	18	4.5	13.5
12	6	6	9	4.5	4.5
18	12	6	13.5	9	4.5
24	24	0	18	18	0
30	30	0	22.5	22.5	0
12	12	0	9	9	0
6	6	0	4.5	4.5	0
18	18	0	13.5	13.5	0
18	18	0	13.5	13.5	0
30	24	6	22.5	18	4.5
24	24	0	18	18	0
24	24	0	18	18	0
42	18	24	31.5	13.5	18
12	12	0	9	9	0
12	12	0	9	9	0
12	12	0	9	9	0
18	12	6	13.5	9	4.5
6	6	0	4.5	4.5	0
6	6	0	4.5	4.5	0

Fuelwood usage in codes per year without Jatropa	Fuelwood usage in codes per year with Jatropa	Benefit (savings) in codes per Yr.	Cost of fuelwood (in US\$) per HH per year without Jatropa	Cost of fuelwood (in US\$) per HH per year with Jatropa	Savings (benefits) in US\$ per HH/Yr.
18	18	0	13.5	13.5	0
12	12	0	9	9	0
24	12	12	18	9	9
30	30	0	22.5	22.5	0
42	30	12	31.5	22.5	9
36	12	24	27	9	18
36	12	24	27	9	18
12	12	0	9	9	0
24	24	0	18	18	0
18	18	0	13.5	13.5	0
12	12	0	9	9	0
18	18	0	13.5	13.5	0
18	18	0	13.5	13.5	0
12	12	0	9	9	0
14.4	14.4	0	10.8	10.8	0
12	12	0	9	9	0
12	12	0	9	9	0
24	18	6	18	13.5	4.5
24	18	6	18	13.5	4.5
12	12	0	9	9	0
12	12	0	9	9	0
12	7.2	4.8	9	5.4	3.6
12	6	6	9	4.5	4.5
12	6	6	9	4.5	4.5
12	12	0	9	9	0
36	24	12	27	18	9
12	12	0	9	9	0
12	12	0	9	9	0
18	12	6	13.5	9	4.5
12	12	0	9	9	0
12	6	6	9	4.5	4.5
36	16.8	19.2	27	12.6	14.4
30	18	12	22.5	13.5	9
24	18	6	18	13.5	4.5
6	6	0	4.5	4.5	0
12	6	6	9	4.5	4.5
12	6	6	9	4.5	4.5
24	18	6	18	13.5	4.5
18	6	12	13.5	4.5	9
12	6	6	9	4.5	4.5
24	14.4	9.6	18	10.8	7.2
24	24	0	18	18	0
12	6	6	9	4.5	4.5
24	24	0	18	18	0
12	12	0	9	9	0

Fuelwood usage in codes per year without Jatropa	Fuelwood usage in codes per year with Jatropa	Benefit (savings) in codes per Yr.	Cost of fuelwood (in US\$) per HH per year without Jatropa	Cost of fuelwood (in US\$) per HH per year with Jatropa	Savings (benefits) in US\$ per HH/Yr.
24	24	0	18	18	0
60	36	24	45	27	18
18	12	6	13.5	9	4.5
6	6	0	4.5	4.5	0
12	12	0	9	9	0
18.804 Average Codes used per household per year	15.061 Average Codes per household per	3.744 Average Codes saved per household per	\$14.10 Average cost per household per year	\$11.30 Average cost per household per	\$2.81 Amount saved per year per household

Abstract

The promotion of oil producing plants for production of biofuel has come to the fore most recently as a result of the concept of it being used to try and uplift livelihoods among rural communities. There are many arguments in favour and against biofuels. However, a current debate focuses on the possible negative social and environmental implications, especially with regards to land competition and sustainability assurance. There has been growing concern on taking arable land out of food production and allocating its use to production of energy crops. Experience gained with the establishment of *Jatropha* hedges, collection of *Jatropha* seeds, oil extraction and use of *Jatropha* oil to run diesel engines present a tremendous potential for developing rural industries and utilizing bio fuel energy. However, establishing oil milling plants as a strategy to provide energy to remote and scattered rural villages requires substantial investment amounts of money and therefore this justifies the need for doing an evaluation to objectively verify the financial viability and economic desirability of the schemes. Interestingly, this analysis of *Jatropha* hedges and oil milling schemes in rural Zimbabwe shows that energy crops such as *Jatropha* have the potential for increasing increasing the economic welfare of people in the rural areas.