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Article

Economic Impact and Challenges of *Jatropha curcas* L. Projects in North-Western Province, Zambia: A Case of Solwezi District

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Abstract: Forest products, wood and non-wood, remain vital among smallholder households in Zambia with charcoal being the most sought after product. This has led to increased exploitation of forest trees to meet the needs for fuel wood, among others. However, *Jatropha curcas* plant has been identified as a potential fuel source. In the early 2000s, profit-making organizations encouraged smallholder households to grow *Jatropha* for use as an alternative fuel source. This paper reports on a study conducted in Solwezi between 2011 and 2014 to evaluate the impact of *Jatropha* cultivation for biofuel production. A sample of 100 small-scale farmers involved in *Jatropha* cultivation and key informants were interviewed to evaluate the impact of growing *Jatropha* at the small-scale level. Results show that farmers lost out on time; income from sale of edible non-wood forest products; and experienced reduction in maize (*Zea mays*) and bean (*Phaseolus vulgaris*) production, worsening household economic conditions. Farmers attributed this loss to unclear policy alignment on biofuel production by government. We therefore recommend that project implementation should involve interactions of all legislative bodies and any other concerned stakeholders. There is also a need to promote the value chain, from production to marketing, which focuses on minimizing detrimental effects on the livelihood of small-scale farmers.

Keywords: charcoal; firewood; *Jatropha curcas*; livelihood; non-wood products; policy

1. Introduction

Energy plays a major role in the developmental process of a country. The availability and affordability of energy supply is particularly important for the social and economic progress of rural communities. In Zambia, woodlands and forests, which are the main sources of wood fuel for the rural communities, are estimated to cover about 60% of the total land area [1–3]. The perceived abundance of the wood resources continues to influence Zambia's energy consumption with about 88% of Zambian households relying on forest resources to meet their energy needs [4]. The majority of resource-poor Zambians, who have limited access to income and employment depend on the forest and its resources for their livelihood [5]. Some of the most exploited forest products supporting resource poor households are wood for firewood and charcoal, wild fruits, edible caterpillars and mushrooms, and of these, charcoal is the most sought after forest resource. The aforementioned forestry products are harvested for both home consumption and trade.

Exploitation of these natural resources puts pressure on the existing forests to support the needs of the resource poor Zambians. This has led to increased levels of deforestation with estimated rates of about 250,000–350,000 hectares per annum (based on 1965–2005 data) [5] across the country. With this high deforestation rate to meet wood fuel demands, there is urgent need to intensely change the way forest resources are handled [6]. The current deforestation rates in Zambia would translate into the loss of all forestland in less than 100 years, unless corrective measure are taken [6], such as artificial planting of trees and provision of alternate sources of products. This means that there is need to integrate the current energy demands with biofuel sources based on promising biofuel plants like *Jatropha curcas* L. *(*hereto referred to as *Jatropha*). *Jatropha* presents an opportunity to provide the raw material needed for biofuel production and lessen pressure on the forest resources, especially trees.

Jatropha is a small perennial plant or large shrub belonging to the genus *Euphorbiaceae*, which has more than 170 species [7]. *Jatropha* has been cultivated in Central and Southern America, Southeast Asia, India and Africa [8]. It is drought resistant and has been said to establish on marginal lands [9,10] and able to grow in areas with as little rainfall as 250 mm per year [11]. The plant shows articulated growth, straight trunk, thick branchlets with a soft wood, flowering in the wet season and with possible oil yield of about 1500 kg/ha [7,12]. *Jatropha* is a promising plant for both bio-energy supply and socio-economic development in developing countries [13]. The seeds that are harvested contain about 32%–40% oil [14], which is the primary requirement for the production of candles, soaps and biofuel. According to [15], *Jatropha* has the potential to economically empower small scale farmers by supplying them with seeds that can be used for production of oil/biofuels and soap. Besides this, the seedcake is rich in nitrogen and a good source of plant nutrients [16]. *Jatropha* plant has been used to control erosion, restoration of degraded ecosystems [17,18] and as a source of green manure [19,20]. *Jatropha* growing has also been recognized as a favorable livelihood broadening strategy for rural communities, alleviating energy demands [21,22] and generating income [23]. When established at the large-scale level, the plant

requires huge labor input for management [24], thereby having the potential for improving the rural economy by creating employment [25–28].

In spite of all the above mentioned positive attributes, only a few can be sustained scientifically [24,29]. For example, critical and peer reviewed literature on production and performance of *Jatropha* under various climatic conditions is lacking [24]. A few studies that have been done show that *Jatropha* seeds are toxic to humans and many animal species [30], labor intensive, and can compete with food crops for land and water [31]. The biodiesel has the potential to cause depositing of carbon in the engine and thickening lubricating oil [32,33], leading to engine damage [24].

The intensification of *Jatropha* cultivation in Zambia has not been fully exploited by many small-scale farmers. The plant has been grown as a hedge or live fence around homesteads, gardens and crop fields as protection against invasion by roaming animals. In the late 1990s and 2000s, large-scale production of *Jatropha* had taken off with profit making organizations, such as Oval Bio fuels, Marli Investment, the Copperbelt Energy Company (CEC), D1 Oils S.A. (Pty) Ltd., and the Biofuels Association of Zambia. These companies committed large tracks of land for growing *Jatropha* or contracted smallholder farmers through the out grower schemes.

In Solwezi, three profit making organizations, namely, Marli Investment, Kansanshi Mines and Northwestern Bio-power, invested in *Jatropha* cultivation by engaging smallholder farmers. These organizations developed contractual arrangements with smallholder farmers on out-grower basis to plant a few hectares of *Jatropha* on their farms [34]. In return, the farmers were to receive incentives in the form of funding and agricultural inputs, such as maize seed, until *Jatropha* seed production started [29]. Fertilizer and farm management trainings were other incentives offered by these *Jatropha* promoting organizations. Each individual farmer was expected to plant 1000 *Jatropha* trees within a period of one year, as *Jatropha* was being regarded as a plant good for livelihood broadening strategy, bio-energy supply and socio-economic development for the rural communities [13,21,22].

In the mid 2000s, interest in the production of biofuels in Zambia surged [35] and organizations that expressed interest used the out grower models [29,35] to increase plant population of *Jatropha*. The out grower scheme was considered to be less-capital intensive [35]. These projects, through partnership with the government, were expected to improve farmers' household income, contribute to agriculture diversification, reduce poverty and increase economic growth. However, the aforementioned positive results were not realized, as the projects collapsed due to various reasons mentioned in this work. Therefore, the objective of this study was to evaluate the impact, benefits, challenges and role of government in the *Jatropha* cultivation project among small-scale and resource poor households of Solwezi in North-Western Province of Zambia.

2. Methodology

2.1. Site Description

The study was conducted in Solwezi district (Figure 1a,b), North-Western Province of Zambia. Solwezi district is located in the northeastern part of the Province between latitudes 11°32″S and 13°28″S and longitude 24°45″E and 27°37″E. Solwezi district lies in agro-ecological zone III of Zambia, which experiences a unimodal rainfall with an average annual rainfall of 1386 mm. The average maximum and

minimum temperatures range from 26 °C–37 °C and 6 °C–19 °C, respectively. The soils are broadly defined as ferrasols, mostly clay, red to brown in color, highly leached, hence acidic with soil pH levels of about 4–6, low in bases retention capacity, and low general soil fertility [36].

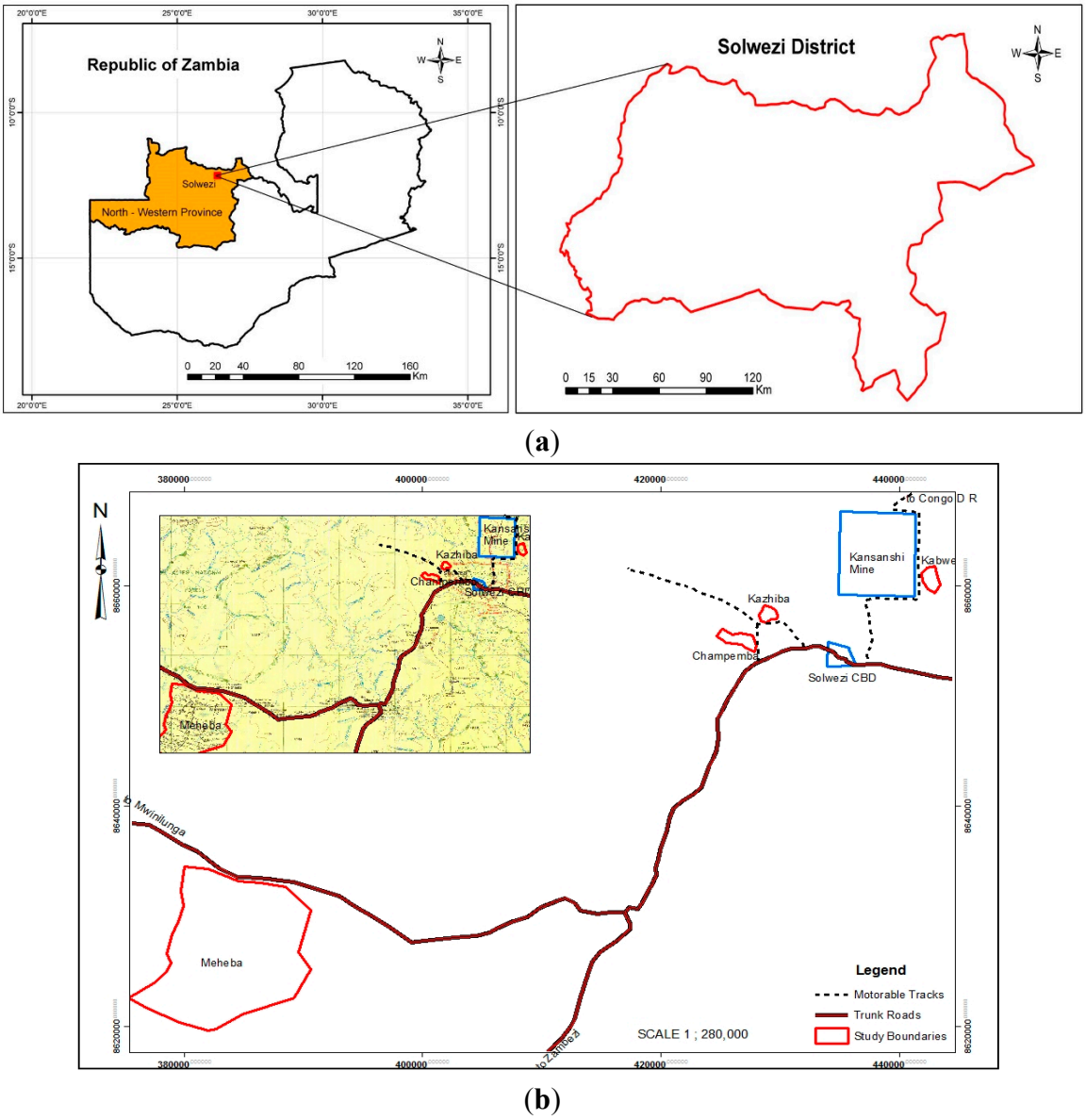


Figure 1. (**a**) Map of Zambia and Solwezi District and (**b**) map of sampled sites in Solwezi.

2.2. Site Selection and Sample Size Selection

Solwezi was purposely chosen because of the known multinational organizations promoting *Jatropha* projects in the district. The three organizations that were promoting *Jatropha* cultivation had individually contracted a number of small-scale farmers to grow *Jatropha*. The overall objective of these projects was to improve livelihood of the local farmers through production of *Jatropha* seed. The other objective was to provide a local resource seed hub for bio-fuel production, especially for the organizations involved in the project. The target areas for the projects were Champembi, Kabwela, Kazhiba and Maheba refugee camp (Figure 1b). The three organizations had a combined population of about 800 farmers initially enrolled in the program, but only 500 farmers had actively taken to planting *Jatropha*.

In each of the areas supported by government and the three organizations that had been promoting *Jatropha* production/growing, household interviews were carried out to identify the farmers who had been contracted. Respondents were selected from a list of *Jatropha* growers prepared for each area and this was done in consultation with local personnel and a few community members in the area concerned. A sample of 100 farmers was selected for this study and a simple random sampling of respondents was employed. The respondents were selected based on the length of period they were involved in the project, with the first priority given to those who participated in the project from time of inception. The other inclusion criterion was based on the size of land under *Jatropha* cultivation. Only farmers whose land size under *Jatropha* growing was about 1.48 ± 0.15 ha were selected. This was done so as to calculate the time spent in management of *Jatropha.*

2.3. Socio-Economic Survey

Household interviews were held and these focused on the socio-economic issues of *Jatropha* related activities such as agricultural and income generating activities, challenges and triangulation of the seasonality of agricultural, and non-agricultural workloads. The household interviews also sought information on land use activities in the areas before introduction of *Jatropha*, reasons for participating in growing *Jatropha*, problems caused by growing *Jatropha* and roles that the government played. Other questions concentrated on finding out the performance of their *Jatropha* plantations in terms of seed yield, current work regarding *Jatropha,* reasons for continuing/discontinuing cultivation and future plans for *Jatropha* fields. Skills gained from cultivation of *Jatropha* cultivation were also investigated.

Six focus group discussion (FGD) informed by redundancy and saturation, two from each area and key informants (KI) interviews, these being extension officers from the project implementing institutions and the Ministry of Agriculture, village headmen, *Jatropha* out growers group leaders were also held. These FDGs and KIs interviews focused on the livelihood aspects such as income generation activities, food security and technical knowledge gained from growing *Jatropha.* Discussions also focused on the role of government and extension personnel from project implementing institutions on informing the farmers on the current technologies and practices in *Jatropha* cultivation and the availability of markets for *Jatropha* seed.

During this study, community leaders provided information on gender participation and also highlights on the resources that were provided by the project implementers to support *Jatropha* plantations.

2.4. Data Analysis

The data, obtained from Household interviews was coded, and analyzed using the Statistical Package for Social Sciences (SPSS) Version 17 (IBM Corporation, New York, NY, USA), while that obtained from FDGs and KIs was digested and summarized. Several statistical approaches were used, starting with descriptive statistical analysis of the socio-demographic data (gender) that was obtained. The analysis of the livelihood activities and major income sources was done using descriptive statistics. To analyze the impact of *Jatropha* growing on time management and crop production, a chi-square test was used. To examine whether the time (number of days) spent in the *Jatropha* fields was significantly different, non-parametric Kruskal-Wallis test was used.

3. Results

3.1. Socio-Economic Demographics of Respondents

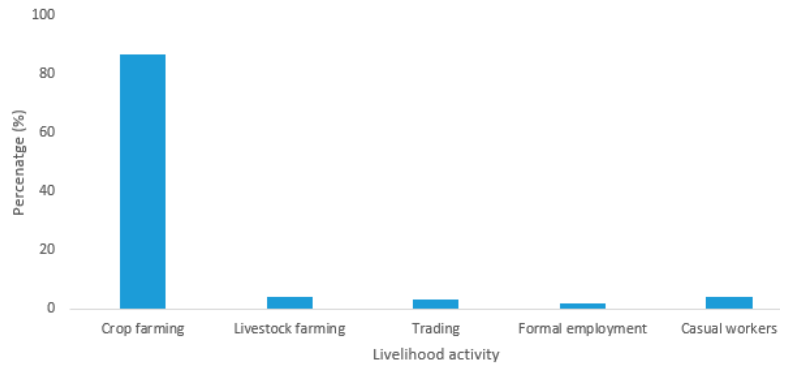
Participation by gender: A survey on the number and type of participants was done and segregated according to gender. The results show that 61% (n = 100) of the respondents were males while 39% were females (Table 1).

Table 1. Household demographics.

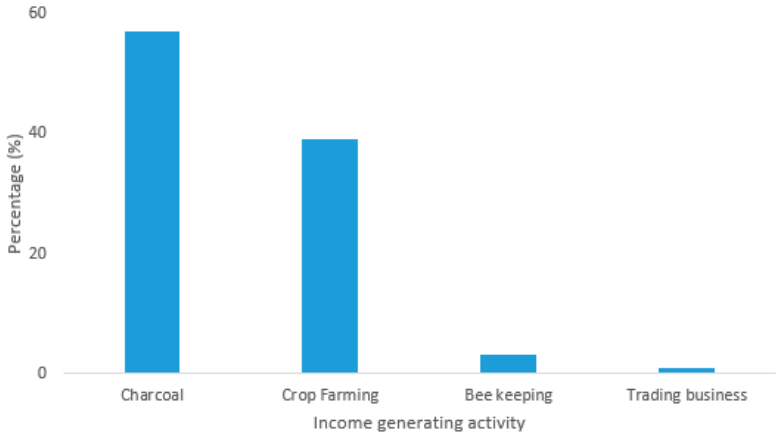
Sex of Respondent	Frequency	Percentage (%)
Male	61	61
Female	39	39

Activity types: The types of livelihood activities being practiced by *Jatropha* growers was investigated and from this study, agriculture crop farming was the most prominent (approximately 87%) compared to other activities, such as livestock farming, trading, and employment. Livestock farming contributed only 4% to the total activities being carried out (Figure 2a).

Other Income Generating Activity: The identified sources of income generating activities among respondents were charcoal production (57%), crop farming (39%), beekeeping (3%) and trading business (1%; Figure 2b). Of these activities, charcoal production was found to be more prominent when compared with trading business (Figure 2b).



(**a**)



(**b**)

Figure 2. (**a**) Type of livelihood activities and (**b**) major income generating activities.

3.2. Impacts of Jatropha Growing on Crop Production

In the projects' sampled sites, farmers used two (2) farming methods, namely, integration of *Jatropha* into *Z. mays* and *P. vulgaris* L. fields, and also mono cropping of *Jatropha* plants. In most fields that were visited, *Jatropha* plants had been planted at 10 m × 10 m spacing, regardless of the type of cropping system used. This kind of spacing was used to reduce shedding effect of *Jatropha* on the beans and maize. This study observed that 53% of the fields were under mono cropping while 46% were under mixed cropping system. Seven (7%) of the fields had a mixture of *Jatropha*, food legumes and fruit trees, such as mangos (*Mangifera indica*). Eighty-eight (88%) of the respondents observed that *Jatropha* growing had negatively impacted on crops such as maize and beans

Two farming practices had been employed in the cultivation of *Jatropha.* The results show that there was neither a relationship ($r = 0.29$) between monoculture and *Jatropha* seed yield nor mixed cropping ($r = 0.43$) and *Jatropha* seed yield. The average seed yield from mono cropped fields was about 98 kg per hectare, while in the mixed cropped fields it was approximately 53 kg per/ha. On the other hand, farmers practicing mono cropping and those practicing mixed cropping both experienced reduced yields in maize and bean grain.

3.3. Impact of Jatropha Cultivation on Farming season Time Budgeting

According to this study, there were significant differences ($p < 0.021$) in the number of days per month spent in the field of *Jatropha* for various *Jatropha* management activities. Fifty-six percent (56%) of farmers spent more than 16 days per month during the growing season caring for *Jatropha*, while 34% spent between 10–15 days.

This study also revealed that 82% of the *Jatropha* farmers had spent less time collecting edible non-wood forest products such as mushrooms, caterpillars and wild fruits such as *Uapaca kirkiana* due to spending more time in their farms. Besides lacking time to collect the aforementioned products, climate change and variability has also brought about changes in the occurrence of rains affecting the flowering and fruiting of indigenous tree species of Zambia. The amount of fruits produced per season has also reduced yet these products contribute to improved household incomes.

Fifty-six (56%) and twenty-six (26%) of the respondents engaged their children and wives, respectively, to collect non-wood forest products such as wild fruits, mushroom and caterpillars and these collections were only enough for home consumption. Fifty-eight (58%) of the respondents also said this translated into reduced availability of food during the dry season. On doing further exploration, results show that there was a significant correlation ($r = 0.6$) between time spent in *Jatropha* fields and the production of crops such as beans and maize. This means that the time spent in *Jatropha* fields greatly affected the yield of crops that the communities were traditionally growing.

3.4. Time Spent in Jatropha Fields and Perceived Household Economic Conditions

A chi-square test of independence was done to show if the skills gained had an effect on the household economies. A Pearson chi-square (χ^2, $n = 100$) value of 1.168 was obtained, showing that skills gained from *Jatropha* planting had no effect on household economic conditions. However, according to the survey conducted, contrary to the expectations of *Jatropha* cultivation improving household economic conditions,

the majority of the respondents (69%) were of the view that their household economic conditions had worsened. The other respondents (31%) saw no change, either positive or negative, in their household economic conditions. On the other hand, some farmers observed that despite the household income levels being low, the skills gained from *Jatropha* management lessons helped them improve the management and agronomic practices in their bean and maize fields.

3.5. Benefits from Technical Training

The project implementing organizations provided farmers with trainings in seed harvesting techniques, field management, tree seedling nursery techniques, marketing and field demarcation trainings to help farmers manage their fields and be empowered with knowledge. Eighty-four (84%) respondents benefited from training. Of the three organizations that provided technical service trainings, Kansanshi mines was ranked first, while North Western Bio-power and Marli Investment came second and third, respectively. According to results (Figure 3) obtained in this study, 48% of respondents benefited from lessons on field management, followed by nursery establishment techniques (46%) and field demarcation (38%) trainings. Harvesting and marketing techniques had 30% and 26% response respectively. Record keeping was the least appreciated of all the trainings offered, with only 13% of respondents gaining from lessons done.

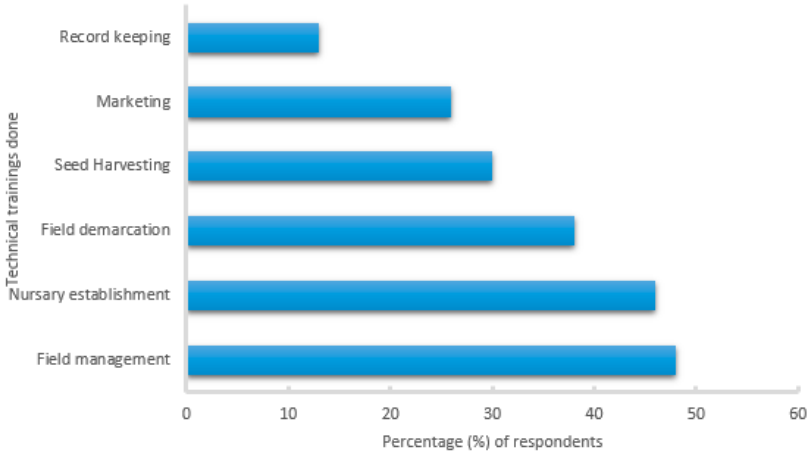


Figure 3. Technical support provided.

Besides technical knowledge, the respondents gained skills such as group mobilization and leadership training which would confidently help them manage future projects. According to this study, implementing institutions invested so much time in training farmers on plant and field management and less on other lessons such as record keeping, leaderships, group cohesion and entrepreneurship. Only 10% of the respondents gained from leadership lesson and 3% gained from entrepreneurship lessons. These lessons were not a priority to the facilitators, as they concentrated more on crop management lessons.

3.6. Challenges

Zambia, besides Mozambique, experienced the greatest *Jatropha* expansion in southern Africa [29]. The study revealed several challenges that were faced by *Jatropha* growers contracted. Some of the challenges that contributed to the collapse of the *Jatropha* projects in North Western Province were, lack

of extension and backstopping services, compensatory incentives, markets, and market information and; unclear government policies on *Jatropha* plant and products handling.. Before introducing the projects, there was no participation from stakeholders, mainly farmers, and it appeared that ideas were imposed on the farmers.

3.6.1. Role of Government

The study showed that 97% of the respondents indicated lack of government support towards these *Jatropha* projects. The *Jatropha* growers received little if any or no extension services from the Zambian government to assist them in understanding the agronomic practices required to manage *Jatropha.* The Zambian government is also lacking guidelines on handling of such crops, especially because they are exotic. The government also failed to provide the market system to handle products of the *Jatropha* projects.

3.6.2. Lack of Compensatory Incentives

In their initial agreements, 87% of the respondent committed their land to *Jatropha* cultivation because of the incentives such as maize seed and fertilizer that they were promised by participating organizations. Other farmers (13%) committed their land because of the monetary benefits that were attached to the *Jatropha* projects. However, 63% of the farmers were not given any of the products they had been promised, while 18% received packs of maize seed in their first growing season only

3.6.3. Lack of Markets and Market Information

At the inception of the projects, farmers were guaranteed markets for the *Jatropha* seed and any other products that would come out of the projects. However, according to 92% of the respondents, no markets were provided for the sale of the seed that had been harvested and this was among the factors that contributed to the failure of the project. Besides lacking markets for the sale of their seed, the majority of the farmers (73%) had no experience in selling and had never sold *Jatropha* seed before. The study further revealed that 79% of the respondents were not provided with market information on *Jatropha* seed prices and pricing in relation to other crops. Where farmers were able to sell their seed, they were unable to bargain and this was compounded by lack of market information. Market information on the pricing structure for crops like maize, rice and others is often provided by the government; however, no information was provided for *Jatropha* and thus, farmers did not understand the pricing structure that was used to come up with *Jatropha* prices.

4. Discussion

4.1. Impacts of Jatropha Growing on Crop Production

Most farmers (53%) grew *Jatropha* as a sole crop as compared to growing it in a mixed cropping system (46%), while 88% of the respondents felt growing of *Jatropha* had a negative impact on grain yield. The possible shading of *Jatropha* made the farmers think that the leaves might have a negative impact on the beans and maize, thus threatening its yield. Plants compete for various limited resources found aboveground (light, space) and belowground (nutrients, space and water) and, according to [37],

competition can bring about reduction in crop yield. When thinking of intercropping crops, it is important to consider the phenology to avoid negative results. There was need to understand and consider the time *Jatropha* sheds its leaves, the branching and rooting pattern, the frequency and how much leafy matter could be put up by the plant. Most farmers, therefore, decided to use mono cropping of due to the perceived competition between trees and crops, among other factors [38].

Organic matter tend to produce allelopathic chemicals, which, according to [39], may be negative or positive to the companion crop. In this case, little if anything is known about the types, composition and effects of allelochemicals in *Jatropha.*

Jatropha cultivation greatly affected the production of crops that the farmers had been growing. This is because, upon its introduction, *Jatropha* was poised to have high returns in terms of income as compared to conventional crops that the farmers had been growing. The two conventional crops, maize and beans, are grown for both home consumption and for sell thus, giving the growers ready cash every season as the price for these crops is provided by the government after every growing season. The price of *Jatropha* seed however, was determined by the institutions that were promoting the plant. On the other hand, it is also possible that farmers did not believe in the organizations that introduced the projects to them and in the promised outcome of the projects. Most often, smallholder farmers do not accept change easily especially if they are not involved in the planning, monitoring and evaluation stage as was the case here.

4.2. Impacts of Jatropha Cultivation on Farming Season Time Budgeting

The study shows that most farmers spent more than 16 days working in their *Jatropha* fields instead of doing other non-farming income generating activities. This greatly reduced the time they had to collect wild fruits and doing contractual weeding for other farmers for extra income. Engaging their children as well as their wives did not help, as they were only able to collect enough non-wood forest products for home consumption. Besides the loss of extra income that could have been earned from contractual weeding, there were other losses in bean and maize grain yield. This is because little or no weeding had been done in these fields. Major grain yield losses in maize and bean fields were recorded among farmers who spent more than 16 days in a month caring for *Jatropha*.

The non-wood forest products collected during the rainy season, instead of selling, are dried and later used as relish during the dry season. The majority of farmers failed to balance the time they needed to do farm activities and other non-farm activities. Time is another very important economic factor and understanding the economics of time helps farmers manage other economic factors effectively. The *Jatropha* farmers failed to balance their time in attending to *Jatropha* and attending to other in-season activities. Inability to balance and budget their time made farmers miss out on the cheap source of proteins, fats and other vitamins from non-wood forest products like caterpillars [40]. This negatively affected their food security and nutrition status. On the broader issue of food security, two contrasting views evolved from several discussions that focused on the involvement of smallholder farmers in *Jatropha* production. It has been observed that *Jatropha* production by smallholder farmers could exacerbate their poverty in the sense that more resources will be diverted from other food crops [41] as was the case in this current study. On the other hand, it has also been argued by the Biofuel Association of Zambia that involving smallholder farmers in *Jatropha* production is a potential route for poverty reduction and an opportunity for meeting the need and expanding market for liquid biofuels [41]. This study has exposed the potential

impacts of promoting *Jatropha* production, especially on resource constrained smallholder farmers, who have limited ability to cope with production and price risks.

4.3. Opportunities of Jatropha Cultivation

Agronomic skills are just as essential as entrepreneurship skills if farmers are to realize profit from their farms. As much as farmers gained agronomic practices, there is need to put these skills gained to cultivating new crops and cultivars, better animals husbandry practices and alternative technologies to increase productivity and diversify production [42]. According to the study, *Jatropha* cultivation provided one opportunity which was not realized and this is the development of local seed hub for biodiesel supply chain. This was going to provide a valuable energy source to fill the everyday needs of rural people. Access to energy is strongly linked to economic development [43,44]. Energy provides both direct (fuel) needs and indirect needs, such as lighting. This means that the availability of energy stimulates economic development [45,46]. The success of the *Jatropha* project was going to provide both employment and a cheap source of energy that was going to be useful in reducing poverty by increasing food productivity through irrigated agriculture as well as reducing post-harvest losses of other food crops grown within the area.

4.4. Lack of Compensatory Incentives, Markets and Market Information

Most farmers did not receive as promised their incentives in terms of cash, maize seed and fertilizers during the time they were involved in *Jatropha* production. This discouraged many farmers who had been contracted as no proper management system had been put in place to follow up on their contractual benefits. In doing contractual farming and in order to obtain meaningful results, [47] recommended proper management and consultation with farmers. Inability by the promoters to fully consult other stakeholders and engage farmers wholly brought about a lack of meaningful management of the plants, abandonment of *Jatropha* growing after investing so much in form of labor and time and consequently a possible precursor to the failure of the project and the development of the biodiesel sector in Zambia [48]. This is contrary to the view of the Biofuels Association of Zambia that promotes involvement of smallholder farmers in *Jatropha* production for poverty reduction and to meet the market demands for liquid biofuels [41].

Besides the inability to provide incentives, inability to provide farmers with direct service such as market information and pricing of *Jatropha* seed was a major problem towards sustainability of the project. This meant that farmers were either not going to find any markets for their farm produce or the market offer price may be very low. According to [49], low prices have usually been offered for *Jatropha* seed. In any business, markets and market information are two important components. Nevertheless, [50] observed that governments play an essential role in encouraging or discouraging markets and for markets to be effective, governments have to provide efficient incentives. The failure by both the government and the *Jatropha* project implementers to provide adequate market information on the pricing of *Jatropha* seed, and inability to provide markets contributed to the abandonment of the project by the farmers. Because of their inability to sell the seed, most seed was left to waste, as the farmers had no use for it.

It was, however, observed that the amount of seed (53–98 kg per ha) that the farmers were harvesting at the end of the cropping season was way below economic levels for both the promoters and the farmers

themselves. Studies [31] show that *Jatropha* has been projected and claimed to be able to produce about 16.6 tons of seed per hectare and that this would translate into 5.8 tons of oil per ha, yielding two to three times more oil per unit land compared to other annual oil crops such as soybeans or sunflower [29]. However, what these studies have shown has never been achieved anywhere. The unpredictable yields could have probably also contributed to failure of the project to continue. According to [51], caution needs to be exercised before encouragement of large-scale cultivation of *Jatropha* in order to reduce many threats such as economic loss as was the case in this study.

Due to the Ministry of Agriculture's lack of involvement in providing efficient incentives and *Jatropha* seed pricing, farmers lacked protection and security from the investors of *Jatropha* growing. The Zambian government did not provide any constant monitoring, evaluation, or back stopping in ensuring that proper management practices were adhered to. This act may lead to farmers being abandoned, if and when investors or donors of such projects decide to leave. Governments' involvement in such projectors will normally provide security, check and balances to the farmers which prevents premature abandonment of projects. The farmers only relied on the skills they had gained from the implementers most of which involved crop management practices.

4.5. Role of Government: Unclear Policy on Jatropha and Bio Fuels

The Zambian government has an Energy Regulation Act of 2008 and a Board to regulate production and utilization of biofuels [49]. However, the Act needs reviewing as it is outdated and there has also been no coordination and monitoring of *Jatropha* projects on the part of the government [52]. The government has also been unable to state its position on *Jatropha* growing due to fears of unknown impacts of the plant on the environment [53]. To date, no guidelines/policies exist in Zambia on the handling of *Jatropha* and its products, among others. Ultimately, this could explain the observed failure to develop and encourage *Jatropha* cultivation across the country According to [54], the government has a number of policies with ambitious strategies, however, the co-relationship between the content and the strategies in these policies seem to be distant.

Despite the support that *Jatropha* received in Zambia, the government still subsidized imported fossil fuels and delayed mandating a standard price for biodiesel it uneconomic for *Jatropha* ventures to operate [29]. Absence of monitoring of projects, lack of defined government policies or legislations on energy on *Jatropha* growing made the organizations that were promoting *Jatropha* cultivation to abandon the farmers. Inability of the government to get involved and deficiency of government commitment in warranting that monitoring of on-going projects led to small-scale farmers not being protected from these organizations [29]. The lack of proper policies affect the viability of *Jatropha* projects too. In the early 2000s, farmers in some areas such as Chibombo, Kasama and Lufwanyama districts who were growing *Jatropha* were abandoned just before selling their seeds, while others were abandoned just after learning the skills on how to add value to their seed [55]. The abandonment and disappointments faced by these farmers could have been avoided if the Zambian government had policies that offer strong monitoring and evaluation of project implementers. The lack of policies or acts in ensuring strict adherence to strict monitoring and evaluation could also have contributed to the failure of the *Jatropha* projects. The lack of institutional support has further been shown to reduce and impact negatively on willingness to adopt *Jatropha* in the future [51]. This can be avoided if governments of

developing countries like Zambia deliberately developed a range of mechanisms and structures led by the experiences and expertise of other supporting institutions so as to underpin these developmental projects into a more sustainable venture.

5. Conclusions and Recommendations

Many organizations, both government and non-government supported, have tried to engage in *Jatropha* growing in many parts of Zambia such as North Western, Central and Northern Provinces, among others. However, findings from this study seem to suggest that *Jatropha* growing in Zambia is still a distance far largely due to many challenges. *Jatropha* cultivation is perceived to impact negatively on productions of other essential crops. In particular, the yields for both maize and bean reduced greatly especially among farmers who had planted the crop in mixed cropping system. Those who had planted *Jatropha* under monoculture reduced the hectarage under beans and maize and this led to reduced yield as they had committed most of their land to *Jatropha* cultivation.

The growing of *Jatropha* led to loss of time which ultimately affected farmers' collection of other non-wood forest products. The loss of income from the sale of these products led to worsening of household economic conditions. The farmers however gained farm management skills from the project. Jatropha growers in the study area as well as Zambia as a whole faced a number of challenges. The study reviewed that there was no support from the government through the relevant ministry during the implementation of the project. This is because the government did not provide a mechanism for the determination of *Jatropha* seed price like prices for other food crops such as maize, beans, groundnuts and rice are determined. Most farmers were not given any incentives by the project implementing organizations for having committed their land towards the cultivation of *Jatropha*. Lack of markets and market information was another challenge that the farmers faced. The farmer had no experience in the sale of *Jatropha* and the lack of information on price fixing for *Jatropha* made it difficult for them to continue with the project. For the sustainability of similar projects, there is need for collective action and interaction among all legislations pertaining production, agriculture markets, labor, human rights and other concerned stakeholders. This will enable transparency in the fixing of the price for *Jatropha* seed. While there may be no funding for immediate plans for revival of *Jatropha* growing, the government should create an enabling environment by providing extension and backstopping services to the private sector desiring to go into trade and also by putting a supportive bio-fuel legislation or policies in place. This should be accompanied by research to fill in the knowledge gaps and variable yields. The government also needs to encourage the development of proper markets through provision of incentives and protection of the local communities by safeguarding their interests and land. There is also need for creating extensive research work into this so as to refine the government policy.

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Author Contributions

The main author was involved in data collection, analysis drafting and arranged the manuscript in the form it was presented for publication. The second author was involved in data collection and analysis. The third author was involved in data analysis and editing the manuscript. The fourth author was involved in drafting and editing. The Fifth author was involved in arrangement and editing. The sixth author was involved in editing and final review. The seventh author was the project supervisor, edited the manuscript and text formatting.

Conflicts of Interest

The authors declare no conflict of interest.

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